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Who's at Stake? Nonhuman Agency Concepts and Cultural (Folk)ecologies

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Abstract. This dissertation presents a program of research on cultural cognition of the natural world, involving long-term research with indigenous Ngöbe partner communities (Panama) and selected comparisons to Western samples (US). In two series of experiments focused on agency concepts, we show that cultural frameworks recruit distinct principles for inferring agency across distinct sets of nonhuman actors, and these frameworks productively guide predictive inferences for the actual behavior of nonhuman actors. We consolidate these findings by using bottom-up consensus modeling to show that Ngöbe and US cultural differences reflect two distinct conceptual models of agency rather than variations on a single (universal) model. We argue that these cultural differences in basic conceptual frameworks reflect distinctive cultural organization of social and ecological domains. Findings are considered in light of current cognitive psychological theories of domain-specific folkpsychology, and an alternative account is offered based on a folktheory of communication that infers agency on the basis of relational interactions rather than having a mind. Finally, we place these findings in the context of broader interdisciplinary research on animism with a focus on recent innovations in ontological anthropology. This dissertation research raises significant questions concerning theories of concepts, culture, and their interaction—and what this means for mutually sustainable human-environment interactions.

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Introduction

In the Ngöbe community, daily life is closely coordinated with neighboring plant, animal, and mineral beings. When I first arrived in the village more than six years ago, I aimed to study development and intergenerational cultural learning in the domain of social cognition. My Western psychological training had prepared me to expect that social cognition would concern reasoning about the mental states of other humans. But ethnographic interviews and daily experiences in the village presented a distinctly different view of social agency. For one, subjective states such as thoughts or dreams seemed to be viewed as relational states that arose out of interactions between beings and environments, rather than as internal states contained in a private mental world. Additionally, it became clear that social reasoning was not restricted to humans: for Ngöbe, trees feel pain, butterflies communicate, and the sun thinks about earth. Studying social cognition in the Ngöbe context required a new starting point for understanding what it means to be social.

Coming to understand this way of relating to nonhuman lives requires an appreciation that environmental cognition is actually, in an important way, an expression of social cognition. Tracing the cognitive consequences of this perspective would occupy my next six years of graduate study. Working closely in the field with my Ngöbe colleague Salino García, I designed a series of experiments with Ngöbe and US adults to pursue the hypothesis that culturally variable views of the social domain could reflect distinct concepts of agency as a psychological or communicative phenomenon.

Three focal projects are presented here. The first set of experiments investigates cultural variation in grounding principles for inferring agency. In studies with Ngöbe and US college students, we employ several converging measures including agency attributions across multiple dimensions, coding analysis of explanations, and an experimental framing manipulation. The second set of experiments builds on this work by investigating how Ngöbe and US informants interpret and make inferences about nonhuman agency, focusing on plants as a critical test case. Our main objective here is to go beyond verbal attributions of agency to test whether folktheories of agency guide distinct predictions for actual plant behaviors linked to complex forms of social agency. In both sets of experiments, we consolidate our findings by using bottom-up cultural consensus modeling to test whether these cross-cultural differences reflect two distinct conceptual models of agency or variations on a single model. Finally, the third project brings this cognitive evidence into conversation with ontological anthropology and the new animism. Building on interdisciplinary theory, we argue that Ngöbe perspectives require a new approach to the basic question of what it means to be a social agent—one that starts from a concept of communication and extends beyond humans to the wider community of beings. Such an ecocentric framework for appreciating human-nonhuman relations is needed in order to address urgent challenges of ecosystem survival.

Grounding principles for inferring agency: Two cultural perspectives

1. Introduction

Agents captivate our attention and animate our worlds. A major goal for cognitive science is to understand how people recognize an agent and conceptualize its capacity to act. These concepts are integral to language, causal reasoning, folk theories, and mind perception, and actively structure social cognition and moral reasoning (e.g., Banaji & Gelman, 2013; Carey, 2009; Lowder & Gordon, 2015; Waytz et al., 2010). In fact, agency concepts are so fundamental that they are often presumed universal (Johnson, 2003; Spelke & Kinzler, 2007; Sperber & Hirschfeld, 2004). At the same time, it is increasingly clear that agency concepts are multifaceted. Exploring the underlying principles for inferring agency is the focus of a growing body of research, typically among Western populations (Gray et al., 2007; Knobe, 2011; Tamir et al., 2016). While some aspects of agency perception may be universal, we believe there is striking cultural variation in concepts of agency based on grounding principles for inferring agency. Here we report one such case, contrasting conceptual frameworks for agency among indigenous Ngöbe of Panama and US college students.

2. Background

Agency, broadly defined as the capacity to act, is a signature property of moving, living, and sentient kinds. Depending on the interpretive stance adopted, an act of agency may be conceptualized quite differently depending on whether it is thought to arise from purely physical mechanisms or meaning-laden social processes, for instance.

How people parse these conceptual categories for agency is an important question for cognitive science (Csibra & Gergely, 2007; Lewis, 1990). One influential view holds that agency is conceptualized under separate frameworks corresponding to specific ontological kinds (Wellman & Gelman, 1992). On this domain-specificity account, which has been developed primarily among Western cultures, people intuitively understand action in terms of distinct folktheories for force dynamics of physical kinds (folkphysics), teleological agency of living kinds (folkbiology), or mental agency of animate kinds (folkpsychology). For instance, individuals may interpret movement toward the sun differently for a cloud versus a plant (physical versus biological), and both differently from a person's movement toward the sun (psychological) (Gutheil et al., 1998; Opfer & Gelman, 2001; Opfer & Siegler, 2004).

Within the folkpsychological domain itself, a further distinction has been proposed between two forms of mental agency associated with either experiential or cognitive capacities (Gray et al., 2007). These two dimensions of mind perception are thought to involve distinct inferences about biological versus representational faculties, respectively (Knobe, 2011). For example, human-created entities such as artificial intelligence or corporations are judged high on cognition but low on experience (as they are not alive), whereas nonhuman animals are judged high on experience but low on cognition (as they do not have conscious representations). This seems to reflect a mirroring of the broader folkbiology-folkpsychology distinction within the domain of psychology proper.

Domain-specificity is widely seen as a universal feature of cognition (Gelman & Legare, 2011; Sperber & Hirschfeld, 2004). At the same time, it is well known that cultures diverge in explicit beliefs about agency. For instance, many indigenous cultures take a broad view of agency by holding that non-animal natural kinds like plants, minerals, celestial bodies and abiotic forces (e.g., thunder, ocean) may perceive, respond, and communicate (Hallowell, 1960; Harvey, 2005). These are capacities that most Westerners, researchers included, view as psychological ones. As such, proponents of domain-specificity theory have treated these cultural beliefs as overextensions of a universal concept of mind beyond its proper domain (Atran & Norenzayan, 2004; Boyer, 1996). These overextension accounts argue that indigenous understandings of nonhuman agency represent counterintuitive, supernatural, or animistic concepts (Barrett, 2000; Boyer, 2003; see also Guthrie et al., 1980) (but see Bird-David, 1999; Ingold, 2006; Kohn, 2007).

An alternative possibility is that presumed overextensions of folkpsychology actually reflect different cultural concepts of agency stemming from diverse principles for inferring agency, and/or different notions of what belongs in the agency domain. As noted above, current theories of folkpsychology in the West emphasize human minds and artifacts, and consequently these theories tend to focus on understanding anthropocentric forms of agency. As an alternative to this, one framework that has been extensively discussed in the literature on indigenous epistemologies is a folktheory where agency is primarily understood as a naturalistic capacity for relational interaction with other agents and environments (Bird-David, 1999; Danziger & Rumsey, 2013; Harvey, 2005; Kohn, 2013). Working from multiple disciplines and Native perspectives, scholars have argued that indigenous theories afford greater recognition of nonhuman agency as it is expressed in diverse ways across the natural world (Kimmerer, 2013; Pierotti, 2011), and that these theories do not share the overtly mentalistic emphasis of Western folkpsychology (e.g., Ingold, 2011; ojalehto & Medin, 2015b; Walker, 2013). This raises the possibility that concepts of agency may be organized differently across cultures.

Our research focuses on the indigenous Ngöbe of Bocas del Toro, Panama. The primary research community is located on a forested island in the Caribbean that forms a political annex to the indigenous autonomous region Comarca Ngöbe-Bugle. The community hosts about 600 people in several dispersed family hamlets that lie within an hour's walking or canoeing distance of each other. Community members' lifestyles are closely coordinated with the surrounding ecology through agroforestry, fishing and diving, and other subsistence practices (Gordon, 1982). Our own experience (S.G.G.) and prior research (ojalehto, Medin, Horton, et al., 2015; ojalehto et al., 2013) indicate that Ngöbe attend to nonhuman agency and ecological relationships in ways that resonate with indigenous relational epistemologies more generally.

Building on these observations, we propose that cultural variability in conceptual frameworks for agency can be distinguished along (at least) two dimensions: (a) ecocentric or anthropocentric prototypes for agency, following from a focus on natural actors broadly or humans specifically; and (b) distinct causal theories of agency as a relational capacity (reasoning about interactions) or a psychological capacity (reasoning about representational mental states). On this account, people may attend to similar basic cues for agency perception across cultures (e.g., Barrett et al., 2005), but those cues acquire very different meanings across cultural frameworks. Our current studies, then, do not ask whether people detect agency differently but whether they infer capacities differently given that agency has been detected.

As we will see, Ngöbe informants focus on different dimensions of agency across a different scope of actors than would be predicted by current (Western) accounts of folkpsychology. From this we argue that grounding principles for inferring agency vary across cultures, leading to folktheories that track distinctive domains of agency: Ngöbe take a communicative stance on agency as a relational capacity to dynamically interact with the world, whereas US individuals take a psychological stance on agency as an individual capacity to internally represent the world.

3. Current research

In two experiments, we adapted the mind perception survey (Gray, et al., 2007) to assess concepts of agency among US college students and indigenous Ngöbe adults of Panama. The key differences in the two hypothesized cultural frameworks center on concepts of agency for non-animal kinds: specifically, plants, abiotic kinds (i.e., nonliving natural kinds),[1] and complex computerized artifacts (henceforth referred to simply as complex artifacts). We predicted that Ngöbe participants would attribute greater agency to plants and abiotic kinds relative to complex artifacts (and as compared to US participants), on the basis of those entities' capacity to interact with the environment. On an anthropocentric prototype, we predicted the opposite: namely, that US participants would recognize greater agency for complex artifacts relative to plants and abiotic kinds (and as compared to Ngöbe), due to their human-designed information processing capacities.

The goal of Experiment 1 was twofold. First, we sought to establish whether there are cultural differences in attribution of agency capacities to various natural and artifact non-animal kinds.[2] Our second goal was to assess conceptual frameworks by analyzing participants' explanations for their agency attributions. We predicted that Ngöbe and US respondents would draw on different framings of and criteria for the capacities under question, corresponding to distinct folktheories of agency.

Experiment 2 aimed to replicate the findings from Experiment 1 with larger samples and provide additional insight into these differences with several measures. First, an experimental manipulation used relational framings of agency probes in order to assess the inferential principles underlying proposed cultural frameworks of agency. Second, additional probes were included to explore the cultural organization of conceptual dimensions relevant to agency concepts, including cognition, experience, and animacy. Last, we used cultural consensus modeling to detect latent conceptual models and identify the conceptual features and individual-level differences associated with each model.

4. Experiment 1

4.1. Participants

Participants in Experiment 1 were indigenous Ngöbe adults of Panama (n = 11; 3 female) and US college students (n = 11; 4 female). Ngöbe participants' ages ranged from 22-63 years (M = 34.73, SD = 12.42). Experience with formal schooling ranged from 0-12 years (M = 6.82; SD = 3.09). Ngöbe participants were bilingual in Spanish and their native Ngöbere. Participants were recruited through household visits or community meetings. Community permission and individual informed consent were received. Ngöbe participants received a small compensation and a donation was made to the community fund.

US participants were undergraduate students enrolled in an introductory psychology course at Northwestern University in the Greater Chicago Area. Ages ranged from 18-21 years (M = 19.45, SD = 1.21). All participants were fluent English speakers. The students came from predominantly upper-middle class backgrounds (60%); and identified as Caucasian (57%), Asian/Asian-American (22%), Black/African-American (7%), Latino/Latina (3%) or other (12%). US participants completed informed consent and received partial course credit for participating.

4.2. Methods

As part of a larger interview (identical for both groups), participants completed an adapted version of the mind-perception survey (Grey et al., 2007) (see Appendix A1). Participants rank-ordered 16

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[1] Entities such as the sun, ocean, or rocks are often referred to as nonliving natural kinds in the Western literature, but we refer instead to *abiotic kinds* (defined by Merriam Webster as "not biological; *especially*: not involving or produced by organisms") because many Ngöbe individuals consider these kinds to be alive, as we will report. For clarity, we will still refer separately to abiotic kinds versus biological organisms (humans, animals, plants), following Western nomenclature.

[2] These capacities (e.g., thought, communication) are typically characterized as mind-perception capacities in the psychological literature, but we refer instead to agency capacities because the specific nature of these conceptual commitments is in question.

entities in terms of their capacity for several kinds of agency, allowing for ties (indicating equal capacity) and exclusions (indicating no capacity). Five representative capacities were selected from the original 18-item mind perception survey: thought, communication, morality, hunger and desire.[3] Each participant ranked (on average) only three of the five capacities to keep interviews of reasonable duration. Participants were probed to explain a subset of their rankings. Ngöbe and US respondents provided a similar number and length of explanations for each capacity and kind (for details, see Appendix A4).

Stimuli were cards with color photographs of individual entities, and included 4 humans (old woman, young woman, infant, fetus), 3 animals (chimp, dog, cow), 2 plants (banana, manioc [Panama]; lettuce, strawberry [US]), 5 abiotic kinds (sun, clouds, rain, ocean, rocks), and 2 complex artifacts (robot, computer). Notably, previous mind-perception surveys have rarely included plants or abiotic kinds, preferring instead computerized artifacts; this is itself a commentary on Western views of agency.

Participants were interviewed in Spanish (Panama) or English (US). The Spanish protocols were independently forward- and back-translated by two trained research assistants in the US. Before use in Panama, Spanish protocols checked for local validity by a trilingual (in Spanish, English, and Ngöbere) researcher (S.G.G.). All interviews were audio-recorded and transcribed, and Spanish responses were translated into English for coding analysis.

4.3. Agency attributions

4.3.1. Data analysis

We used a weighted rank system (weighted by level in order to account for ties) to calculate mean ranks, with ranks assigned by level and lower numbers indicating higher rank (range: 1-16). Ties were treated as the median score across that level (e.g., if two items were tied for the first level, each received a score of 1.5), and excluded items were scored as tied for last place (e.g., if two items were excluded, each received a score of 15.5).

Agency attribution profiles. Cultural models can be inferred by comparing how non-animal kinds are ordered relative to one another within each cultural group.[4] Focusing on the critical comparison set of three non-animal kinds (plants, abiotic kinds, and complex artifacts), profiles could fall under one of two general models. On a hypothesized ecocentric prototype, Ngöbe responses should follow a natural kinds model (NKM) where both plants and abiotic kinds are included more frequently and ranked above complex artifacts. On a hypothesized anthropocentric prototype, US responses should follow an artifact kinds model (AKM) where complex artifacts are included more frequently and ranked above natural kinds, either abiotic kinds or plants or both.

We did not predict marked cultural differences for animals and humans, or for mammals versus non-mammals, on these particular measures. Ngöbe and US individuals may in fact take distinct views of animal agency, particularly for complex capacities such as morality as we have found in other studies (ojalehto et al., 2015). But the present measures were aimed at discriminating coarse-grained differences across the animal/non-animal divide rather than subtle distinctions in the actual degree of capacity accorded to any one kind.[5]

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[3] The five probes were selected to include capacities associated with both mind-perception dimensions, but specifically probing these two dimensions was not the goal of Experiment 1; see Experiment 2.

[4] Because exclusions were scored as tied for last place, mean rank is insensitive to differences between items that were excluded and those included but ranked last. For this reason it is most straightforward to assess cultural differences in terms of differences in inclusion profiles, as we do in the first three sections of Experiment 2 results.

[5] On an anthropocentric prototype, one might also predict that US participants would rank humans relatively higher, and mammals relatively higher than non-mammals, than Ngöbe participants. Assessing these possibilities would

Table 1. Mean rankings and percent inclusions for agency[a]

	Mean Percent Inclusions							Mean Ranks						
	Ngöbe		**US**			**Overall**		**Ngöbe**		**US**			**Overall**	
	(n = 11)		(n = 11)			(N = 22)		(n = 11)		(n = 11)			(N = 22)	
Kind	*M*	*SD*	*M*	*SD*	*t*-test	*M*	*SD*	*M*	*SD*	*M*	*SD*	*U*-test	*M*	*SD*
Humans	0.93_a	(0.10)	0.85_a	(0.14)	*ns*	0.89_a	(0.12)	3.86_a	(1.58)	4.21_a	(.58)	*ns*	4.03_a	(1.18)
Animals	1.00_a	(0.00)	0.83_a	(0.21)	2.79*	0.91_a	(0.17)	6.51_b	(1.94)	5.66_b	(1.16)	*ns*	6.08_b	(1.62)
Plants	0.55_b	(0.33)	0.21_b	(0.26)	2.72**	0.38_b	(0.34)	10.65_c	(1.23)	$11.08_{c,d}$	(1.19)	*ns*	10.87_c	(1.20)
Abiotic kinds	0.45_b	(0.37)	0.08_b	(0.17)	3.04**	0.26_b	(0.34)	11.00_c	(1.71)	11.78_d	(0.85)	*ns*	11.39_c	(1.38)
Complex artifacts	0.38_b	(0.36)	0.29_b	(0.26)	*ns*	0.34_b	(0.31)	12.35_c	(1.55)	10.58_c	(1.40)	25.0*	11.47_c	(1.70)

[a] Agency is a composite measure of thought, communication, morality, hunger, and desire.

[b] Mean ranks: Lower numbers indicate higher ranks (range: 1 - 16); with excluded items scored as tied for last place.

[c] Main effect for kind: Means in the same column not sharing the same subscript differ significantly at $p < .05$ in Wilcoxon signed-rank tests.

Note: * Indicates $p < .05$; ** $p < .01$; *** $p < .001$.

4.3.2. Results

Our main predictions concerning culturally distinct frameworks for nonhuman agency were borne out, as summarized in Table 1. Here we focus on results key to the hypothesized cultural differences. (Main effects for kind are summarized in Table 1; for other detailed results see Appendix A2.) We analyzed results by considering which entities were included in agency rankings (inclusion) and by their mean rank (ranking). Each measure was averaged by kind across the five agency capacities, then analyzed with a 2 (culture) X 5 (kind: artifact, abiotic kind, plant, animal, human) repeated-measures ANOVA. Degrees of freedom were corrected using Huynh-Feldt estimates due to violation of assumption of sphericity (inclusion: $\chi^2(9) = 28.31$, $p < .01$, $\varepsilon > .75$; ranking: $\chi^2(9) = 18.02$, $p < .05$, $\varepsilon > .75$).

Inclusions. Agency inclusions for each kind differed substantially across cultures, $F(3.24, 64.87) = 2.86$, $p <.05$, $\eta2 = .13$. As predicted on an ecocentric prototype, Ngöbe were more likely than US participants to include non-animal natural kinds in their agency ranks, including both plants (Ngöbe: $M = 0.55$, $SD = 0.33$; US: $M = 0.21$, $SD = 0.26$), and abiotic kinds (Ngöbe: $M = 0.45$, $SD = 0.37$; US: $M = 0.08$, $SD = 0.17$), as well as animals (Ngöbe: $M = 1.00$, $SD = 0$; US: $M = 0.83$, $SD = 0.21$), $ps < .05$. However, the two groups did not differ reliably on inclusion of complex artifacts. Thus, our prediction that US participants would be more likely to include complex artifacts on an anthropocentric prototype was not borne out.

Rankings. We considered agency attribution profiles by analyzing differences in mean ranks for each non-animal kind across cultures, as well differences in the mean rank ordering of those kinds within each cultural group. Mean ranks varied by kind across the two groups, $F(3.47, 69.35) = 2.70$, $p < .05$, $\eta2 = .12$. Follow-up comparisons using the Mann-Whitney U test confirmed that US rankings were significantly higher than Ngöbe rankings for complex artifacts (US: $M = 10.58$, $SD = 1.40$; Ngöbe: $M = 12.35$, $SD = 1.55$), $U = 25$, $p < .05$. Ngöbe tended to rank plants and abiotic kinds higher than US participants, but these differences did not reach reliability.

Within-culture pair-wise rank comparisons using the Wilcoxon signed-rank test revealed modest differences between non-animal kinds consistent with the hypothesized agency frameworks, although not all the predicted differences reached reliability. Ngöbe followed the predicted natural kinds model by tending to rank plants and abiotic kinds above complex artifacts, and the higher rank for plants relative to complex artifacts was marginally significant ($Z = -1.89$, $p = .06$). The opposite held for the US rank profile, which followed an artifact kinds model where complex artifacts were ranked significantly higher than abiotic kinds ($Z = -2.03$, $p < .05$).

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require an interval measure of perceived distance between human, mammal, and non-mammal capacities, such as a rating scale. The present measures of ordinal ranks and inclusion rates are not sensitive to such differences.

4.4. Interim summary

So far, US attribution profiles are consistent with a view of psychological agency as a property primarily restricted to humans and animals, whereas Ngöbe profiles align with a more ecologically oriented view of agency as a capacity expressed by many natural kinds including plants and abiotic kinds. The inferential principles at stake in these cultural frameworks for agency were further investigated by analyzing participants' explanations for their agency rankings.

4.5. Explanatory frameworks for agency

An entity can express agency in many ways. Whether those expressions are interpreted as relevant to a particular capacity hinges on one's conception of agency. We assessed cultural stances on this matter by analyzing participants' explanations for their agency rankings.

Building on previous accounts of Western and indigenous cultural epistemologies (see Medin et al., 2013), as well as the (predominantly Western) literature on folkpsychology and mind-perception, we developed a coding scheme to assess constructs associated with each hypothesized cultural framework.

Our first hypothesis holds that conceptual frameworks for agency are structured around different prototypes, which we expect will correspond to distinct framings of agency. If US folkpsychology treats humans as the prototype, this should be linked to a *scalae naturae* model where organisms are hierarchically ordered on a scale from simple to complex human agency. In contrast, Ngöbe are predicted to frame agency as a pluralistic capacity for relating (with others and the environment) that is exercised by many human and nonhuman entities. Accordingly, we predicted that US explanations would contain more human-centric and scalar framings of agency, while Ngöbe explanations would contain more relational framings of agency.

Our second hypothesis holds that cultural frameworks take different stances on the relevant causal principles for inferring agency—namely, as an interactive or a psychological phenomenon. Accordingly, Ngöbe and US explanations are expected to focus on different indicators of and criteria for ascribing agency.

4.5.1. Coding scheme

All explanations were analyzed with a coding scheme designed to assess framings of, and explanatory constructs considered relevant to, agency on both hypothesized cultural frameworks (see Tables 2 and 3). Our coding system measured the extent to which participants' explanations focused on the following variables: human-centric, scalar, or relational framings of agency; internalized or interactive indicators of agency; and consciousness or directedness as criteria for agency (each is detailed below). Reference to a construct of interest (e.g., brain) was coded whether it was invoked for agency endorsement (e.g., "chimps can think because they have a brain") or denial (e.g., "plants cannot think because they don't have a brain"). Coding categories were not mutually exclusive.

Table 2: Coding categories related to anthropocentric psychological agency

Code	Description	Examples
Human-centric framing	Implicates humans as prototypical agents by referring to: (i) Human-nonhuman comparisons (ii) Human perception of agency (iii) Human intervention on agency	(i) Animals "don't have the capacity to think like people" (NG, Th.) (ii) Animals "not so much, because they're difficult to interpret" (US, Com.) (iii) Dogs have "been conditioned to act that way" (US, Mor.)
Scalar framing	Frames agency as scalar capacity by: (i) Assessing agency in terms of hierarchical scales or timelines (ii) Hedging the sense in which an entity has capacity, implying an ideal	(i) Mammals "tend to be smarter, have a more complex brain" (US, Th.); Baby will "given time, overcome the chimpanzee" (US, Mor.) (ii) Plants "feel emotion in *like a different sense*" (US, Com.); "But the plant doesn't *really* get hungry" (NG, Hun.)

Internalized indicators	Focus on internal parts or substrates underlying indicators of agency: (i) mind or brain (ii) interior or bodily substrates	(i) Animals “have receptors and stuff in their brain that signal when they’re hungry” (US, Hun.) (ii) Robot has “electric cables in their body” (NG, Com.); Human “body requires nutrients” (US, Hun.)
Consciousness	Consciousness is criterial to agency, as indicated by: (i) self-awareness (ii) autonomy over own actions (iii) (not) instincts or mere reactions	(i) Plants “perform actions” but “have no concept of being moral” (US, Mor.); Baby “can’t recognize” its hope (US, Des.) (ii) Animal’s “brain doesn’t control what he’s communicating” (US, Com.) (iii) Cows have “primal instinct rather than...more technical cognition levels” (US, Th.)

Abbreviations: (NG/US) Ngöbe/US; (Hun.) Hunger; (Th.) Thought; (Mor.) Morality; (Des.) Desire; (Com.) Communication

Table 3: Coding categories related to ecocentric relational agency

Code	**Description**	**Examples**
Relational framing	Frames agency as relational capacity by referring to interactions and other-orientated states involving: (i) other agents (ii) environments	(i) Chimps “have a good sense of social structure” (US, Th.); Cows “know their owner” but are “fierce” to others (NG, Mor.) (ii) “Plants have hunger, for the rain that falls” (NG, Hun.); Sun “communicates with [water] in the moment of rising” (NG, Com.)
Interactive indicators	Focus on observable interactions as cues to agency, including: (i) Behavioral patterns (ii) Means of expressing agency	(i) Dogs have “certain things that they do or don’t do, when they live with people” (US, Mor.) (ii) Plants “communicate in the way they go growing” (NG, Com.); Animals “have their distinct forms to wait, express, know” (NG, Des.)

The dependent variable was the percent of explanatory content associated with a given coding category (number of codes divided by total words in explanation, times 100).

Two raters (b.o. and a US research assistant blind to the hypotheses) each coded half the data independently, after working together to iteratively develop and train on the coding scheme. Inter-rater agreement was good, with intra-class correlations for each coding variable ranging from $r = .62$ to $r = .85$, all $ps < .01$, ($df = 232$) (see Appendix A3, Table A1). To ensure the most accurate code assignment possible, both raters separately coded nearly all the data (90% of explanations, including those used to establish reliability), disagreements were discussed, and the consensus decision was used for the final data set.

Directedness	Directedness is criterial to agency, as indicated by: (i) goal-directed needs or wants (ii) teleological processes (iii) variable states of the entity	(i) Plants are "hungry for something that will allow them to survive" (US, Hun.) (ii) Sun "has the thought to light the world" (NG, Th.); Rain "has thoughts, that it falls as the rain" (NG, Th.) (iii) Oceans "have a moment where they wait for the change" (NG, Des.)

Abbreviations: (NG/US) Ngöbe/US; (Hun.) Hunger; (Th.) Thought; (Mor.) Morality; (Des.) Desire; (Com.) Communication

4.5.2. Results

The results roundly supported the proposal for two distinct conceptual frameworks, as confirmed by significant cultural differences observed across the majority of coding categories (summarized in Table 4). All tests reported below are 2 (culture) x 2 (kind: animate versus inanimate, as defined on Western categories) repeated-measures ANOVAs on the coding variable of interest. Data were collapsed over the five kinds into two categories (in/animate) to reduce empty cells, given that not all participants provided specific explanations for each kind on every ranking (this split allowed us to include 10 of 11 participants from each cultural group). Here we report only results that reached statistical significance (see Appendix A4 for detailed results).[6]

(i) Human-centric framing of agency

On an anthropocentric model, we predicted that US explanations would treat humans as the exemplar or standard agent, and thus contain more human-centric framings of agency. An anthropocentric framing was assessed by coding for (i) comparison of nonhumans to humans (e.g., chimps think because "they're very similar to human minds"); (ii) taking a human vantage point on perceiving or appraising nonhuman agency (e.g., animals have minimal communication because "they're difficult to interpret"); or (iii) human intervention on nonhuman agency (e.g., dogs only behave morally because they are trained to follow rules).

As predicted, there was a main effect for culture, $F(1,18) = 8.65$, $p < .01$, $\eta 2 = .33$, such that US participants provided substantially more human-centric content ($M = 2.66\%$, $SD = 1.93\%$) than Ngöbe participants ($M = 0.78\%$ $SD = 0.63\%$).

(ii) Scalar framing of agency

Following from an anthropocentric prototype, we also predicted that US explanations would treat humans as the most complex or "developed" agents, and thus contain more scalar framings of agency. A scalar framing was defined as explanations that (i) assess agents according to hierarchical taxonomies or developmental scales (e.g., mammals "tend to be smarter, have a more complex brain"); or (ii) hedge the sense in which an entity possesses a capacity (e.g., in an "abstract" or "different" sense), implying an anchoring concept based on a prototypical (human) agent.

The predicted main effect for culture emerged, $F(1,18) = 7.82$, $p < .05$, $\eta 2 = .30$, such that US explanations relied much more on scalar framings ($M = 6.22\%$, $SD = 2.54\%$) than Ngöbe explanations ($M = 2.71\%$, $SD = 3.06\%$).

(iii) Relational framing of agency

On an ecocentric model, we predicted that Ngöbe explanations would frame agency in terms of relational action, both social and ecological. A relational framing was assessed by coding references to relationships, interactions, and other-oriented states involving (i) other agents (e.g., "babies know who their mother is") (social relations); and (ii) environments (e.g., a plant "wants to wet itself with rain and eat sun") (ecological relations).

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[6] There were no main effects for kind (in/animate) or interactions of culture by kind for any coding outcome variable.

As expected, there was a main effect for culture, *F(*1,18) = 7.76, $p < .05$, $\eta 2 = .30$, such that Ngöbe participants provided almost twice as many relational framings (*M* = 7.47%, *SD* = 3.41%) than US participants (*M* = 3.82%, *SD* = 2.37%). The same cultural trends held for both social and ecological relations separately, according to kind (see Appendix A4 for details).

(iv) Indicators of agency

Following from a focus on psychological capacities linked to having a mind, we predicted that US explanations would focus more on internalized indicators of agency by referring to (i) minds and brains, or (ii) other interior substrates (e.g., cables in robot) that underlie such capabilities. Contrary to our prediction, there was no main effect for culture on explanatory content associated with internalized indicators, *F(*1,18) = .20, ns, (US: *M* = .53%, *SD* =.50%; Ngöbe: *M* = .91%, *SD* = 2.62%).

In contrast, we expected Ngöbe explanations to focus on interactive indicators of agency by referring to (i) observable behavioral patterns as evidence of a capacity (e.g., learning from experience), or (ii) tangible means and multiple ways of expressing a capacity (e.g., barking as evidence of communication). As predicted, there was a significant main effect for culture, *F(*1,18) = 9.01, $p < .01$, $\eta 2 = .33$, such that Ngöbe participants focused more on interactive indicators (*M* = 1.78%, *SD* = .91%) than US participants (*M* = 0.60%, *SD* = .85%).

(v) Criteria for agency

If agency is understood as psychological, then we expected US participants to treat consciousness as criterial to agency by focusing on (i) self-awareness or consciousness and (ii) autonomy over own actions, distinguishing these from (iii) mere instincts or mechanistic reactions. As predicted, there was a reliable main effect for culture, *F(*1,18) = 10.83, $p < .01$, $\eta 2 = .38$, with US participants providing substantially more content associated with consciousness (versus instincts) (*M* = 1.31%, *SD* =.92%) than Ngöbe participants (*M* = 0.24% *SD* = 0.47%).

Following from a focus on relational agency, Ngöbe explanations were predicted to treat directedness as criterial to agency by focusing on (i) goal-directed needs or desires, (ii) teleological processes (e.g., "plants have the thought to grow"), and (iii) directed change or organized continuity of the entity's own states (e.g., growth, transformation, homeostasis or modulation). As expected, there was a reliable main effect for culture on directedness, *F(*1,18) = 24.97, $p < .01$, $\eta 2 = .58$, with Ngöbe participants providing much more such content (*M* = 4.32%, *SD* = 1.92%) than US participants (*M* = 0.93%, *SD* = 0.96%).

Table 4. Explanatory content associated with coding constructs by culture

		Percent explanatory content (across all kinds)				
		US		Ngöbe		Over
Agency framework	Coding construct	*M*	*SD*	*M*	*SD*	*M*
Anthropocentric & psychological (US)	Human-centric framing	2.66*	(1.93)	0.78*	(0.63)	1.72
	Scalar framing	6.22*	(2.54)	2.71*	(3.06)	4.46
	Internalized indicators	0.53	(0.50)	0.91	(2.62)	0.72
	Consciousness	1.31*	(0.92)	0.24*	(0.47)	0.78
Ecocentric & relational (Ngöbe)	Relational framing	3.82*	(2.37)	7.47*	(3.41)	5.65
	Interactive indicators	0.60*	(0.85)	1.78*	(0.91)	1.19
	Directedness	0.93*	(0.96)	4.32*	(1.92)	2.62
Overall content coded		16.07%	(3.43%)	18.20%	(5.10%)	17.14%

* Cultural main effect: $p < .05$ for cultural difference on that code.

As an example of this observed cultural difference in criteria for agency, consider whether a dog is capable of communication. Many Ngöbe respondents saw the act of barking as sufficient evidence for the affirmative, while US participants often sought evidence of conscious intentions before making a judgment (e.g., does the dog intend to communicate a message?).

4.6. Interim summary

The coding analysis revealed distinct cultural frameworks for agency as indicated by the different sets of framings, indicators, and criteria considered relevant for agency attribution, with the exception of internal indicators of agency. US respondents were more likely to frame agency in terms of a hierarchical scale where nonhuman entities are compared against human minds. They were also more likely to treat consciousness as a criterion for agency attribution. These findings are consistent with a concept of agency as a psychological capacity tied to having a mind (as humans know it). Anthropocentric framings were significantly less pronounced in Ngöbe explanations, which instead framed agency in terms of relational capacities expressed by many nonhuman kinds. Ngöbe also relied more on interactive indicators and behavioral directedness as criteria for agency. This is congruent with a concept of agency as a relational capacity based on an ecocentric prototype that encompasses multiple natural actors. On this model, agency may be conceptualized as a capacity with many unique endpoints more akin to a heterarchical network than a hierarchical progression along the *scalae naturae* (for related observations, see Hall, 2011; Narby, 2006).

4.7. Experiment 1: Discussion

Experiment 1 revealed systematic cultural variation in agency attribution, even with modest sample sizes. We found that Ngöbe were more likely to attribute agency to plants and abiotic kinds than were US participants, who tended to restrict agency attributions to humans and animals with moderate extensions to complex artifacts, which they ranked reliably higher than did Ngöbe participants. The fact that the two groups did not differ on artifact inclusion rules out a generalized tendency for Ngöbe to attribute more agency to everything. However, we did expect that US participants would be more likely than Ngöbe to include complex artifacts in the agency domain, which we did not find in this small sample. Still, each culture's agency attribution profile for natural versus artifact non-animal kinds, although not always statistically significant, was suggestive of distinct models. Converging evidence for this proposal came from the coding analysis revealing divergent explanatory frameworks for agency. US participants tended to describe agency as a scalar, prototypically human capacity requiring consciousness, whereas Ngöbe participants tended to describe agency as a relational capacity expressed in the interactions and directed behaviors of many natural kinds.

Taken together, these results are consistent with the proposal that Ngöbe hold an ecocentric model of agency as a relational capacity, and US participants hold an anthropocentric model of agency as a psychological capacity. However, these findings are based on small samples and a limited number of capacity probes. An additional concern is that explicit verbal reports do not always align with underlying conceptual commitments, as other cultural research has shown (Astuti, 2001; Astuti et al., 2004). Stronger evidence for distinct cultural models would come from experimental manipulation of hypothesized agency frameworks, as well as a larger set of probes that can illuminate conceptual dimensions underlying agency frameworks across cultures. These were the objectives in Experiment 2.

5. Experiment 2

Experiment 2 sought to extend findings from Experiment 1 while providing additional insight into cultural concepts of agency. The first objective was to replicate the findings from Experiment 1 with larger samples (Ngöbe $n = 24$, US $n = 35$). We expected cultural differences in both inclusions and rankings for the three key non-animal kinds (plants, abiotic kinds, and complex artifacts).

Second, we introduced a new experimental condition that framed agency as a relational capacity. In the original mind-perception survey, agency predicates are presented with no grammatical object (e.g., Is x capable of feeling hunger?), which implicitly frames the capacity as a property of the individual entity (we refer to this as the original condition). The Ngöbe explanations in Experiment 1 suggested that a more culturally fluent way of reasoning about agency capacities is to include the object(s) (e.g., Is x capable of feeling hunger for food or nutrients?). Accordingly, in the relational condition we presented each agency predicate with grammatical objects that place the subject in relation to other entities, implicitly framing the capacity as a relational property. We predicted that Ngöbe would attribute greater agency to non-animal kinds (especially plants and abiotic kinds) in the relational condition as compared to the original condition, because a relational framing resonates with folkcommunication and facilitates an ecocentric perspective on agency. By contrast, we predicted that US participants would show no effect of condition (or possibly the opposite trend).[7]

Second, we selected a set of probes from the mind-perception survey to assess the two-dimensional structure of mind perception, with three probes each for the dimensions we refer to as experience and cognition (Gray et al., 2007).[8] Examining these dimensions of mind perception across cultures can offer insight into principles for inferring agency. Some researchers have argued that having internal representations is especially important for inferring capacities associated with the cognitive dimension, whereas having a body (or biological functions) is relevant for inferring experience (Knobe, 2011). If so, then this distinction can be leveraged to assess the inferential principles underlying agency frameworks. If the distinction between representational versus non-representational states is important to

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[7] On folkpsychology, a mental-state term presumably points back to the individual entity regardless of the framing: feeling hunger, and feeling hunger for food, are both contingent on the subject having a mind to process feelings. Hence our prediction. Alternatively, a stronger hypothesis could be that US participants will be less likely to attribute agency to (perceived) insentient kinds in the relational condition, because the inclusion of a grammatical object stresses the explicit contents of a mental state (i.e., its “aboutness”), inducing a representational stance on agency and thereby setting a higher standard for capacity attribution than an open-ended predicate. For example, basic experiential capacities (fear) might shift to become interpreted as cognitive capacities (fear of enemies as a mental state with specific contents). Consistent with this possibility, we found that the relational condition decreased US agency attributions to plants for 4 of 6 capacities, but these trends did not reach reliability.

[8] Gray et al (2007) refer to the two dimensions of mind-perception as experience and agency. They define agency specifically in terms of moral agency and responsibility, as distinct from the broader definition of agency we use here (namely, any entity that is perceived as capable of acting). For clarity, we refer to this dimension as cognition to distinguish it from our composite measure of agency (which includes all six capacities).

folkpsychology, then US participants should distinguish between cognition and experience in their attributions to non-animal kinds. But if agency is inferred on the basis of relational rather than representational grounds, then for Ngöbe this distinction should be less pronounced. Additionally, we introduced two new probes associated with animacy, life and movement, to explore relationships between agency and animacy concepts. We predicted that they would correspond closely for Ngöbe participants because both are premised on a common capacity to interact, whereas agency and animacy should track separately among US participants who perceive them as distinct domains (folkpsychology and folkbiology).

One additional concern from Experiment 1 is that cultural differences are due to language, given that Ngöbe interviewed in Spanish and US participants in English. To address potential language effects in Experiment 2, US bilingual Spanish-English speakers completed the task in Spanish using identical protocol to that used in Panama. We expected to observe no effects of language with respect to cultural differences.

Other methodological changes in Experiment 2 allowed us address minor questions from Experiment 1. We included a simple artifact (a tote bag) to assess notions about generic (non-computerized) artifact capacities, on the prediction that agency attributions to this simple artifact would be uniformly low across cultures. This can provide a baseline measure of non-agency, and also help rule out a positive response bias in either sample. Additionally, Experiment 2 stimuli included two non-mammal animals (a bird and frog) in addition to two of the mammals from Experiment 1 (a dog and chimp) to assess whether cultural concepts of agency differ for distinct kinds of animals. We predicted that both Ngöbe and US individuals would ascribe agency to all animals, with similar patterns of ranking for mammals (generally higher) and non-mammals (generally lower).

5.1. Participants

Participants were indigenous Ngöbe adults from the primary research community[9] (*n* = 24; 10 females) and US college students (*n* = 35; 18 females).[10] Ngöbe participants' ages ranged from 19-62 years (*M* = 37.21, *SD* = 13.93). Experience with formal schooling ranged from 0-12 years (*M* = 4.54, *SD* = 3.24).

US participants' ages ranged from 18-23 years (M = 19.00, SD = 1.26). The US students came from the same university's introductory psychology class with similar demographics reported for Experiment 1. Recruitment, community permission, informed consent, and participant compensations for each sample were conducted in the same manner as in Experiment 1.

Participants also reported their occupation, religiosity (church attendance and three belief items used in Gray et al. 2007), language identity (their first language, and language spoken with their family), and experience with nature (farming/gardening, hunting/fishing, and pet experience, and urban/rural residence). (For item details see Appendix B1; for individual differences results, see Section 5.4.)

Condition. Participants were randomly assigned to an experimental condition, with approximately half of each group assigned each to the original (Ngöbe: *n* = 12; US: *n* = 19) and the relational (Ngöbe: *n* = 12; US: *n* = 16) condition.

Language. The US sample included 11 bilingual English-Spanish speakers, all of whom completed the study in Spanish. Language could not be randomly assigned due to the small number of bilingual

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[9] Ngöbe participants in Experiment 2 were different individuals from those in Experiment 1, with the exception of 3 participants who participated in both studies. The two experiments were conducted far enough apart that task transfers were unlikely (Experiment 1: December 2011; Experiment 2: August-September, 2014).

[10] One additional Ngöbe participant and 14 additional US participants did not complete all probes and were not included in results reporting. The greater number of incomplete tasks for US participants was due to a time constraint during one academic quarter of data collection that truncated interviews.

participants. Among the Ngöbe sample, all participants completed the task in Spanish (occasionally, Ngöbere was used for clarification purposes).

5.2. Methods

5.2.1. Materials and protocol

Stimuli were color photographs of 14 entities depicted on cards (4" by 4.25"), presented in random order. Entities were the same as in Experiment 1, with the addition of a bird, frog, and a tote bag (see Appendix B1). Eight capacity probes assessed three dimensions of agency: 1, cognition (communicate, memory, and morality); 2, experience (fear, pain, and hunger); and 3, animacy (alive and move). The first six probes are from the original mind-perception survey. All capacity probes were presented to all participants. Order of presentation for the animacy probes was fixed, with move always presented first as a warm-up task, and alive always presented last. Intervening probes for the six agency capacities were presented in one of two counterbalanced orders (see Appendix B1). Each experimental condition used one of two question formats (relational or original) that applied to all six mind-perception probes but not the animacy probes (see Appendix B2 for bilingual protocol).

Participants were asked to explain a subset of inclusions and exclusions on some of their capacity rankings. This was done to replicate the methods from Experiment 1, but explanations were not analyzed as part of the current experiment.

This experiment was administered as either the first or second task in a larger three-task interview (identical in the US and Panama). There were no effects of task order on agency attributions. As in Experiment 1, participants were interviewed in Spanish (Panama and US) or English (US) and interviews were audio-recorded. Also as before, the Spanish protocols were forward- and back-translated and checked for local validity by S.G.G. in Panama.

5.2.2. Data analysis

We analyzed weighted ranks as in Experiment 1, with exclusions tied for last place (range: 1 - 14). Occasionally, participants (n = 8, all Ngöbe) reported that they did not know how to respond for a particular item. These items were treated as missing data. Two Ngöbe participants (accounting for 19/25 "don't know" responses) are excluded from rank results due to substantial missing data (see Appendix B3).

5.3. Results

Our hypotheses predict the following for the key comparison set of non-animal kinds (plants, abiotic kinds, and complex artifacts): (1) Ngöbe and US participants will attribute agency differently to these three kinds on a NKM versus AKM respectively; (2) the relational framing will increase Ngöbe but not US agency attributions; and (3) the relevant dimensions of agency attribution will differ, with US participants (more so than Ngöbe) distinguishing between the two mind-perception dimensions, and Ngöbe (more so than US) coordinating their agency attributions with a third dimension of animacy. Finally, we conducted cultural consensus modeling to verify and extend the underlying conceptual models of agency implied by these results.

In testing these hypotheses we report results based on rates of inclusion rather than mean ranks. Reporting both sets of outcome measures would be redundant and inclusion rates provide the more straightforward account using standard comparative tests.[11] (Mean ranks were the object of analysis for

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[11] All analyses reported below were also conducted for mean ranks and the story was roundly consistent with inclusions; thus, supplementary results from rank data are presented only where they clarify the main findings from inclusion data.

Table 5. Mean percent inclusions for agency[a]

	Mean percent inclusions						
	Ngöbe (n = 24)		**US** (n = 35)			**Overall** (N = 59)	
Kind[c]	*M*	*SD*	*M*	*SD*	*t*-test[b]	*M*	*SD*
Humans	0.95_a	(0.06)	0.99_a	(0.04)	-2.71*	0.97_a	(0.05)
Animals	0.98_a	(0.04)	0.98_a	(0.04)	*ns*	0.98_a	(0.04)
Plants	0.70_b	(0.30)	0.39_b	(0.22)	4.59***	0.52_b	(0.30)
Abiotic kinds	0.31_c	(0.30)	0.04_d	(0.06)	4.49***	0.15_c	(0.23)
Complex artifacts	$0.15_{c,d}$	(0.20)	0.24_c	(0.13)	-1.86*	0.20_c	(0.17)
Simple artifacts	0.07_d	(0.17)	0.00_e	(0.03)	*ns*	0.03_d	(0.11)

[a] Agency is a composite measure of memory, communication, morality, hunger, pain, and fear.

[b] T-tests compare mean inclusion rates across cultures for the kind in that row.

[c] Main effect for kind: Means in the same column not sharing the same subscript differ significantly at $p < .05$ in pairwise tests (Bonferonni-adjusted).

Note: * Indicates $p < .05$; ** $p < .01$; *** $p < .001$.

cultural consensus modeling.) Unless otherwise noted, statistical tests were conducted with a 2 (culture) by 2 (condition: original, relational) repeated-measures MANOVA with dimension (2: cognition, experience) and kind (6: humans, animals, plants, abiotic kinds, complex artifacts, simple artifact) as within-subjects variables.[12] Degrees of freedom are adjusted where appropriate using Huynh-Feldt estimates (on F-tests); or where equality of means is violated, t-tests are reported with equal variances not assumed.

5.3.1. Preliminary results

Language. Among US participants, there were no reliable effects of Spanish versus English on rates of inclusion or mean rankings for any key outcome measure (i.e., overall agency attributions, attribution by kind or experimental condition, or the separate dimensions of cognition, experience, and animacy).

Mammals versus non-mammals. Patterns of agency attribution to mammals and non-mammals (inclusions and ranks) did not reliably differ across cultures. Thus, we collapsed all four items into a single category of animals. (For additional preliminary analyses, see Appendix B4).

5.3.2. Cultural models of agency

We begin by considering cultural variability in overall agency attributions (across all six capacities). As hypothesized, we found a reliable interaction of culture by kind, $F(3.07, 165.73) = 33.1$, $p < .001$, $\eta^2 = 0.38$.[13] Across culture follow-up comparisons showed that, as predicted on an ecocentric prototype, Ngöbe were more likely than US participants to include non-animal natural kinds (plants and abiotic kinds) in their agency attributions (Plants: $t(57) = 4.59$, $p < .001$, $d = 1.24$; Abiotic kinds: $t(24.29) = 4.49$, $p < .001$, $d = 1.44$) (see Table 5). Corresponding to an anthropocentric prototype, US individuals were more likely than Ngöbe to include complex artifacts in agency attributions, $t(57) = -2.00$, $p = .05$, $d = -0.54$.

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[12] In analyses that include mind-perception dimensions as a factor, some Ngöbe participants ($n = 2$ for ranks; $n = 1$ for inclusion) are excluded due to missing ("don't know") data on one dimension.

[13] In these and subsequent results, degrees of freedom are adjusted using Huynh-Feldt estimates due to violation of assumption of sphericity for kind ($\chi^2(14) = 64.91$, $p <.001$, $\varepsilon = 0.53$; and dimension by kind ($\chi^2(14) = 34.48$, $p < .01$, $\varepsilon = 0.7$).

Each cultural profile of agency attribution for non-animal kinds also differed (see Table 5). Ngöbe followed the predicted NKM privileging plants and abiotic kinds above complex artifacts, as evidenced by inclusion rates and reliably differentiated in ranks (where plants and abiotic kinds are both ranked significantly higher than complex artifacts, see Appendix Table B1). Judging by inclusion rates, the agency domain for Ngöbe includes plants as well as animals and humans (plants were included at rates well above chance, $t(23) = 3.30$, $p < .01$). US attributions followed a partial AKM insofar as complex artifacts are accorded greater agency than abiotic kinds but not plants; this pattern was mirrored in ranks (where plants and complex artifacts are tied at a level above abiotic kinds, see Table B1). Among US participants, plant inclusion is significantly below chance, $t(34) = -2.93$, $p < .01$, indicating that plants stand farther outside the agency domain on this model. Still, it is interesting that US participants included plants at all, and did so at rates comparable to complex artifacts. This may reflect distinct notions of what plants "do" (e.g., have biological states) and what computers "do" (e.g., have representational states).

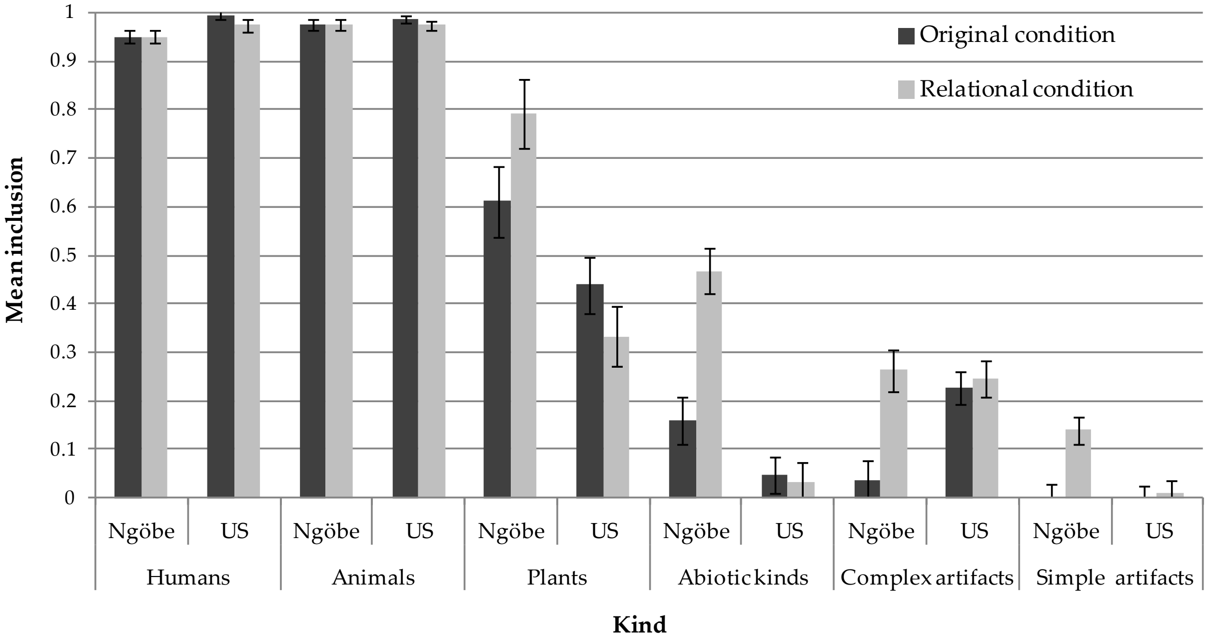
As expected, the two cultural groups did not differ in inclusion rates for animals, $t(57) = -0.44$, $p = .66$, $d = -0.12$. US participants were reliably more likely than Ngöbe to include humans, $t(35.5) = -2.49$, $p < .05$, $d = -0.73$, but this difference was of slight magnitude (mean difference = .04) and both groups were near ceiling in their attributions.

5.3.3. Experimental condition: Relational framings of agency

Ngöbe agency attributions differed more across experimental conditions than did US attributions, as indicated by the reliable 3-way interaction for kind, culture, and condition ($F(3.07, 165.73) = 5.91$, $p <. 01$, $\eta^2 = 0.10$). To further investigate these effects, we analyzed agency attributions by condition separately for each cultural group. Inclusions were analyzed with a 2-factor (condition: original, relational) repeated-measures ANOVA with kind (6) as a within-subjects variable. We continue to focus on agency as a composite variable of all six capacities, with accompanying tests of each capacity to clarify key findings.[14] We consider Ngöbe and US results in turn, which are summarized in Figure 1 (see Appendix B5 for detailed results).

Ngöbe. As expected, Ngöbe included more entities in the relational condition ($M = .60$, $SD = .15$)

Figure 1: Inclusion in agency attributions for each kind by condition and culture



than the original condition (*M* = .46, *SD* = .07), *F*(1, 22) = 8.78, $p < .01$, $\eta^2 = 0.29$, and this interacted with kind, *F*(2.54, 55.83) = 3.77, $p < .05$, $\eta^2 = 0.15$. Follow-up tests confirmed that Ngöbe inclusions were reliably higher in the relational condition for abiotic kinds, complex artifacts, and simple artifacts (*ps* < or = .05). The same trend held for plants but did not reach significance ($p = .14$)

Separate analyses of Ngöbe inclusions for each capacity confirmed that the effect of condition held for four of six capacities (*ps* < .05), with the two exceptions being morality and pain, where the same trends held but did not reach significance. This systematic pattern is consistent with the hypothesis that these capacities recruit a common conceptual framework for agency.

US. US agency attributions were unaffected by experimental condition, as indicated by the non-significant interaction of condition by kind, *F*(2.22, 73.25) = 1.58, $p = .21$, $\eta^2 = 0.05$. [15] There were no reliable differences in inclusions across conditions for any kind.

Cross-cultural comparisons. As noted above, the significant 3-way interaction of kind, culture, and condition indicated that the effect of condition varied across cultures. We analyzed cross-cultural differences for each kind across the two conditions, confirming that key differences held reliably for each non-animal kind across both conditions, with the only exception being the inclusion of complex artifacts in the relational condition (where the two groups did not differ).[16] The finding that cultural differences hold either way strengthens the interpretation of two distinct cultural models. In other words, a given framing does not appear to push one group away from an underlying "default" model that is actually shared with the other cultural group.

5.3.4. Conceptual dimensions

Next we consider whether cultural agency concepts track differently along the mind-perception dimensions of experience and cognition, and how these relate to animacy concepts.

So far we have treated agency as a unified construct, but there may also be important distinctions within this domain. As noted, prior research among Western samples has shown that folkpsychological attributions track two separate dimensions corresponding to faculties perceived as either experiential (sensory) or cognitive (representational) (Gray, et al., 2007). For example, human-made artifacts such as robots are seen as high on cognition but low on experiential capacities, whereas human infants are seen as high on experience but low on cognition. If representational capacities are a salient principle for inferring (or denying) agency on folkpsychology but not folkcommunication, then we should expect agency attribution patterns for non-animal kinds to differ on these two dimensions among US participants, but not among Ngöbe participants.

For Ngöbe, we predicted that a new dimension entirely would be relevant to agency attributions. We have thus far contrasted abiotic kinds (sun, ocean, rocks) with biological kinds (plants, animals, and humans) as if only the latter are alive, following standard Western notions. But the concept of animacy, as defined in terms of the capacity for life and movement, may tap into different conceptions across cultures. On the folkcommunication proposal, we expected Ngöbe attributions of both cognition and experience to correspond closely with animacy judgments because all three dimensions may be inferred in tandem on the basis of a capacity to relate and interact with the environment.

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[15] Separate analyses for each mind-perception dimension likewise confirmed that condition did not affect either experience or cognition ranks among US participants.

[16] In both the original and relational conditions, Ngöbe were significantly more likely than US participant to include plants and abiotic kinds, *ps* < .001. In the original condition only, US participants were more likely than Ngöbe to include complex artifacts, $p < .001$. Simple artifacts did not reliably differ across cultures in either condition.

Table 7. Mean percent inclusions for cognition and experience[a]

	Cognition					Experience				
	Ngöbe (n = 24)		US (n = 35)			Ngöbe (n = 24)		US (n = 35)		
Kind	*M*	*SD*	*M*	*SD*	*t*-test[b]	*M*	*SD*	*M*	*SD*	*t*-test
Humans	0.91_a	(0.11)	0.97_a	(0.08)	-2.4*	0.99_a	(0.03)	1.00_a	(0.00)	*ns*
Animals	0.95_a	(0.08)	0.96_a	(0.08)	*ns*	1.00_a	(0.00)	1.00_a	(0.00)	--
Plants	0.59_b	(0.38)	0.35_b	(0.31)	2.62*	0.85_b	(0.22)	0.43_b	(0.30)	5.02***
Abiotic kinds	0.36_c	(0.33)	0.07_c	(0.12)	4.09***	0.28_c	(0.30)	0.01_c	(0.04)	4.43***
Complex artifacts	$0.17_{c,d}$	(0.23)	0.40_b	(0.26)	-3.36**	0.12_d	(0.21)	0.08_c	(0.15)	*ns*
Simple artifacts	0.06_d	(0.16)	0.01_d	(0.06)	*ns*	0.09_d	(0.21)	0.00_c	(0.00)	*ns*

[a] Cognition is a composite of memory, communication, and morality. Experience is a composite of hunger, pain, and fear.

[b] T-tests compare mean inclusion rates across cultures for the kind in that row.

[c] Means in the same column not sharing the same subscript differ at $p < .05$ in pairwise tests (Bonferonni-adjusted).

Note: * Indicates $p < .05$; ** $p < .01$; *** $p < .001$.

5.3.4.1. Mind-perception dimensions

As summarized in Table 7, agency attributions differed across the two dimensions for both US and Ngöbe participants, but did so in distinct ways. To follow up the reliable 3-way interaction of kind, culture, and mind-perception dimension, $F(2.79, 150.5) = 4.62$, $p < .01$, $\eta^2 = 0.08$, we explored rates of inclusion by dimension within each culture using repeated-measures ANOVAS with dimension (2: experience, cognition) and kind (6) as within-subjects variables. Each mind-perception dimension represented a composite variable of three capacities (experience: fear, hunger, pain; cognition: morality, communication, memory). As a complementary analysis, we also examined correlations between mean ranks (see Table 8) to assess the strength of relations among conceptual dimensions.

The key cultural differences in agency attribution to non-animal kinds generally held (and reliably so) across both experience and cognition (see Table 7), with the sole exception that complex artifacts were similarly low on experience for both groups ($p = .30$) (see Appendix B5). Thus, we focus on how these dimensions differed within each culture for US and Ngöbe participants in turn.

US. As predicted, US agency attributions differed across the two mind-perception dimensions, $F(1, 34) = 4.47$, $p < .05$, $\eta^2 = 0.12$, and this varied by kind $F(2.35, 79.93) = 15.36$, $p < .001$, $\eta^2 = 0.31$. Prior literature suggests that complex artifacts should be seen as having more cognitive capacities relative to experiential capacities, on the basis that computers can represent information but are not alive (Knobe, 2011). The opposite should hold for plants because they are considered alive but lacking in representational faculties. Consistent with this, complex artifacts were more likely to be included in cognition than experience (complex artifacts: $t(34) = -5.65$, $p < .001$, $d = -1.51$), as were (surprisingly) abiotic kinds ($t(34) = -3.11$, $p < .01$, $d = -0.78$). The opposite trend held for plants, which were included more often on experience than cognition, but this did not reach reliability, $p = .30$.[17]

Correlations between mean ranks for each kind were consistent with this two-dimensional structure (see Table 8). If experience and cognition represent distinct dimensions of agency for US participants, then these two sets of attributions should be extended on the basis of distinct considerations for each non-animal kind such that ranks are not reliably correlated across dimensions. As predicted,

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[17] Inclusion rates for humans and animals were also higher on experience than cognition (humans: $t(34) = 2.24$, $p < .05$, $d = 0.54$; animals: $t(34) = 2.94$, $p < .01$, $d = 0.71$), but these differences were small as attributions for both kinds were at or near ceiling.

Table 8: Intercorrelations between mean ranks across dimensions by culture

Kind	US		Ngöbe	
	Experience[a] - Cognition[a]	Agency[a] - Animacy[b]	Experience[a] - Cognition[a]	Agency[a] - Animacy[b]
	r	*r*	*r*	*r*
Humans	.43**	.55***	.56**	.42*
Animals	.05	-.02	.65***	.76***
Plants	.28	.13	.69***	.55**
Abiotic kinds	.03	-.31†	.56**	.38†
Complex artifacts	.12	.44**	.55**	.44*
Simple artifacts	-.08	.66***	.57**	.22

[a] Agency is a composite of Cognition (memory, communication, morality) and Experience (pain, hunger, fear).

[b] Animacy is a composite measure of Life and Movement.

Note: * Indicates $p < .05$; ** $p < .01$; *** $p < .001$, † indicates $p < .10$

there were no reliable correlations between experience and cognition attributions for any non-animal kind among US participants (all *rs* = *ns*). Instead, cognition and experience are reliably correlated only for humans, which would be expected if humans serve as the prototype for both dimensions.

Ngöbe. We expected that Ngöbe agency attributions would not distinguish between the dimensions of experience and cognition, but Ngöbe inclusions did differ across the two dimensions, $F(1, 22) = 4.86$, $p < .05$, $\eta^2 = 0.18$, and this varied by kind, $F(3.10, 68.26) = 10.26$, $p < .001$, $\eta^2 = 0.32$. Like US participants, Ngöbe more frequently included plants in experience than cognition, $t(23) = 3.66$, $p < .01$, $d = 0.68$, whereas abiotic kinds were more often included in cognition than experience, $t(22) = -2.2$, $p < .05$, $d = -0.31$. Unlike US participants, however, there was no reliable difference for Ngöbe attributions to complex artifacts across the two dimensions, $t(23) = -1.37$, $p = .18$, $d = -0.23$.[18] Considering that abiotic kinds were high on this dimension while complex artifacts were low, it does not appear that representational principles are central on the Ngöbe framework for inferring cognition.

Although Ngöbe agency attributions did differ across dimensions, they were still closely related. Unlike the US sample, Ngöbe ranks for experience and cognition were significantly correlated for every kind, both animal and non-animal (*ps* < .05). This is consistent with our prediction that for Ngöbe, experience and cognition are inferred on the basis of similar principles.

In sum, US participants differentiated more strongly than Ngöbe participants between cognition and experience for all three non-animal kinds. Both groups shared a biology-based model for experience, but US attributions for cognition followed an artifact kinds model whereas Ngöbe followed a natural kinds model. The strongest differences on cognition emerge for distinct kinds across Ngöbe and US models (abiotic kinds versus complex artifacts), suggesting that different inferential principles are at stake in each model of agency. One relevant factor may be concepts of life, to which we now turn.

5.3.4.2. Animacy

If Ngöbe individuals see abiotic kinds as animate, then they may be using a unified conceptual model of agency that infers experience, cognition, and life on the basis of similar principles.

Cross-cultural differences. Cultural differences in concepts of animacy for abiotic kinds (sun, ocean, rocks) were dramatic. Ngöbe were far more likely than US participants to recognize abiotic kinds as alive

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[18] As witnessed for US participants, humans and animals also differed, but again this was a minor effect with all inclusions at or near ceiling (humans: $t(23) = 3.72$, $p < .01$, $d = 1.05$; animals: $t(23) = 3.06$, $p < .01$, $d = 0.90$).

(Ngöbe: $M = .75$; $SD = .26$; US: $M = .11$; $SD = .23$), $t(57) = 9.86$, $p < .001$, $d = 2.66$, and capable of movement (Ngöbe: $M = .76$; $SD = .18$; US: $M = .54$; $SD = .33$), $t(54.79) = 3.26$, $p < .01$, $d = 0.79$.[19] The sun and ocean were together ranked above all other kinds on animate capacities by fully half of Ngöbe participants (11/22 for life, 15/22 for movement), in stark contrast to US participants (1/35 for life, 5/35 for movement). The fact that the sun and ocean were ranked so prominently in Ngöbe models of animacy suggests their prototypical status as animate forces. In contrast, US life attributions followed a categorical biological kinds model: plants, animals, and humans were almost always included and all other kinds excluded. US movement attributions were more graded, with abiotic kinds and complex artifacts included at levels near 50%.

Otherwise, the two groups converged on life and movement inclusions for each kind, with the only other minor difference for complex artifacts, $t(57) = -2.56$, $p =.05$, $d = -0.69$, such that US participants were more likely than Ngöbe to say that robots (but not computers) could move (US: $M = .71$, $SD = .46$; Ngöbe: $M = .46$, $SD = .51$). This could reflect different levels of familiarity with robots, and/or different interpretations of movement as autonomous versus automated.

One other comparative property of life ranks should be noted. Among US participants, all living kinds (plants, animals, humans) were often ranked on a single level and everything else excluded, representing a binary concept of alive/not alive. Interestingly, Ngöbe rankings for life were just as graded as for any other agency capacity. Evidently, entities may possess distinct degrees of life force on the Ngöbe folktheory.

Animacy and agency. The proposal for folkcommunication would predict a strong relationship between animacy and agency for Ngöbe participants, insofar as both capacities are inferred from similar principles. As summarized in Table 8, Ngöbe attributions of animacy and agency were indeed reliably correlated for each kind (*ps* < .05) except abiotic kinds, which only reached marginal significance ($p = .08$). We did not expect a strong relationship for agency and animacy among US attributions given that the two constructs should tap into distinct inferential principles for folkpsychology and biology respectively. Indeed, the two constructs were reliably correlated only for humans but none of the natural nonhuman kinds. Interestingly, the two constructs were also correlated for human-made artifacts, but this is based on a small number of US respondents who attributed animacy to those kinds.

Animacy judgments are especially informative when examined in relation to cognition, as that is the agency dimension where the largest cultural differences emerged with respect to non-animal kinds. It is clear from Figure 2 that Ngöbe attributions of animacy and cognition track together across all three non-animal kinds: the more alive an entity is perceived to be, the more it is capable of cognition. In direct contrast, US attributions of cognition and animacy to these non-animal kinds bore no relationship: life and cognition were inferred independently of one another.

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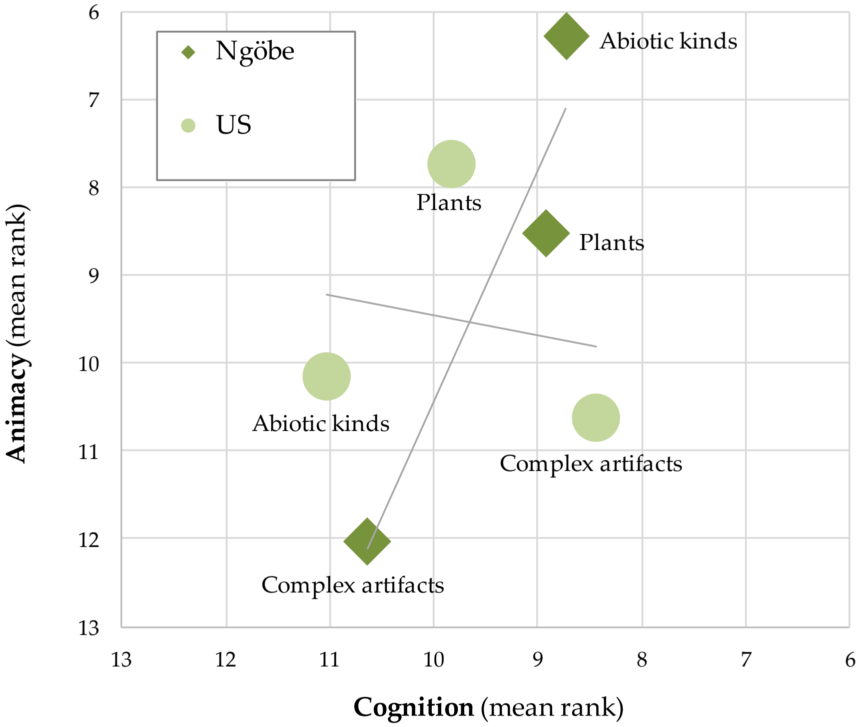
[19] Examining these attributions for each of the three abiotic kinds shows that Ngöbe roundly agree on the living kind status of the ocean (M = .96, SD = .20) and the sun (M = .88, SD = .34), in stark contrast to the US majority conception of these kinds as lifeless (ocean: M = .14, SD = .36; sun: M = .20; SD = .41) (*ps* < .001). Ngöbe were also significantly more likely to include the sun and ocean in movement attributions (*ps* < .05), although there was greater cross-cultural agreement on this point (Ngöbe sun: M = .96, SD = .20; Ngöbe ocean: M = 1.00, SD = .00; US sun: M = .63, SD = .49; US ocean: M = .74, SD = .44). Rocks figure less prominently in Ngöbe animacy attributions (inclusions for life: M = .42, SD = 50; and movement: M = .33; SD = .48); but this still contrasted with US participants' total denial of life to rocks (M = 0, SD = 0), $p < .001$, although movement attributions were more similar across cultures (US: M = .26, SD = .44) (p = .54). Notably, rocks still stand far above complex artifacts in Ngöbe attributions of life (M = .08, SD = .28, identical for robot and computer), which differed not at all from simple artifacts (M = .08, SD = .28). Interestingly, US participants tended to attribute life to robots (M = .14, SD = .36) and computers (M = .11, SD = .32) more often than Ngöbe participants, but these differences were not reliable (*ps* = .50 and .71, respectively).

Figure 2. Animacy & cognition: attributions to non-animal kinds by culture



In sum, these striking cultural differences in animacy concepts suggest that the Ngöbe framework for agency may be grounded in a view of life as a graded force where powerful abiotic kinds like the sun or ocean are prototypes. This contrasts with the US view of life as a binary category that is evidently based on distinct principles from those used for inferring folkpsychological (especially cognitive) agency.

5.4. Detecting multiple conceptual models without "culture"

5.4.1. Cultural consensus modeling

In this section our analysis shifts from asking what kind of conceptual model a culture has, to what kinds of cultures a model has. Setting aside any predefined cultural groupings, we used cultural consensus modeling to identify whether multiple latent conceptual models of agency are present in the dataset (collapsing across US and Ngöbe participants), and to explore between- and within-culture variations on these conceptual models. Our first objective was to determine if there are one or more consensus conceptual models. This is an important step beyond the cultural differences reported above because two groups can differ even while one group fails to converge on a consensus model (Le Guen et al., 2013). If more than one consensus is detected this will indicate that multiple coherent models are latent in the responses. Second, we are interested in the agency attribution profile of each consensus model, including which items are the most difficult to reach consensus on. Comparing these rank profiles can shed light on the conceptual frameworks and forms of competence that structure each consensus model. Third, we are interested in how participants cluster into the consensus models according to their actual cultural membership and individual characteristics, as well as how individual-level variables may predict expertise within each model. This will enrich understanding of across- and within-group variability and point to individual factors that may influence one's conceptual model of agency. Our modeling is conducted on the mean rank data in order to complement and extend the prior inclusion results.

Cultural consensus modeling (CCM) (Romney et al., 1986) has been applied extensively in prior cultural research on biological cognition (Atran & Medin, 2008; Medin et al., 2007). Conceptually similar to factor analysis, CCM determines if a single underlying model exists, as well as whether patterns of residual agreement beyond the overall consensus suggest additional models that hold for subgroups in the sample. Each participant is assigned a cultural "competence," where higher scores on a factor loading indicate that an individual's responses are closer to the cultural consensus. CCM also calculates the consensus model "answer key" with a competency weighted consensus rating for each item, providing a more reliable approximation of the common truth than traditional data aggregation techniques (France & Batchelder 2014).

Recent advances in CCM provide a model-based way to derive multicultural consensus from continuous response data (Anders et al., 2014). This new Bayesian inferential approach to consensus modeling (Anders, 2013) offers two key advantages over prior CCM techniques. 1. It treats culture as a latent variable by providing a model-based way to assess whether separate consensus models exist within a sample and to identify each participant's consensus group membership (rather than relying on known cultural membership specified in advance, as in traditional CCM methods). This confers a theoretical advantage over statistical models that treat culture as a fixed independent variable, by focusing on conceptual models and allowing cultural membership to remain latent. To emphasize this analytic distinction, we refer henceforth to "conceptual/consensus models" rather than "cultural models." 2. It introduces a new response precision parameter to assess whether some items are more difficult than others, unlike traditional CCM methods that assume all items are equally difficult. The resulting consensus model answer key accounts for variable item difficulty in addition to respondent expertise, providing a more sensitive estimate of the shared conceptual model.

5.4.2. Methods and procedure

Using the CCTpack R software package (Anders, 2013), we applied the Bayesian CCT model to the agency ranks data (both mind perception dimensions, but not animacy capacities)[20] from all US and Ngöbe participants together (*N* = 57). The participant-level mean ranks for each kind on both experience and cognition were subjected to cultural consensus modeling at the item level (k = 14), for a 57 (participants) X 28 (14 items X 2 dimension) matrix. For ease of interpretation and consistency, results are presented at the kind level.

In CCTpack, analysis is executed by running many iterations of a given model with various parameters adjusted between models (e.g., number of derived "cultures" or consensuses, difficulty of items). Two posterior predictive checks are used to compare which model best fits the actual data. 1. To check that the consensus structure of the data is appropriately fit by the model (i.e., the appropriate number of consensuses), a scree plot of eigenvalues assesses the fit between the model-generated estimates and the actual structure of the data (see Royce, 2013 for details). 2. To check whether the item difficulty parameter should be treated as uniform (i.e., homogenous item difficulty) or variable (i.e., heterogeneous item difficulty), a variance dispersion index (VDI) reports how well the model captures

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[20] CCM was conducted on the two mind-perception dimensions excluding animacy for a more conservative test of latent conceptual models, insofar as the stark cultural difference in life judgments for abiotic kinds could contribute disproportionately to detection of consensus models and membership. Nonetheless, the consensus models for experience and cognition remain virtually identical when the CCM included Alive, and membership clustering results were similar (27 of 35 US participants into Culture 1 and 21 of 22 Ngöbe participants into Culture 2).

differences across items due to response variability; these VDIs are compared and the model with better fit is selected (see Anders et al., 2014).

Our use of CCTpack constitutes exploratory work on the capacity of the Continuous Response Model (CRM) to handle multicultural ranking data, which has not been done before. In that sense, our results contribute to the CCM literature by confirming the robustness of this model (see Appendix B6).

5.4.3. Results

5.4.3.1. Model selection and identification of latent conceptual models

The data were simulated using a series of models with 1, 2, and 3 consensuses, with and without heterogeneous item difficulty.

Item difficulty. The VDI check for item difficulty indicated that a model assuming heterogeneous (versus homogenous) item difficulty better fit the data.

Consensus fit. The scree plots of eigenvalues showed that the first factor was substantially larger than subsequent factors, with a second factor evident but less pronounced. Posterior predictive checks showed that the data structure was well fit by both a one- and two-consensus model, but a three-consensus model failed to fit the data.[21] This suggests an overarching consensus accompanied by subgroups. The overall consensus was expected due to the substantial agreement on ranks for humans and animals. A two-consensus model would be expected to pick up additional patterned variability concerning non-animal kinds. In the past, we have consistently found a good overall consensus paired with systematic subgroup differences (Medin, et al., 2007). Thus, we selected a two-consensus model with heterogeneous item difficulty.

5.4.3.2. Consensus Models

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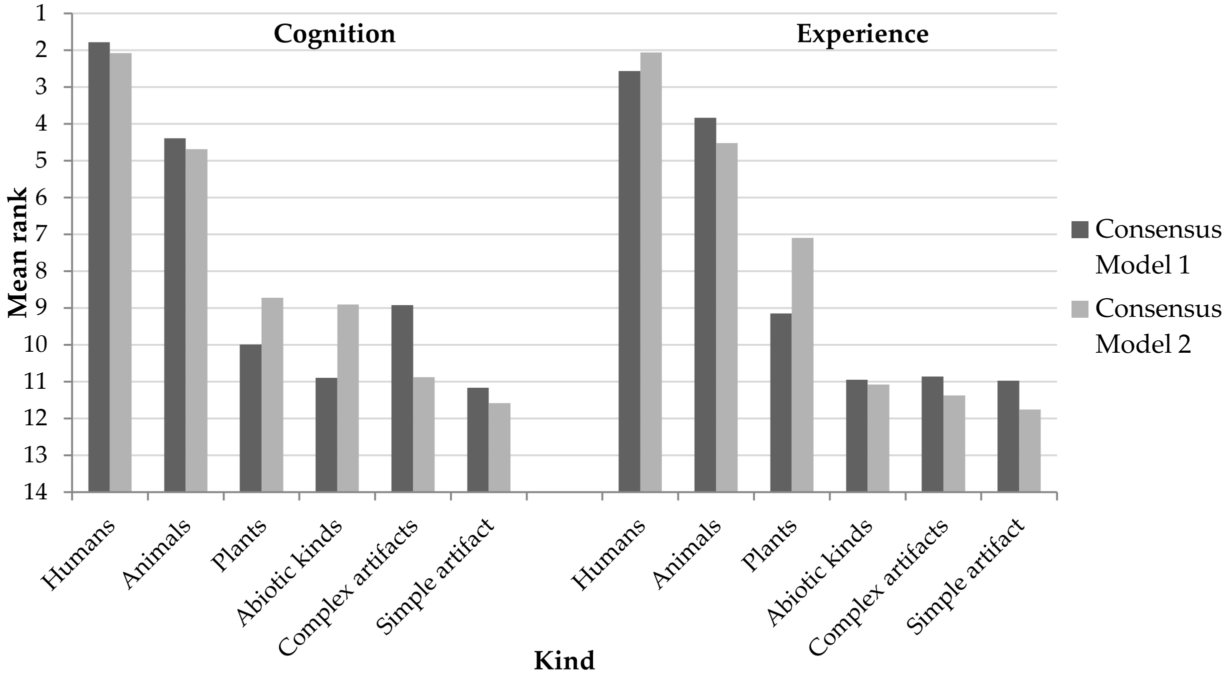
[21] A 3-consensus model was unable to reach convergence of modeling chains (Anders, 2014), indicating that there were no detectable third components and/or too many degrees of freedom.

Figure 3: Model-based consensus models for agency by dimension



The model identified two consensuses latent in the agency rank responses (see Figure 3). The two consensus models that emerged were consistent with hypothesized frameworks for ecocentric versus anthropocentric agency. The items that are in largest disagreement between the two models are non-animal kinds, reflecting that plants, abiotic kinds, and complex artifacts were organized differently across the two consensuses. The first consensus model for agency fit an artifact kinds model (AKM) for cognition (complex artifacts were ranked above both abiotic kinds and plants), but experience followed a biology-based natural kinds model (NKM) (plants ranked above both complex artifacts and abiotic kinds). The second consensus model followed a NKM for both cognition and experience, with cognition relatively ecology-based (abiotic kinds and plants ranked together above complex artifacts) and experience relatively biology-based (plants ranked higher than both abiotic kinds and complex artifacts). Comparing the two consensus models, cognition is where the more pronounced differences arise. Model 1 appears to treat cognition as a property of information-processing artifacts (only), whereas Model 2 treats cognition as a property of all natural kinds but not artifacts.

Item difficulty. We used item difficulty results to illuminate the forms of competence associated with each conceptual model. One unique strength of CCM is that it goes beyond sample means to assess each individual's level of competence on the consensus model. CCTpack improves on this feature by analyzing item difficulty for each item in the model. The most difficult items are the hardest to reach consensus on, and so can be used to distinguish more from less competent members of a consensus group.[22]

On Model 1, complex artifacts and humans were the most difficult item kinds for cognition, such that greater competence was correlated with higher rankings for complex artifacts ($r = -.35$, $p < .05$) and

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[22] This interpretation of item difficulty builds on the property of the CCM model that in general, more competent respondents will tend to get the hard items correct more frequently than less competent members.

lower rankings for humans ($r = .34$, $p < .05$), indicating that these two kinds shifted places near the top of rank hierarchies depending on competence.[23] For experience, humans and animals were the most difficult items, such that those with greater competence ranked animals lower ($r = .38$, $p < .05$) and tended to rank humans higher ($r = -.28$, $p = .08$).[24] On Model 2, abiotic kinds and humans were the most difficult item kinds for both cognition and experience. Greater competence was correlated with ranking abiotic kinds higher (*rs* = -.90 and -.67 for experience and cognition respectively, *ps* < .001) and humans lower (*rs* = .53 and .49, *ps* < .05), indicating that these two kinds shifted places near the top of rank hierarchies depending on competence.

These results suggest that the two consensus models represent qualitatively distinct forms of reasoning about agency. For the anthropocentrically oriented Model 1, competence means an increased recognition of complex artifacts' capacity for cognition, coupled with lower estimation of animals' capacity for experience. For the ecocentrically oriented Model 2, competence means greater appreciation of both the cognitive and experiential capacities of abiotic kinds like the sun and ocean.

5.4.3.3. *Consensus model membership*

These item-specific differences in competence motivate further questions concerning individual and conceptual variability in consensus model membership, both across and within the two models.

Consensus group membership. The model detected and clustered individual participants into the two consensus models in close correspondence with actual cultural membership. The majority of US participants (31 of 35) were clustered with Model 1, and the majority of Ngöbe (14 of 22) with Model 2. It is notable that US participants clustered so strongly into a single model despite being the larger sample and being drawn from two distinct language samples (monolingual and bilingual). The Ngöbe sample exhibited more clustering variability, which may speak to the presence of multiple cultural models of agency.

Individual differences in consensus model membership. Ngöbe. The clustering results indicate substantial within-culture variability among Ngöbe. Based on prior research, we anticipated that Ngöbe members of the ecocentric Model 2 would also lead more traditional community-based lifestyles, as indexed by five measures (livelihood, Indigenous church membership, age, language identity, formal schooling). Of these variables, livelihood and language identity reliably distinguished between Ngöbe clustered with Model 1 and Model 2. Members of Model 2 were comparatively more likely to be engaged in subsistence activities versus externally organized occupations (e.g., wage-earning work), $F(1, 19) = 4.28$, $p = .05$, $\eta^2 = .18$, and to identify Ngöbere as their primary language rather than Spanish, $F(1,19) = 9.90$, $p < .01$, $\eta^2 = .34$.[25]

Model 2 members were also more likely to be in the relational condition, $F(1, 19) = 7.80$, $p < .05$, $\eta^2 = .29$. If the ecocentric Model 2 reflects a conceptual orientation widely available in the Ngöbe community, as we propose, then this could be interpreted as further evidence that the relational framing of agency facilitated that framework. At the same time, the characteristics of Model 2 may also be partially due to the experimental condition. Sample sizes do not permit us to factor out the influence of condition on consensus models (*n*s are too small for a 2-culture model fit in each condition separately).

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[23] Recall that ranks are reverse scored, hence the negative correlation between expertise and higher ranks.

[24] In practice this often meant that Model 1 experts increased the distance between humans and animals in their experience rankings, relative to less expert participants. Interestingly, the specific items of highest difficulty from the animal category were the bird and frog, consistent with an anthropocentric model that places mammals closer to the human prototype than non-mammals.

[25] Due to missing demographic information, Ngöbe $n = 21$ for these analyses.

US. Among US participants, there were no reliable differences between participants clustered with Model 1 versus Model 2 for experimental condition, task language, or individual characteristics. This analysis, however, is limited by the small number of US participants clustered with Model 2 ($n = 4$).

Conceptual differences in cross-model membership. Given that a cultural majority emerged for each conceptual model, we were interested in the responses of those individuals who were cross-clustered with the other consensus model (i.e., that of their non-majority culture). The agency attribution profiles of these subgroups could speak to what happens at the boundaries of each conceptual model. All differences reported below were significant at the $p < .05$ level in MANOVAs (either by culture or model membership) comparing agency attributions for cognition and experience.

US participants who clustered with the Ngöbe-majority Model 2 differed from their US Model 1 counterparts in their treatment of plants (more experience and cognition) and complex artifacts (less cognition). They remained distinct from Ngöbe members of Model 2, however, in their rejection of cognition for abiotic kinds. Ngöbe participants who clustered with the US-majority Model 1 diverged from their Ngöbe Model 2 counterparts in their attributions to plants and abiotic kinds (less agency to both, which held at or near significance for both experience and cognition). However, they remained distinct from US members of Model 1 by attributing more cognition to abiotic kinds and less cognition to complex artifacts.

These findings suggest that the general view of agency among US individuals seems to afford variation towards a solidly biology-based model that encompasses all living kinds but rejects anything considered inanimate. Conversely, the general Ngöbe stance on agency affords variation toward a more animal-centric model where the agency of non-animal natural kinds is relatively diminished.

Individual differences in within-group competence. We next analyzed individual differences associated with competence scores, which indicate how well an individual fits the consensus model to which they were assigned. Analyses were run separately for Model 1 and Model 2 scores within each cultural group (Ngöbe or US) given that demographic features were hardly comparable between groups.

Ngöbe. We anticipated that competence scores for Ngöbe participants clustered with Model 2 ($n = 14$) would correlate with more traditional Ngöbe lifestyles, given that this model reflects an ecocentric orientation to agency. Indeed, greater competence was reliably correlated with greater age ($r = .64$, $p < .05$), less formal schooling ($r = -.73$, $p < .01$), and, unexpectedly, gender (males more expert, $r = .57$, $p < .05$). This supports the idea that the ecocentric model of agency is facilitated by greater engagement with Ngöbe cultural knowledge (e.g., being an elder) and/or less involvement with non-Ngöbe cultural discourses. There were no reliable correlations between competence and individual characteristics among Ngöbe clustered with Model 1 ($n = 8$), but the modest sample size limited this analysis.

US. We had no hypotheses concerning individual predictors of competence scores among US participants, beyond the possibility (based on prior pilot work) that religious belief or experience with nature may be relevant to notions about plants. Among US participants clustered with the anthropocentrically oriented Model 1 ($n = 31$), grade level was positively correlated with greater competence ($r = .37$, $p < .05$). This may suggest that university schooling (possibly psychology-specific, given that these participants were drawn from a psychology subject pool) strengthens the dominant cultural model of agency. Unexpectedly, competence for US members of Model 2 ($n = 4$) was *negatively* related to religion (in contrast to our prior pilot work), such that those reporting fewer religious beliefs were more competent ($r = -.96$, $p < .05$).[26] The small sample prohibits firm conclusions, and both these relationships should be interpreted with caution given the lack of predictions.

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[26] Religiosity was a composite measure of the three religious belief items, see Appendix B1.

5.5. Experiment 2: Discussion

Two distinct cultural understandings of agency are evident in these results. The Ngöbe model offers an ecocentric perspective on which plants and abiotic kinds are both significantly more agentic than complex artifacts, and plants in particular figure as robust agents. In contrast, on the US model the domain of agency appears to include only humans and animals as agents proper, while complex artifacts are significantly more agentic than abiotic kinds and on par with plants. US results held across Spanish and English task versions so these cross-cultural results do not simply reflect cross-linguistic differences.

To test our proposal that these agency attribution models point to distinct grounds for inferring agency, we introduced an experimental manipulation and also probed the conceptual dimensions underlying agency attribution. The relational framing of agency facilitated greater agency attributions for Ngöbe participants only, indicating that relational principles are important to inferring agency on this cultural model. Further evidence for diverse inferential principles came from analysis of conceptual dimensions underlying cultural models of agency. Both groups shared a similar biology-based model of experience, but the dimension labeled cognition taps into distinct attribution profiles across cultures: an information-based view of cognition as potentially separable from animacy (US), or an ecology-based view of cognition as closely linked to animate force. US results especially were consistent with a two-dimensional mind-perception framework where agency is conceptualized according to experiential or cognitive capacities, and cognition in particular is decoupled from animacy judgments. The experience-cognition distinction was less pronounced for Ngöbe participants and both dimensions tracked together with a third dimension of animacy.

Cultural consensus modeling allowed us to identify two conceptual models from the overall data while treating culture as a latent variable, and to analyze the conceptual properties and individual characteristics associated with each consensus model. Three key findings emerge. 1) Beyond the overall agreement on the agency of animal kinds, two separate consensus models were detected, confirming that the ecocentric and anthropocentric models of agency represent separate coherent bodies of conceptual knowledge about non-animal kinds. 2) Forms of competence associated with each model provided converging evidence for the hypothesized conceptual frameworks in terms of conceptual content (items that predicted competency on each model were either computerized or abiotic natural kinds) and individual variability (with competence associated with either university schooling or traditional cultural engagement). 3) Modeling results suggest that there are multiple conceptual models of agency available in the Ngöbe community, with the more pronounced cultural model being an ecocentric model of agency. The US sample reached strong convergence on a single dominant model of anthropocentric agency.

6. General discussion

Across two experiments, converging measures paint a robust picture of distinct cultural frameworks for understanding agency. Findings consistently presented two different agency attribution profiles wherein Ngöbe were more likely to attribute agency to plants and abiotic kinds than US college students, who in turn were more likely to attribute agency to complex computerized artifacts.

We argue that these disparate models point to culturally diverse grounds for inferring agency as a relational capacity understood on an ecocentric prototype (folkcommunication), or as a psychological capacity understood on an anthropocentric prototype (folkpsychology). The current experiments provided several sources of evidence to support this proposal. First, coding analysis of explanations showed that US participants interpret agency as a scalar, prototypically human capacity requiring consciousness. Ngöbe instead interpreted agency in terms of directed interactions with environment and others, indicating a concern for the relational dimensions of agency. Second, by introducing a relational framing of capacity probes, we demonstrated that Ngöbe (but not US) agency attributions are facilitated by a relational perspective, consistent with the claim that the capacity to relate is a grounding principle for inferring agency on folkcommunication.

Third, the conceptual organization of agency dimensions differed across cultures. US attributions suggested a nested domain-specific approach whereby animacy followed a wide biology-based model, experience followed a narrower biological model that mostly excluded non-animals, and cognition followed an artifact-kinds model that included computerized artifacts as well as animals. That US models diverged across these dimensions indicates that distinct inferential principles are at stake in these domains, and cognition especially points to an anthropocentric framework where agency is understood as a representational property on a human prototype. By contrast, the conceptual organization observed for Ngöbe agency attributions presents a more unified framework for agency. All three dimensions fit an overarching natural kinds model, under which experience was more biology-based while cognition and animacy were more ecology-based. This suggests that for Ngöbe the grounding principles for inferring agency are similar for all three domains, consistent with our proposal for folkcommunication where agency is based on a capacity to relate.

Finally, we consolidated these findings by using a recently developed method for analyzing cognitive variability through a hierarchical Bayesian inferential approach to cultural consensus modeling. With culture treated as a latent variable, these bottom-up modeling results confirmed that the observed differences in agency attribution arise from two distinct bodies of consensus knowledge, rather than deviations from a single model. The two consensus models were consistent with the hypothesized anthropocentric versus ecocentric prototypes for agency. Individual membership on each consensus model largely clustered with actual cultural membership, while at the same time highlighting cross- and within-culture variability in conceptual models and forms of competence. Ngöbe participants appear to have access to multiple models of agency as ecocentric (the more pronounced cultural model) or relatively animal-centric, while US participants reach strong consensus on a single model of agency that reflects an anthropocentric orientation.

Limitations

Before discussing the implications of these findings we address potential limitations. One potential concern arises with our experimental condition. Perhaps by including an object following a capacity predicate in the relational condition, we implied that the capacity in question properly applies to the subject (e.g., asking if plants can feel hungry for nutrients may imply that plants can feel hunger), and perhaps Ngöbe participants are more sensitive to this implicature than US participants. Even if this were the case, the key predicted cultural differences also hold for the original condition so this would not explain away our results. More to the point, however, we would argue that this pragmatic implicature (such as it is) is conceptually aligned with our argument for a relational agency framework. If one's focus is on the interaction between subject and object, then agency predicates do in fact play a conceptual role of binding two entities in a particular kind of relationship (see also Knobe & Prinz, 2008). To the extent that the predicate-object pairing accentuates the relational aspect of agency, we interpret this as a meaningful property of a folkcommunication framework.

Another remark involves the presence of multiple models in the Ngöbe sample. One consideration is that this finding may reflect the greater range of individual differences among the Ngöbe sample (age, schooling, etc.) and our US college student participants were simply too homogenous to yield multiple models. It is certainly plausible that all communities have access to multiple models of agency and we do not wish to suggest that all US individuals conform to a single agency framework. However, our US participants did vary on potentially important characteristics such as bilingualism, religiosity, and experience in nature, but they nonetheless presented a single dominant cultural model. This raises important questions for further research concerning the kinds of variability that can support the presence of multiple models within a community. For instance, it would be informative to explore diverse US samples beyond the college classroom and Western samples beyond the US, as we are currently doing in follow-up research.

Finally, another potential concern is that differential familiarity with complex artifacts (robots and computers) may explain the observed differences between Ngöbe and US attributions to these items. These cross-cultural differences were most evident on the cognition dimension, and we interpreted this to indicate that Ngöbe and US infer cognition based on distinct principles.[27] But it is important to consider whether this could instead reflect different knowledge about such artifacts. In fact, complex artifacts (cell phones, radios, and increasingly televisions and computers) are now common in the Ngöbe community although certain individuals such as elders or subsistence farmers may use them less frequently. This points to the larger issue that familiarity with complex artifacts is itself a cultural factor that may relate to any number of lifestyle choices. While further research could investigate the extent to which familiarity with complex artifacts entails differences in agency attribution, our two national samples differed in many other ways including formal schooling, economic status, and (presumably) personal familiarity with plants and non-urban ecosystems. Each factor reflects and reinforces cultural epistemologies, including beliefs about agency, and a research agenda that aims to "parcel out" all such differences in this manner risks losing sight of what is at stake.

Given the complexity of cultural systems, it may not be feasible (or desirable) to isolate one factor and give it explanatory priority in a system where many variables interrelate with one another and epistemological orientations. For this reason, consensus modeling can be a useful tool to highlight how distinct conceptual models arise in a larger sample while refraining from categorizing individuals into a priori cultural categories. This approach allowed us to focus on latent differences in conceptual models and explore multiple forms of variability within and across those models. Indeed, we found that lifestyle factors do cluster together in ways that converge predictably with forms of competence on a given consensus model of agency. If we assume that culture is a complex system, then such findings can offer insight into the factors that contribute to diverse ways of organizing conceptual knowledge, rather than serving as nagging confounds that detract from understanding of "pure" cultural differences.

Interpretation of cultural differences

There are several layers of cultural variability evident in these findings, which present multiple potential interpretations of cultural difference. Taken alone, the findings for agency attribution profiles could be consistent with an overextension account on which the two cultural groups mobilize a similar (universal) concept of agency but simply extend it at different rates to different non-animal kinds. On this account, one could argue that Ngöbe versus US frameworks carve out agency domains that are nested sets—with one cultural framework more restrictive than the other, or one framework overextended relative to the other—rather than tapping into distinct frameworks.

However, this account is inadequate to explain the full picture of results. For one, the findings for complex artifacts versus natural non-animal kinds go in opposite directions across cultures. For another, our results point to distinct organization of agency concepts across the conceptual dimensions of experience, cognition, and animacy. Both findings challenge a simple over- or under-extension account by pointing to more complex forms of diversity. Furthermore, participants' own explanations attested to different forms of explicit reasoning about agency, and the importance of relational reasoning to the

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[27] In fact, the results for complex artifacts remain somewhat inconclusive. In Experiment 2, we observed a reliable trend for US participants to attribute greater agency to complex artifacts as compared to Ngöbe. However, Experiment 1 findings for complex artifacts were mixed (US rankings were higher as expected, but inclusions were similar across both groups). Further work is needed to clarify the extent of the difference.

Ngöbe framework was confirmed experimentally through a subtle framing manipulation. Finally, a bottom-up approach to consensus modeling identified two distinct and coherent patterns of reasoning in these cross-cultural responses, rather than a single model accompanied by deviations. The evidence considered as a whole lends itself most readily to the interpretation that different principles for inferring agency are at stake.

More specifically, these findings are consistent with our hypotheses concerning cultural diversity in the conceptual structure of the agency domain. For US individuals, the overall picture suggests a domain-specific profile that holds animate kinds and psychological kinds in different (but overlapping) categories, and infers folkpsychological agency differentially on the basis of either a biological capacity for experience or a representational capacity for cognition. For Ngöbe informants, the overall picture suggests an integrated conceptual framework that holds diverse natural kinds under a common domain of folkcommunicative agency, and infers a variety of agency capacities (i.e., experience, cognition, animacy) on the basis of similar principles—principles that we propose are fundamentally relational in nature. Ngöbe conceptual models and explanatory frameworks challenge the idea that agency concepts are universally structured around a concern for minds as distinct from their embodied interactants.

Interestingly, a sizable minority of US respondents were willing to ascribe experiential capacities to plants. This suggests a more expansive appreciation of sentience than one strictly tied to having a brain, although prior research based on domain-specificity theory has rarely considered this possibility (or considered it a surprise when results indicated such) (e.g., Arico et al., 2011; Opfer & Gelman, 2001).

These findings raise a wealth of questions about the interaction of agency concepts and broader cultural systems (ojalehto & Medin, 2015). For instance, one might speculate that the US folkpsychological stance on agency is tied to a heightened focus on (human) minds under Cartesian dualism, whereas the Ngöbe ecological stance on agency partakes of a cultural worldview that sees humans as part of nature (Kimmerer, 2013; Medin & Bang, 2014a). In fact, Western researchers working from an anthropocentric folkpsychology may have mischaracterized indigenous concepts by claiming that they represent a supernatural or anthropomorphic overextension of (human-like) mental-state concepts to non-animal kinds. If one is not working from a human psychological prototype, then the view that plant behavior (for instance) reflects intentional agency is quite plausible. Indeed, this is precisely the message offered by an increasing body of scientific evidence for the intelligent behavior of plants, bacteria, and other natural kinds, including even some abiotic forces (Calvo & Keijzer, 2011; Chamovitz, 2012; Haila & Dyke, 2006; Kauffman, 2008; Marder, 2013; Narby, 2006; Trewavas, 2016). Furthermore, our proposal that such forms of agency may be interpreted under a folkcommunication framework builds on mounting research that shows how people—including typical Western samples—organize conceptual knowledge around relational categories and social dimensions of agency (e.g., Hirschfeld, 2013; Luhrmann, 2011; Mascaro & Csibra, 2012; ojalehto, et al., 2013; Tamir, et al., 2016).

7. Conclusion

We have argued that Ngöbe individuals hold a conceptual framework for agency that is fundamentally geared toward understanding interactions and relationships, which differs from the US folkpsychology focused on internalized mental states. Our findings suggest that grounding principles for inferring agency diverge across cultures, leading to agency attribution models that cut across different domains and track different conceptual dimensions rather than fitting a neat "animistic" overextension account of folkpsychology to non-animal kinds. While an emphasis on psychological agency as distinct from other (biological, physical) forms of agency has been widely assumed to be a conceptual prior, these findings suggest it may instead be a feature of Western cultural epistemologies.

The implications of our account are potentially far-reaching, given that agency concepts play a fundamental role in cognitive processes ranging from causality and mind perception to morality (e.g., Banaji & Gelman, 2013). The present research offers a novel perspective on the universality of domain-specific folktheories for agency and resonates with calls to reevaluate the privileged role of mentalistic folkpsychology in social cognition (Heyes, 2014; Hirschfeld, 2013). Furthermore, human-nature relationships are currently under tremendous stress as a result of Western worldviews and ways of interacting with the rest of nature (Kahn et al., 2010; Mace, 2014). Ngöbe perspectives could be useful in offering a way to understand agency based on an ecologically inclusive principle of relational capacity, providing a complementary perspective to the common Western narrative of human-centered agency. Given that our intuitive recognition of other kinds as agents helps to shape their role in our social and moral communities, it seems well worth exploring a conceptual framework for ecocentric agency.

Conceptualizing agency: Folkpsychological and folkcommunicative perspectives on plants

1. Introduction

A long-standing question in psychology concerns how people recognize and reason about agents—the kinds of things that are capable of acting in, about, and towards the world. It is widely proposed that this rests on a dualistic distinction between psychological agents versus insentient actors (Johnson, 2003; Wellman & Johnson, 2008). Specifically, the actions of psychological agents like humans or other animals are explained in terms of mental states like beliefs and desires—a conceptual framework known as folkpsychology (e.g, Erickson et al., 2010). By contrast, the actions of other kinds of actors like plants or clouds are explained by appeal to non-intentional biological (folkbiology) or physical forces (folkphysics). For instance, people purportedly activate different folktheories to interpret what causes movement toward the sun by a cloud versus a plant (folkphysics versus folkbiology), and both would be interpreted differently from what causes a person to move toward the sun (folkpsychology) (Gutheil et al., 1998; Opfer & Gelman, 2001; Opfer & Siegler, 2004). This partitioning of domains presents a worldview in which entities in the natural world can be adequately described in terms of physical and biological causes without recourse to intentionality or sociality—properties that are considered exclusive to humans and perhaps some other animals. The corresponding theory of folkpsychology represents an anthropocentric model that may extend agency to some "higher" animals such as mammals, but excludes entities such as plants, minerals, or water bodies on the grounds that they do not share similar forms of agency to humans (e.g., Carey, 1985).

This is the account proposed by domain-specificity theory, which sees these intuitive folktheories as fundamental, untutored ways of organizing knowledge about the world that reflect universal cognitive structure (Hirschfeld & Gelman, 1994; Sperber & Hirschfeld, 2004; Wellman & Gelman, 1992). However, this particular delineation of intuitive domains has been formulated by Western psychologists and much of the evidence in support of it has come from Western study populations (Carey, 2009; Gutheil, et al., 1998; Keil, 1995; Opfer, 2002; Opfer & Gelman, 2001), and some industrialized Eastern cultures (Hatano & Inagaki, 1994; Inagaki & Hatano, 2004). Yet more recent research suggests that this organization of domains may reflect Western cultural epistemologies. For instance, the Western anthropocentric stance leads to patterns of folkbiological reasoning that differ markedly from those of Indigenous communities that take an ecological stance (Herrmann et al., 2010; Ross et al., 2003; Unsworth et al., 2012; Waxman & Medin, 2007). Based on such findings, it has been proposed that alternative partitionings of domains may provide a better match for conceptual patterns in different cultures—for example, folkecology may be more apt than folkbiology in some Indigenous communities (ojalehto & Medin, 2015). Similarly, it is a distinct but untested possibility that the anthropocentric stance in folkpsychology may likewise reflect a Western orientation that is not shared in other cultures. In the current research, we propose that folkcommunication may be more apt than folkpsychology in the Indigenous Ngöbe community of Panama. The present experiments investigate whether Indigenous Ngöbe adults and US college students hold different conceptual frameworks for agency that facilitate distinct sets of inferences about and interpretations of nonhuman agency, focusing on plants as a critical test case.[28]

2. Background

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[28] On Western folkpsychology, capacities like "want" and "think" are interpreted as mental states associated with minds, but it may be that Ngöbe interpret these capacities differently. Thus, we refer broadly to "agency" rather than "minds" or "mental states" in order to avoid specific folkpsychological connotations.

2.1. Indigenous perspectives on agency

Anthropological observations suggest that many Indigenous communities organize knowledge about agents in ways that differ from Western folkpsychology (Lillard, 1998; Luhrmann, 2011). First, understanding of others is framed more in terms of relational interaction or communication than individual subjectivity (Ingold, 2010). Here the focus is on explaining actions in terms of overt behavior, relationships and social roles, and speech acts or other signs rather than explicit inferences about the private mental states of others (Danziger, 2006, 2010; Danziger & Rumsey, 2013; Duranti, 1988, 2008; Robbins & Rumsey, 2008). Second, communication with nonhumans is a significant concern in communities where everyday life involves intimate interaction with ecologies (Harvey, 2005; Ingold, 2006, 2011; Kohn, 2013). Personally navigating relationships with nonhuman kinds such as soil, thunder, plants, or animals requires close attention to nonhuman behaviors and responses (Anderson, 1996, 2012; Hallowell, 1960; Rappaport, 1979; Reichel-Dolmatoff, 1976). Native and non-native scholars alike have argued that these exchanges are founded on a conception of nonhumans as beings with a perspective or locus of agency, where agency is understood to be expressed through the capacity to participate in relationships (e.g., predator-prey relations, healing relations) (Bird-David, 1999; Cajete, 2000; Descola, 1996; Kimmerer, 2013; Lima, 1999; Pierotti, 2011; Santos-Granero, 2009; Viveiros de Castro, 1998) (see also Ramos, 2012).[29]

As a consequence of these views on agency, nonhumans are often included in social relationships within Indigenous communities. For instance, dogs are administered medicinal treatments to enhance their perceptual acuity while hunting, and their behaviors, from barking (while awake or dreaming) to body language and eye contact, are analyzed as meaningful forms of communication (e.g., Kohn, 2007). Plants and animals are also included in the moral circle, as exemplified by such customs as prohibiting rude actions (e.g., spitting) toward plants (Santos-Granero, 2012) and chastising children for wanton harm to insects (Anderson, 2005).

In sum, many Indigenous communities emphasize attention to nonhuman agency and communication—two principles that anthropologists have argued diverge from the Western focus on humans and psychology. To be sure, there is great diversity among Indigenous communities (Descola, 1996). Yet within this diversity, a common principle of many Indigenous epistemologies is that animals, plants, and other natural forces are agents capable of relating and communicating with others and their environments (Pierotti, 2011). In fact, the widespread salience of these principles across so many native societies has generated important debates about the nature and extent of cultural variability in this cognitive domain.

2.2. Understanding cultural variability in agency concepts

Indigenous ideas about nonhuman agency have figured prominently in theories of cognitive variability across cultures (e.g., Guthrie et al., 1980). Several influential accounts have treated the attribution of agency to nonhuman kinds such as plants as a mistaken inference. Building on the assumption that Western folkpsychology is a universal framework that applies to the proper domain of animates (i.e., humans and animals), these accounts argue that attributing agency to plants represents a "category error" by extending mentalistic attributions beyond the proper intuitive domain (Atran & Norenzayan, 2004; Boyer, 1996). Such "overextensions" imply a conceptual slippage that requires explanation, and scholars have argued that they represent counterintuitive concepts, religious beliefs, or a

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[29] These observations have been theorized under distinct frameworks, including animism, perspectivism, and relational epistemology. There are significant differences among these approaches and among Indigenous communities (e.g., Ramos, 2012). However, while anthropological theories of human-nonhuman interaction are debated, the significance of such interactions in everyday life among Indigenous communities is not (Ramos, 2012, p. 483).

strategy adopted in the absence of knowledge (e.g., mistakenly assuming that plants have minds) (e.g., Barrett, 2000; Boyer, 2003; for similar arguments in the developmental domain, see also Kelemen, 2003). In short, overextension accounts assume that the Western folkpsychological concept of mind is universal and cultures vary in how far they extend the concept to nonhumans, resulting in incorrect inferences.

An alternative approach would be to remain neutral about the epistemological status of agency attributions to nonhumans and instead ask on what conceptual grounds such a framework could support useful inferences. Such inferences would presumably be based on a folktheory that provides a framework for understanding complex behaviors of diverse nonhuman kinds, unlike folkpsychology which (by definition) is not applicable to plants and other non-animals. One possible alternative could take the form of a folktheory of communication where the relevant explanatory constructs revolve around relationships and interactions rather than mental states. By focusing on mental states, Westerners take an anthropocentric stance on the psychological causes of action, presumably using knowledge about the kinds of entities that have a brain or nervous system as a fundamental constraint on folkpsychology. Ngöbe do not share this constraint, which frees them to recognize plant behavior as an instance of agency. A folktheory that uses communicative principles as the basis for inferring agency would provide a framework for viewing both plants and animals (as well as other kinds) as agents actively relating to their environments. By hypothesis, this approach would also encourage a broader stance for observing and expecting complex plant behaviors, specifically forms of interacting and relating. From a folkcommunication perspective, recognition of nonhuman agency need not index a misguided attribution of mind, but could instead represent an empirically grounded observation of agency as it is expressed through relationships.

The ethnographic record suggests that such a folktheory of communication is evident in various Indigenous communities (e.g., Harvey, 2005; Kohn, 2013), and we have found evidence for this among Ngöbe individuals (ojalehto, Medin, & Garcia, 2015). When explaining why they attribute agency to plants and other natural abiotic kinds (e.g., sun, ocean), Ngöbe tend to construe agency as a relational property by referring to observable interactions (e.g., growing toward sunlight) and relationships (e.g., producing seedlings). By contrast, we found that US participants tend to construe agency as a psychological property characterized by unobservable mental states underlying actions. These findings suggest that Ngöbe and US individuals use different conceptual frameworks for interpreting the actions of agents, and the Ngöbe framework might be better characterized in terms of folkcommunication than folkpsychology.

The above study, like prior ethnographic and psychological studies of animism, relied on verbal reports and predicate attributions (e.g., "Can [entity] think?"). Assessing whether Ngöbe frameworks lead to productive inferences requires other measures such as predictive reasoning. To do so we draw on methods by Opfer & Gelman (2001). They tested the development of folkpsychology and folkbiology by asking US children and adults (1) to predict whether different nonhuman kinds (animals, plants, machines, artifacts) could engage in goal-directed actions, and then (2) to judge the psychological capacities of each kind. This design leverages converging measures to highlight the interaction between inferential reasoning (e.g., *predicting* that a plant will engage in communicative behavior) and interpretive frameworks (i.e., *saying* that a plant can communicate). Both forms of evidence are critical for assessing the conceptual commitments underlying nonhuman agency attributions.

3. Current research

The present research investigates whether Ngöbe adults and US college students hold distinct folktheories of agency that invoke different interpretations of and guide distinct inferences about nonhuman agents, specifically plants. Plants are a good test case for several reasons. First, plants exhibit the hallmark action patterns that cue agency perception beginning in infancy (Johnson, 2003), including goal-directedness (e.g. phototropism) and contingent interaction (e.g., using chemical defenses when attacked by insects).[30] Plants are also seen as living kinds on both Western and Indigenous epistemologies, unlike other natural kinds such as the sun or ocean which Ngöbe but not US participants recognize as alive (ojalehto et al., submitted). This provides common ground for recognizing plant movements as cues to autonomous agency, even if Westerners use folkbiology rather than folkpsychology to interpret plant agency (e.g., Opfer & Gelman, 2001).

Second, the nature and development of conceptual knowledge surrounding plants and plant-human interactions has recently emerged as a topic of inquiry in cognitive psychology (Wertz & Wynn, 2014a, 2014b). At the same time, biologists are introducing the question of plant intelligence to psychology (Abramson & Chicas-Mosier, 2016; Cvrčková et al., 2016; Marder, 2012; Trewavas, 2016). Constructs that are central to psychological theories of domain-specific conceptual organization, such as agency or intelligence, are increasingly complicated by the documentation of sophisticated plant behaviors that challenge anthropocentric definitions of those terms.

Finally, plants occupy a contested category in Western science and philosophy (e.g., Hall, 2011). Traditionally, Western scholars have viewed plants as passive objects rather than active agents and favored explanations of plant activity in terms of automatic reactions and mechanistic processes (Hall, 2011; Trewavas, 2002). For instance, Darwin's claim that plant phototropism is an inductive behavior (not a mechanical process) on the part of plants was hotly contested among botanists in the 1800s (see Julius von Weisner (1878) (cf Chamovitz, 2012; Whippo & Hangarter, 2006). Contemporary debates in plant science center on recent findings that demonstrate complex social capacities of plants, including communication and kin resource sharing (Bhatt et al., 2011; Biedrzycki & Bais, 2010; Brenner et al., 2006; Dudley & File, 2007). These findings were unexpected given the prevailing view of plants as having limited capacities. Yet there is now mounting evidence to suggest that basic forms of awareness, memory, and sensory perception are present among plants—indeed, some scientists argue that plant behavior cannot be understood without appealing to these capacities (Chamovitz, 2012; Trewavas, 2002, 2003).[31] Nonetheless, the evidence remains highly debated and some plant scientists flat out reject the possibility of plant sentience (Alpi et al., 2007). It is plausible that these debates are tied to broader cultural conceptions of plants as passive organisms in contrast to sentient animal agents. If so, this would provide indirect evidence to support our hypothesis that interpretative frameworks for agency interact with expectations for actual behavior. On this hypothesis, Ngöbe conceptions of plant capacities may match recent botanical science better than do US college student intuitions. This provides a test bed for observing the role that cultural frameworks play in agency concepts, one that we exploit in the present studies.

The aim of the present research is to explore whether cultural frameworks offer different interpretations for plant capacities and how these frameworks guide predictions for actual plant behavior. Each of our two experiments assessed (a) how people make inferences about behavior (action predictions), and (b) how they interpret that behavior (capacity attributions). These converging measures allow us to test whether conceptual differences go beyond interpretive differences to correlate with distinct inferences about behavioral patterns. We predicted that both groups would predict basic forms of goal-directed action among plants (Exp. 1) but that Ngöbe would be more likely than US participants to predict complex social behaviors among plants (Exp. 2). We also predicted that interpretive frameworks would differ such that Ngöbe would be more likely than US participants to attribute intentional agency

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[30] One obvious difference between plant and animal action patterns is the slower time scale for sessile plants than motile organisms (in most cases). Apprehending plant agency may require close observation.

[31] In this regard, it is interesting that some early psychologists argued for a view of psychology that would be broad enough to encompass sessile forms of agency (Heidelberger, 2004; Johnson, 1945; Lindsay, 1876).

capacities (i.e., those associated with goal-directed behavior in Exp. 1) and social agency capacities (i.e., those associated with social behavior in Exp. 2) to plants.

Our proposal implies that agency predicates (e.g., want, communicate) acquire different meanings depending on one's cultural folktheory of agency. A folk-communicative grounding for agency is supported by our prior experiments as well as anthropological reports. But we will also need to consider an alternative interpretation: one might argue that instead of having a different framework for agency, Ngöbe interpret agency predicates in a psychological sense just as Westerners do but differ by extending them to plants. Alternatively, it may also be argued that Ngöbe have greater ecological expertise than US college students, which informs their knowledge about plant behavior independently of underlying agency concepts. We consider both possibilities further in the general discussion.

3.1. Language

The distinct languages across our cultural samples introduce the possibility of cross-linguistic variation in agency concepts. English is the primary language among US college students. In our Panama research community, most Ngöbe are bilingual in Spanish and Ngöbere, a Chibchan language currently spoken by an estimated 133,000 people in Panama and Costa Rica (Lewis, 2009). A substantial portion of everyday conversation in the community is conducted in Ngöbere, but Spanish is also used frequently and particularly in conversation with non-Ngöbe individuals. With respect to these various languages, one concern is that differences in agency attribution may reflect different semantic mappings for agency terms across English, Spanish, and/or Ngöbere. As an exploratory analysis of potential language effects, we included language as a factor within each cultural group (US: Spanish and English; Panama: Spanish and Ngöbere).

Previous research points to both universals and variability in cross-linguistic constructions of agency. Some researchers have argued that universal semantic primitives underlie basic agency terms (e.g., think, feel, want, know, say) across languages, including Spanish and English (Goddard, 2010). This research has focused on agency terms as they apply to human subjects, however, so it is unclear if these semantic primitives also extend (or not) to nonhuman subjects similarly across languages. Furthermore, subtle linguistic differences surrounding these putatively universal primitives could still have psychological consequences (Goddard, 2003). Additionally, different grammatical constructions of volitional agency in Spanish versus English have been linked to differential memory for accidental agents (Fausey & Boroditsky, 2011; Fausey et al., 2010).[32] These latter findings suggest that language could be a factor in agency attributions.

There is no comparable linguistic work on the semantic mapping of agency terms in Ngöbere (P. Young, personal communication, April 25, 2013), but the basic inventory of mental-state terms in Ngöbere has been documented (Kopesec, 1975; Reid, 1994; Sarsaneda del Cid, 2009). These terms correspond to those used in the current protocol with adjustment for regional dialect. Notably, Ngöbere has a distinct classifier system for the category of living plants, which is uncommon among world languages and underscores the attention paid to the vegetal world in Ngöbe culture (Young, 1986).

4. Methods and study populations

Participants in both two-part experiments were drawn from the same samples of 23 Ngöbe adults (7 female) living in an Indigenous community in Panama and 34 US college students (16 female) attending a private Midwestern university, as described below.

4.1. Panama

Ngöbe population

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[32] To the extent that the effects observed by Fausey et al. might be relevant to the current tasks, they would work against our hypothesis by predicting *less* agency attribution to actors (and specifically non-volitional actors) among Spanish speakers than English speakers.

The Ngöbe people have resided for millennia in what is now Panama. The primary research community is located on a forested island off the Caribbean coast and numbers around 600 people. Here individuals live in a small-scale community and personally interact with ecosystems through a subsistence relationship with the land and sea, including agroforestry, fishing, and diving. Daily life is closely coordinated with the surrounding ecology (Gordon, 1982; Johannessen, 1970). In terms of formal institutions, the local public school offers primary and partial secondary education taught in Spanish based on a westernized curriculum. The community also hosts two Christian churches and an Indigenous nativistic church (Young, 1975).

Ethnographic literature and participant observation indicates that the Ngöbe church teaches Indigenous philosophy and practices and also represents a cultural revitalization movement (Young, 1975). Church meetings are conducted in Ngöbere and many traditional oral histories are maintained in this context (see also Montezuma, 1991; Reid, 1994; Sarsaneda del Cid, 2009). Religious practice includes ecological observances, such as celebrations of lunar events and harvest rituals. Thus, attendance at the Ngöbe Church can be seen as one index of an individual's broader alignment with Ngöbe cultural epistemologies, including ways of knowing, practices, and values.

Ngöbe sample

Ages ranged from 18 to 60 years (*M* = 34.91; *SD* = 12.89). Participants reported 0 to 13 years of formal schooling (*M* = 5.74, *SD* = 3.26). Our sample included 13 self-reported members of the nativistic Ngöbe church, 6 Evangelical church members, and 4 non-churchgoers. Ngöbe adults were recruited through personal visits or word of mouth. Each participant received a small compensation and a donation was made to the community fund for their participation. Community permission and individual informed consent were received.

4.2. United States

US population

US participants were part of a subject pool associated with an introductory psychology class at Northwestern University. Students came from predominantly upper-middle class backgrounds (69%); and students identified as Caucasian (55%), Asian/Asian-American (21%), Black/African-American (5%), Latino/Latina (6%) or other/multiracial (13%).

US sample

Ages ranged from 18-21 years (*M* = 18.8, *SD* = 0.9). With respect to religiosity, a majority of participants reported being at least somewhat religious or spiritual (n = 19) and the remainder reported no religiosity (*n* = 9).[33] US participants also reported their childhood places of residency, either in an urban setting (a city or town) (*n* = 11) or a non-urban setting (a suburb, small town, or countryside) (*n* = 17). Participants completed informed consent and received partial course credit for participating.

4.3. Procedure

In Panama, participants were interviewed in Ngöbere or Spanish by two authors (S.G.G. and b.l.o.). In the US, participants completed a computer-based survey in English or Spanish. These were selected as the most culturally appropriate methods for each context, reflecting typical methods used in small-scale communities and university settings, respectively.

The Spanish protocols were independently forward- and back-translated between English and Spanish by two trained research assistants in the US; before use in Panama, protocols were reviewed for local accuracy by S.G.G. Ngöbere protocol translation was also conducted by S.G.G., who has linguistic expertise in Ngöbere. A second community member trained in research methods reviewed and back-translated critical phrases of the Ngöbere protocol. During Ngöbere interviews in Panama, S.G.G. translated the participant's responses immediately into Spanish. Interview responses were audio-

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[33] Demographic data were available from 28 of the 34 US participants.

recorded and later transcribed and translated from Spanish into English by a trained bilingual research assistant in the US.

5. Experiment 1A: Goal-directed action predictions

Acting toward self-beneficial goals represents a basic survival behavior that is a pervasive, readily observable characteristic of living kinds (Opfer, 2002; Opfer & Gelman, 2001). As such, plant goal-directed behavior should be recognized by both US and Ngöbe informants even if, as we hypothesize in Experiment 1B, it will be interpreted under different frameworks. Therefore, we predicted cultural agreement on action predictions for plant goal-directed agency in Experiment 1A.

5.1. Participants

Participants were 23 Ngöbe (7 females) and 33 US participants (16 females). One additional US participant was excluded due to experimenter error. Gender was not found to have an effect on the primary findings for any experiments. Where gender effects were found for secondary analyses, those are reported in footnotes.

5.2. Materials and methods

Stimuli were colored line drawings of plants, animals, machines, and simple artifacts (three of each kind) from Opfer and Gelman (2001) (see original study for materials). Participants predicted whether each entity would change its current direction of movement in response to the presence of an object, representing either a self-beneficial goal object such as food or sunlight (Benefit Present condition, BP) or a neutral object, such as a rock or picture (Benefit Absent condition, BA). In the BP condition, predicting that the entity would change its direction of movement towards the beneficial object was coded as a goal-directed action prediction (scored as 1). Otherwise, predicting that the entity would not change its direction of movement (toward a neutral object in the BA condition, or at all in the BP condition) was coded as no goal-directed action (scored as 0). Following the original study, the purpose of the BA condition was to provide a control where changes in movement would *not* be systematically predicted, to strengthen the interpretation that predictions for a change in movement for the BP condition are genuinely goal-directed judgments. Stimuli were randomly presented within randomized (US) or counterbalanced (Panama) kind blocks.

Culturally appropriate adjustments were made to select stimuli in Panama to avoid potential confounds related to item familiarity (see Appendix A1). A few modest changes were made part way through the study. We began our interviews with the original indoor potted plant item ($N = 13$) but then replaced it with an outdoor ground vine (conserving the growth movement pattern and goal of sunlight) for subsequent interviews ($N = 10$). Ngöbe do not grow plants indoors, so the vine represented a more familiar context for reasoning about sunlight-directed growth patterns. Where differences are found for the plant item, analyses are reported in footnotes. We also replaced the original novel machine items with three familiar machines to ensure that Ngöbe informants were not reasoning based on inferred special properties of novel machines. There were no differences in action predictions or agency attributions for novel ($N = 10$) versus familiar ($N = 13$) machine stimuli.

5.3 Results

We predicted cultural agreement on predictions for goal-directed action, such that plants and animals, but not machines and artifacts, will be viewed as capable of acting toward self-beneficial goals. There should also be an overall agreement that agents will *not* systematically act toward neutral objects, as this does not represent a case of genuinely goal-directed behavior. Goal-directed action predictions were averaged across the three entities for each kind. Tests were conducted with a 4-factor (kind: animal, plant, machine, other artifact) repeated-measures ANOVA on action predictions, with condition (benefit present versus absent; BP, BA) and culture as between-subjects variables. Interactions were investigated with separate analyses for either kind or condition, as appropriate. Follow-up tests were conducted with Bonferroni corrections.

As expected, there was broad cultural agreement on action predictions. No reliable cultural differences emerged for any individual item or kind (all *ps* > .10) (see Table 1).[34] Both Ngöbe and US participants expected plants and animals to act toward goals more often than machines and simple artifacts, and to do so more when a benefit was present than when it was not. The main effect of kind, $F(3, 156) = 97.42$, $p < .01$, $\eta^2 = .65$, when broken down by specific contrasts, indicated that participants predicted goal-directed actions for animals more than all other kinds ($M = .85$, $SD = .27$), and also predicted more goal-directed action for plants ($M = .61$, $SD = .38$) than machines ($M = .20$, $SD = .32$) or artifacts ($M = .17$, $SD = .25$) (all p's < .05) (machines and simple artifacts did not differ).[35] Additionally, participants were more likely to predict goal-directed actions in the BP condition ($M = .59$, $SD = .16$), than the BA condition ($M = .32$, $SD = .16$), $F(1, 52) = 39.67$, $p < .01$, $\eta^2 = .43$, indicating cross-cultural agreement that self-beneficial (as compared to neutral) objects prompt more goal-directed actions among both plants and animals.

Table 1: Predictions of goal-directed action by culture, kind, and condition

		Ani		Plant		Mach		Artif
Condition / Culture	mals		s		ines		acts	
	ean	*D*	ean	*D*	ean	*D*	ean	*D*
Benefit-Present Condition								
Ngöbe			.82	*.35*	.18	*.40*	.33	*.30*
US	.96	*.11*	.91	*.25*	.37	*.38*	.11	*.26*
Benefit-Absent Condition								
Ngöbe	.72	*.4*	.36	*.22*	.14	*.22*	.17	*.22*
US	.69	*.27*	.29	*.21*	.06	*.13*	.1	*.16*

5.4. Discussion

We expected and found cross-cultural agreement on predictions concerning the kinds of agents that can act toward self-beneficial goals—namely, plants and animals, but not machines or artifacts. We now turn to the critical question of how such action capacities are interpreted.

6. Experiment 1B: Capacity attribution

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[34] Among our Ngöbe sample, differences were found across the two plant stimulus versions (original and culture-specific). Participants were more likely to predict goal-directed action for the culturally familiar ground vine ($M = .80$, $SD = .42$) than the original indoor potted plant ($M = .31$, $SD = .48$) across both BP and BA conditions, $F(1, 19) = 5.16$, $p < .05$, $\eta^2 = .21$. However, this effect held for all three plant items although the indoor/outdoor plant was the only item that differed across versions, so the observed difference cannot be due to the familiar versus unfamiliar item. This finding may instead reflect participant demographics, given that participants in the familiar plant stimulus condition also tended to have less schooling (correlated with stimulus version $r = -.62$, $p < .01$) and were also more likely to be members of the Ngöbe church ($r = .59$, $p < .01$).

[35] Among US participants, females predicted more goal-directed actions for machines ($M = .56$, $SD = .41$) than males ($M = .19$, $SD = .24$) in the BP condition only, $F(3, 87) = 2.97$, $p < .05$, $\eta^2 = .09$. This gender difference was unexpected. Action predictions for the other three kinds did not differ.

After completing Experiment 1A, the same participants judged five agency capacities (see, want, feel, think, feel pain) of each entity (following Opfer & Gelman, 2001).[36] The key question concerns capacity attributions to plants. We predicted that Ngöbe but not US participants would extend capacity attributions (e.g., thinking, feeling pain) to plants as well as animals. By hypothesis, this difference arises because these predicates correspond to two different sets of meanings (communicative or psychological) on the two cultural frameworks for agency. If agency capacities are conceptualized under a folkcommunicative framework focused on interactions with the environment, then capacity attribution profiles should keep plants closer to animals than to inanimate machines and simple artifacts (Ngöbe). If these capacities are conceptualized under a folkpsychological framework focused on having a mind, then plants should be closer to other inanimates than they are to animates (US).

6.1. Materials and methods

Stimuli were the same as in Experiment 1A (including the culture-specific plant and machine items). Participants were asked if each entity could see, want, feel, think, and feel pain (see Appendix A2). Items were blocked by kind in counterbalanced (Panama) or randomized order (US) and capacity probes were presented in counterbalanced order.

6.2. Results

Capacity attributions were averaged across the three entities by kind. To explore cultural differences, attributions were analyzed with a 2 (culture) by 4 (kind) by 5 (capacity) repeated-measures ANOVA. Here we report only the focal cultural contrasts; for full results, see Appendix A3.

As shown in **Error! Reference source not found.**, the critical interaction of culture by kind was significant, $F(3, 162) = 13.09$, $p < .001$, $\eta^2 = .20$. Follow-up comparisons (Bonferroni-corrected) showed that Ngöbe attributed more capacities to plants ($M = .61$, $SD = .33$) than did US participants ($M = .26$, $SD = .20$), $t(32.75) = 4.62$, $p < .001$, $d = 1.61$. Cultural patterns of attribution to artifacts also differed, $t(22.30) = 2.32$, $p < .05$, $d = 0.98$, but not to animals or machines (see Appendix A3).

As is evident from the overall attribution profiles in **Error! Reference source not found.**, both groups differentiated among animals, plants, and artifacts (machines and simple objects), but the distinctions drawn between those categories fell at different points. For Ngöbe, plants possess substantial agency capacities and stand closer to animals than to inanimate artifacts. By contrast, US participants denied almost all capacities to plants, placing them closer to inanimate artifacts than animals.

On the proposed folkcommunication framework, one prediction is that mappings between action predictions and capacity attributions should be nearly one-to-one because the ability to interact may itself be interpreted as communication. If so, we should find that goal-directed action predictions correlate with agency attributions among Ngöbe participants. This was in fact the case for all three non-animal kinds: action predictions and capacity attributions were correlated for plants (*partial* $r = .47$, $p < .05$, df = 20, controlling for BP/BA condition), artifacts (*partial* $r = .49$, $p < .05$. df = 20) and machines (*partial* $r = .43$, $p < .05$, df = 20). In contrast, US individuals should not evidence this same mapping because action is selectively linked to folkpsychological agency attributions, as action is interpreted differently for different kinds according to domain-specific frameworks (physical, biological, or mental). Consistent with this, there were no reliable correlations between action predictions and agency attributions for any kind among US participants. These observations indicate that the mapping from goal-directed action to agency attribution is more direct for Ngöbe than for US participants, in line with the idea that Ngöbe infer agency on the basis of a capacity to interact.

Ngöbe informants also made more capacity attributions across all four kinds than US participants , $F(1, 54) = 15.26$, $p < .001$, $\eta^2 = .22$, and this trend held reliably for every capacity except thinking, *ps* < .05.

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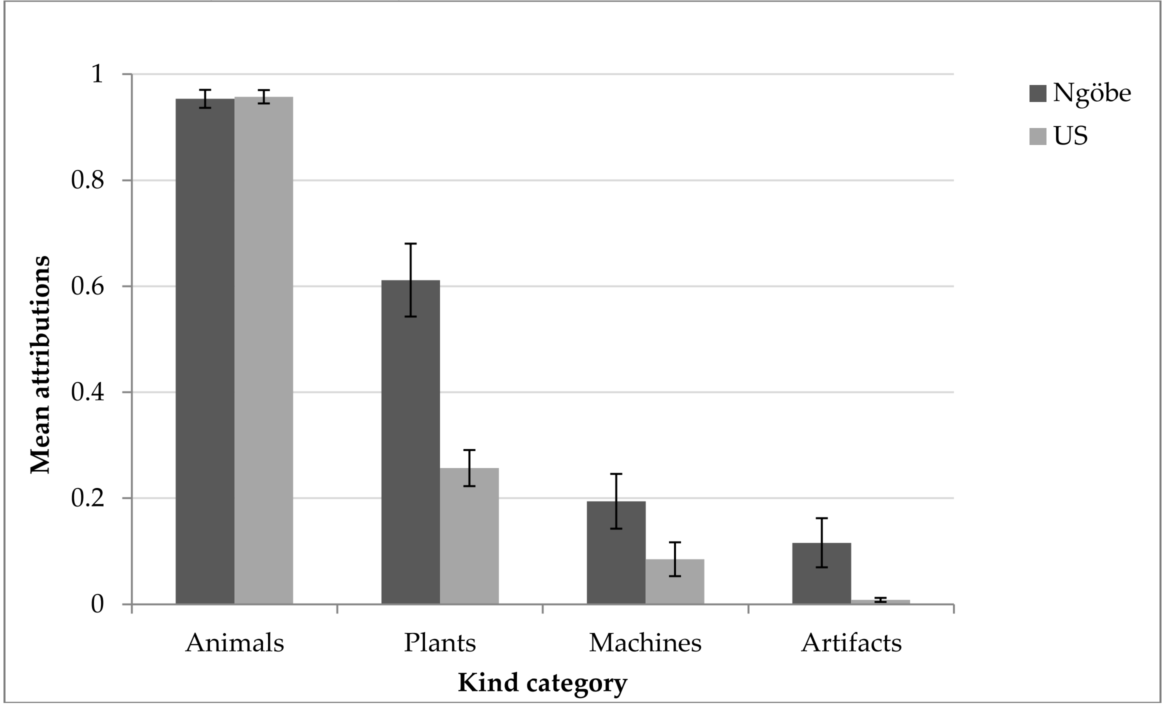
[36] One additional US participant did complete Exp. 1A but was excluded from Exp. 1B due to experimenter error.

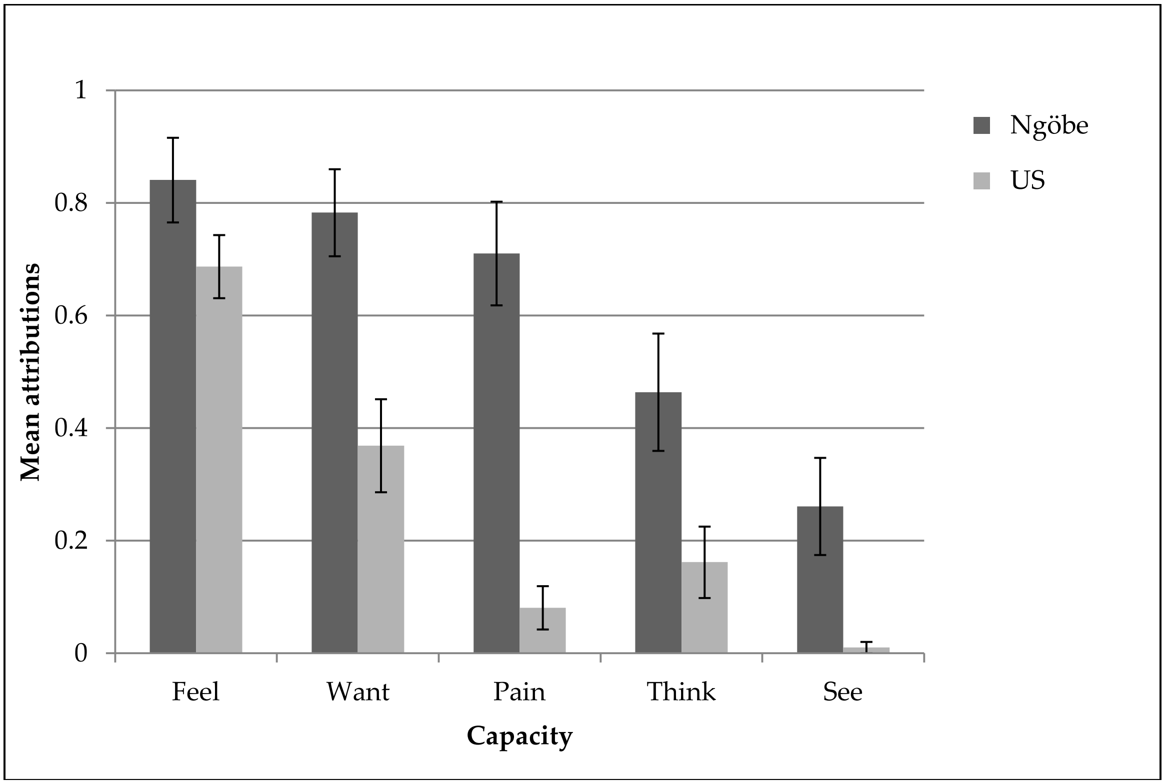
The three-way interaction among culture, capacity, and kind, $F(12, 648) = 4.59$, $p < .001$, $\eta^2 = .08$, indicated that cultural attributions for each kind varied according to specific capacity. To illuminate these patterns, a 2 (culture) by 5 (capacity) repeated-measures ANOVA was performed on attributions for each kind separately; here we report findings for the key test case of plants (see Appendix A3 for other kinds).

Figure 1: Capacity attributions by kind and culture



Plants. As indicated in **Error! Reference source not found.**, Ngöbe were more likely than US participants to attribute every capacity except thinking to plants. Ngöbe endorsed plant capacities for feeling, wanting, and pain at levels well above chance (2-tailed *ps* < .05), while thinking was endorsed slightly above chance (*ns*). In contrast, US attributions dropped off precipitously for every agency capacity except feeling, with wanting endorsed at low levels (*ns*), and pain and thinking strongly rejected (2-tailed *ps* < .01). Notably, Ngöbe were over seven times more likely than US participants to say that plants can experience pain.

Figure 2: Capacity attributions to plants by culture



6.3. Discussion

In Experiment 1B, our key prediction concerning plant agency was borne out: Ngöbe were far more likely than US participants to attribute agency capacities to plants. Not only was this cultural pattern robust across every capacity except thinking (which was still a strong trend), but also the effects were large enough to suggest qualitatively distinct models for plant agency. On the Ngöbe model of agency attribution, plants stand in closer relation to animate agents than they do to inanimate artifacts. In direct contrast, the US model denies most capacities to plants, placing them in closer relation to inanimate objects than to animals.

Interestingly, most participants in both groups agreed that plants can feel, replicating Opfer and Gelman's findings with US college students. It is unclear to what extent this represents a quasi-psychological construal of plants for US participants, or "a metaphor in the biological domain" as Opfer and Gelman suggest (p. 1380). Likewise, both US and Ngöbe participants tended to agree that plants cannot see, evidently interpreting sight as a visual capacity requiring eyes. Presumably, attributions would have been higher for a more neutral probe such as "detect" or "perceive." It may be that the observable relationship between eyes and sight supports cross-culturally shared intuitions about this capacity (see also Meltzoff & Gopnik, 2013). By contrast, the properties (e.g., mind) underlying folkpsychological construals of capacities such as wanting or pain are less observable, and this may contribute to greater cross-cultural divergence in corresponding intuitions. We speculate that "thinking" may have elicited relatively fewer attributions among Ngöbe because it rarely lends itself to expression through an observable relationship such as wanting (e.g., growing toward sunlight) or pain (e.g., producing sap when cut), so could be less relevant to a communicative folk theory.

A limited number of Ngöbe informants also endorsed certain capacities for artifacts and machines, producing small but reliable cultural effects in agency attributions for those two kinds. Though these attributions may suggest a positive response bias for some Ngöbe participants, the effects were not of sufficient magnitude to account for the focal cultural differences in plant agency attributions.

6.4. Experiment 1: Overall discussion

Experiment 1 showed that Ngöbe and US participants both recognize goal-directed action among plants and animals, but the interpretations given to this agency differ across cultures. On the US model, these agency capacities are seen as unique to animals so that plant goal-directed action does not warrant attribution of psychological states. The Ngöbe results, by contrast, indicate that these agency capacities are construed as properties shared to a substantial extent by both plants and animals. By hypothesis, this reflects an alternative interpretive framework: Ngöbe view plant goal-directed action as evidence of a relational capacity for communication. Ngöbe capacity attributions represent a departure from the domain-specific view that plants are denied the intentional capacities typically associated with animals. In Experiment 2 we tested the idea that different frameworks for agency will afford distinct inferences and interpretations in a novel domain of plant behavior—social agency.

7. Experiment 2A: Action predictions for plant social interactions

Experiment 2 focuses on concepts of plant social agency, specifically plant communication and kin altruism.[37] These social capacities were selected because they represent a recent area of Western botanical science where the interpretation of findings is still subject to debate. Not surprisingly given the recentness of these discoveries, plant social interactions are subtle and less directly observable than the self-beneficial goal-directed actions from Experiment 1. Presumably then, plant social interactions are not common knowledge among laypersons. This provides a test bed for assessing how people reason about plant behavior on the basis of intuitive conceptual frameworks rather than simple fact retrieval. We hypothesize that Ngöbe should be more likely than US participants to predict that plants will engage in social behaviors, on the basis of an ecocentric folktheory that provides a lens for observing and expecting complex communicative exchanges among organisms and their environments.

As in Experiment 1, illustrated scenarios were used to assess action predictions (Experiment 2A) and corresponding capacity attributions (Experiment 2B) concerning communication and kin altruism. Unlike Experiment 1, however, we now expected action predictions to differ in addition to capacity attributions.

7.1. Participants

Participants were 17 Ngöbe (5 female) and 30 US (13 female) participants from Experiment 1. Ngöbe samples were smaller than in Experiment 1 because pilot interviews were conducted to refine the protocol (see Appendix C1).

7.2. Materials and methods

Participants were presented with four line drawn sequences of plants engaged in events characteristic of communicative signaling and kin-selective resource sharing (see **Error! Reference source not found.**; complete materials in Appendix C2). For each scenario, participants were told that the plants were connected via roots and asked to predict whether or not one plant would modify its activity in response to another plant. Thus they always chose between two outcomes: either the plants would interact, leading to an adaptive change for one plant, typically the receiver plant (coded as a social interaction prediction, scored as 1); or there would be no interaction between the plants and therefore no adaptive change for either plant (coded as no social interaction prediction, scored as 0).

The two communication scenarios involved root-connected plants signaling in response to drought or an insect plague, prompting an anticipatory adaptive response in the receiving plant (modeled on experimental results reported in Falik et al., 2011; Heil & Karban, 2010) (see **Error!**

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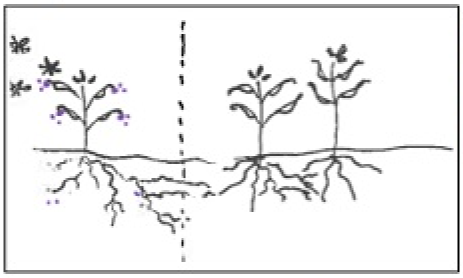
[37] We describe these plant interactions as communication, kin recognition, and kin altruism following the scientific botanical literature (e.g., Bhatt, et al., 2011; Biedrzycki & Bais, 2010; Falik et al., 2011), while recognizing that some readers may prefer leaner terms such as signaling.

Reference source not found.). In each scenario, participants predicted whether or not the receiver plant(s) would already be in a prepared state prior to the arrival of the threatening event. The two kin altruism scenarios involved resource sharing, either between two sibling plants or a mother tree and her seedling (modeled on experimental results and observations reported in Dudley & File, 2007; Simard, 2009; Wilkinson, 1998). In each scenario, participants predicted whether or not the more mature plant would modify its resource consumption such that the less mature plant would benefit. For all four scenarios, the experimental logic was that action predictions would be made on the basis of inferred communication or kin resource sharing, respectively. Analysis of explanations confirmed that most participants did follow this reasoning (see Appendix C3).[38]

In Panama, prediction scenarios were blocked by domain, with kin altruism (mother tree, then sibling plants) appearing before communication (insects, then drought) for half the participants. In the US, the communication block was always presented first (insects, then drought) followed by the kin altruism block (sibling plants, then mother tree).

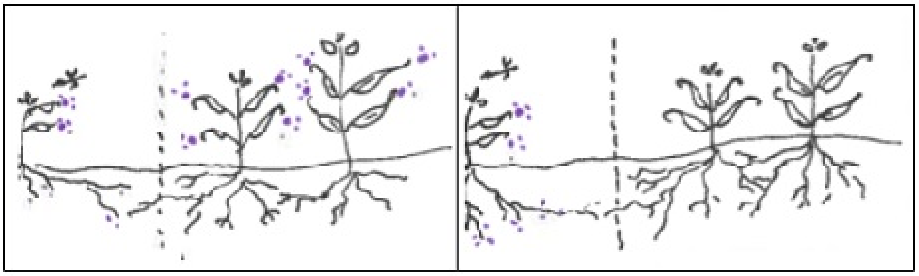
Figure 3: Illustration of prediction scenario for plant interactions

Drought scenario



1a. Here are three plants of the same species. Aboveground, a wall separates the left plant from the two on the right, but the roots are connected. Insects have arrived and are irritating the plant on the left. As a result, the plant has released chemicals to defend itself. The chemical is released through both leaves and roots.

1b. What will happen to the two plants on the other side, after the left plant releases defensive chemicals? (Assume the insects have not arrived on the right side of the wall yet.)



2a. The other two plants will also release chemicals to defend themselves.

2b. The other two plants will remain in the same state as before, without releasing chemicals.

7.3. Results

As indicated in **Error! Reference source not found.**, Ngöbe were more likely than US participants to predict that plants would communicate and share resources with kin. The two prediction scenarios in each domain (communication, kin altruism) were conceptually similar and exhibited similar results (see Appendix C3), so a composite measure was created by averaging across those two predictions

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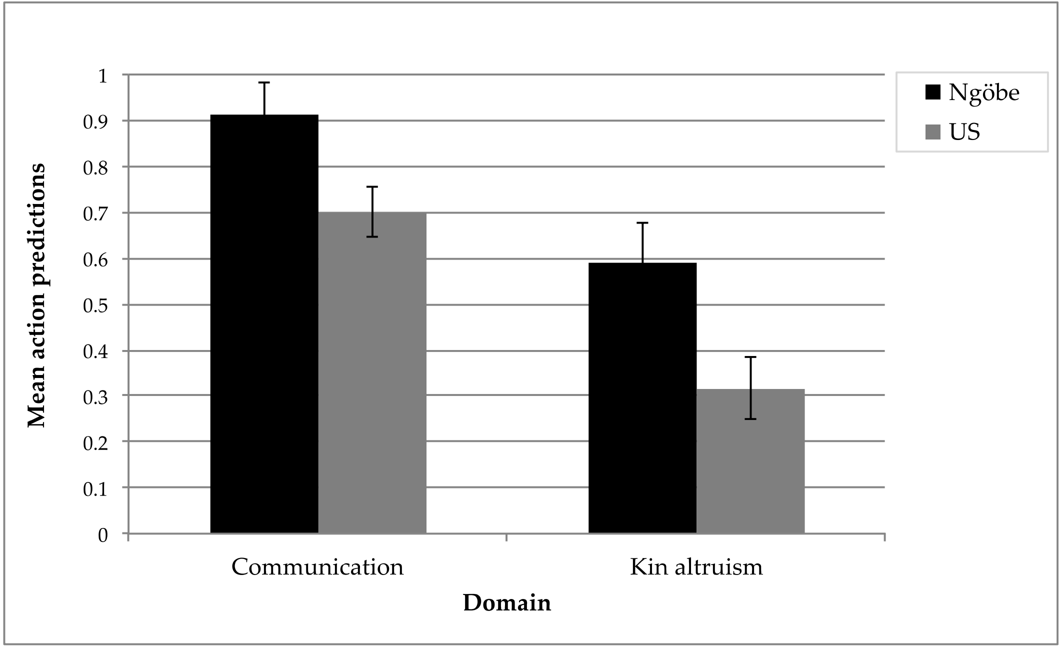
[38] For the drought communication scenario, some participants explained that the connected plant would survive the drought due to water sharing between plants, thus inferring that the interaction involved resource sharing rather than communication. These responses were analyzed in the same manner as other communication predictions as they are consistent with an overall focus on plant social behavior.

for each participant. Instances where participants did not offer a prediction ("don't know" or no opinion) were treated as missing data (2 US participants, 1 Ngöbe participant).

Communication: Ngöbe were reliably more likely to predict that connected plants would be prepared for the arrival of drought or insects ($M = .91$, $SD = .26$) than were US participants ($M = .70$ $SD = .31$), $F(1, 45) = 5.59$, $p < .05$, $\eta^2 = .11$.[39] *Kin altruism:* Ngöbe were reliably more likely to predict that plants would share resources with kin ($M = .59$, $SD = .32$) than US participants ($M = .32$, $SD = .40$), $F(1, 45) = 5.66$, $p < .05$, $\eta^2 = .11$.

Figure 4: Action predictions for plant social interactions by culture



The finding that a majority of both Ngöbe and US participants predicted plant communication raises the question of how such interactions among plants are interpreted. To explore this hypothesis, we analyzed explanations for positive communication predictions (excluding participants who predicted no communication). We predicted that Ngöbe participants would explain plant communication as a genuinely social interaction involving intentional transactions directed toward other plants, whereas US participants would be more likely to see communication as a byproduct of individual survival goals or reductive biological mechanisms.

Each explanation received one of three mutually exclusive codes: (1) social goal, (2) individual goal, or (3) (non-goal-directed) biological and/or physical mechanisms (see coding table in Appendix C4). Explanations that identified a purposive action of one or both individual plant(s) and linked this to a beneficial outcome (e.g., adaptation, survival, growth) were coded as goal-directed. Goal-directed explanations then could fall into one of two categories. An explanation that cited an other-beneficial goal as the cause or purpose of one plant's interaction with another plant was coded as a social goal (e.g., signaling for the receiving plant's benefit; helping or protecting another plant; such as, "They were communicating underground and telling the other tree, they were warning it that it has to save some

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[39] Gender effects were found for kin altruism predictions among US participants, $F(1, 28) = 4.12$, $p = .05$, $\eta^2 = .13$, such that males ($M = .44$, $SD = .43$) were more likely than females to predict kin altruism ($M = .15$, $SD = .32$). There were no reliable effects of gender among Ngöbe participants.

water.”). An explanation that cited self-beneficial goals as the cause of plant interaction was coded as an individual goal. In such cases, the beneficial outcome was facilitated by plant interaction (e.g., root contact), but it was a byproduct rather than the goal of that interaction (e.g., “They sense the chemicals and it’s a natural response to survive”). Explanations that did not identify any goal but instead focused on non-purposive causes of action (biological processes, physics, or generic factors) were coded as mechanistic (e.g., innate reactions, automatic processes, or physical mechanisms, as well as species-level evolutionary mechanisms).

As indicated in Table 2, there were reliable cultural differences in interpretations of plant communication for both scenarios (*Drought:* χ^2 (1, *N* = 36) = 9.24, exact, 2-sided *p* < .01; *Insects:* χ^2 (1, *N* = 37) = 18.60, exact, 2-sided *p* < .01).[40] Ngöbe were far more likely to explain plant communication in terms of social goals (20/31) than individual goals (8/31) or non-intentional mechanisms (3/31). By contrast, US participants rarely explained plant communication as a social interaction (2/42) and instead favored individual goals (20/42), or non-intentional mechanisms (20/42). US respondents in particular often stressed the non-intentional nature of plant activity, as in, “Some sort of chain reaction thing…no thinking, just reactions.”

Table 2: Interpretations of plant communication for each prediction scenario

Scenario / Culture	Social goal	Individual goal	Mechanistic	Total
Drought scenario (*N* = 36)*				
Ngöbe	9 (60%)	3 (20%)	3 (20%)	15
US	1 (5%)	10 (48%)	10 (48%)	21
Insect scenario (*N* = 37)*				
Ngöbe	11 (69%)	5 (31%)	0 (0%)	16
US	1 (5%)	10 (48%)	10 (48%)	21

**N* = number of participants who made a positive action prediction for that scenario (excluding explanations given by participants who predicted no action).

Summary. Experiment 2A revealed cultural differences in inferences about plant social behavior. Ngöbe were more likely than US participants to predict both plant communication and kin altruism. Furthermore, analysis of explanations showed that Ngöbe were more likely to interpret plant communication in terms of social goals, whereas US participants tended to interpret communication as a byproduct of individual survival goals and biological mechanisms. In the next experiment, these cultural beliefs were further investigated with direct probes for capacity attributions concerning plant social agency.

8. Experiment 2B: Capacity attributions for plant social interactions

Experiment 2B involved judgments of four agency capacities linked to plant communication (signaling) and kin altruism (kin recognition, helping, feeling another plant’s pain). We predicted that Ngöbe would be more likely than US participants to attribute these social agency capacities to plants,

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[40] We report the N-1 chi-square test rather than Pearson’s chi-square, because the N-1 is more robust to low expected counts and is recommended for small samples (Campbell, 2007). The linear-by-linear association test generated in SPSS CROSSTABS is equivalent to the N-1 chi-square (Weaver, 2013).

particularly those associated with kin altruism, in keeping with their greater recognition of complex social behaviors among plants.

8.1. Participants

15 Ngöbe (5 female) and 30 US (13 female) participants from Experiment 2A also participated in Experiment 2B.

8.2. Materials and methods

Participants judged whether plants are capable of four capacities: (1) recognizing kin, (2) helping offspring via roots, (3) signaling or communicating, and (4) feeling pain for another injured plant (see full probes in Appendix C4). Each item was presented immediately after the matching illustrated prediction scenario from Experiment 2A (and in the same order) such that Experiments 2A and 2B were interwoven. The pain item was always presented last, accompanied by a photograph of a fallen tree surrounded by other trees.

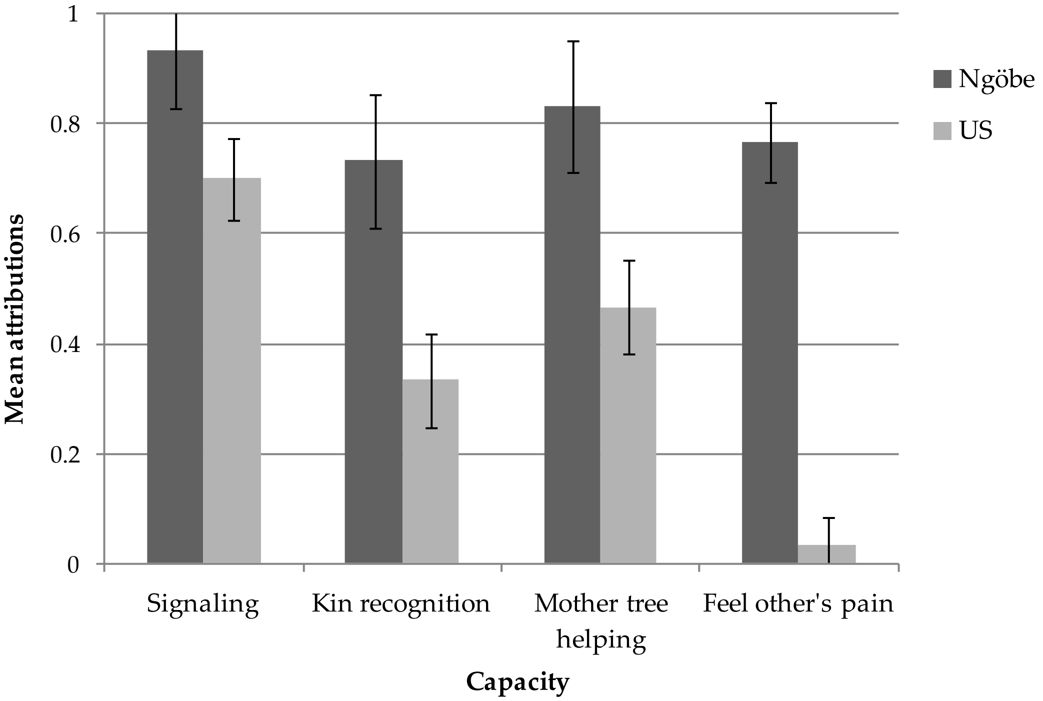
8.3. Results

Capacity attributions were scored as yes or no, excluding "don't know" responses. The data from one Ngöbe participant who provided 2 such responses were excluded from analysis. Attributions were analyzed with a 2 (culture) by 4 (capacity) repeated-measures ANOVA. Only the focal cultural contrasts are reported here; for full results, see Appendix C5.

As indicated in **Error! Reference source not found.**, Ngöbe were more likely than US participants to attribute social agency capacities to plants (Ngöbe $M = .84$, $SD = .27$; US $M = .38$, $SD = .27$), $F(1, 42) = 27.39$, $p < .001$, $\eta^2 = .40$. This was reliable for each capacity individually (Fs (1, 42) = from 6.67 to 68.28, all $ps < .05$), except plant signaling, where the cultural trend was only marginally significant, $F(1, 42) = 2.90$, $p = .10$, $\eta^2 = .07$.

The interaction of culture by capacity, $F(3, 126) = 3.47$, $p < .05$, $\eta^2 = .08$, showed that the extent of divergence between US and Ngöbe attributions differed across particular capacities, with individual social capacity attributions varying more among US than Ngöbe participants. US attributions did not extend to feeling another plant's pain, leading to reliable interaction effects, $F(3, 87) = 16.12$, $p < .001$, $\eta^2 = .36$. In contrast, Ngöbe attributions were uniformly high (all were above chance, $ps < .05$, except kin recognition $p = .07$), and there were no reliable differences in attributions across the four capacities, $F(3, 39) = .07$, *ns* (for pairwise comparisons, all $ps > .99$).

Figure 5: Social capacity attributions to plants by culture



These results provide converging evidence for the key findings from Experiment 2A. Most US and Ngöbe participants agree that plants are capable of communicative signaling, but only Ngöbe are likely to agree that plants also possess capacities linked to kin altruism, including kin recognition, resource sharing, and feeling another plant's pain.

8.4. Experiment 2: Discussion

In Experiment 2, we found converging evidence from action predictions and capacity attributions that Ngöbe are more likely than US individuals to recognize complex social behaviors of plants. In line with recent botanical science, the majority of Ngöbe informants predicted that plants would communicate and share resources with kin. These findings extend the observed cultural differences in capacity attribution from Experiments 1B and 2B by suggesting that different ways of interpreting plant agency carry cognitive consequences for inferential reasoning about actual plant behavior.

9. Language

We conducted exploratory analyses of language differences in the capacity attribution tasks in both Experiments 1B and 2B to assess whether these different predicate assignment patterns reflect cross-linguistic differences among Spanish, English, and Ngöbere. If attribution patterns hold across languages within each of our cultural samples, then this would offer preliminary evidence that cultural differences in capacity attribution do not merely reflect linguistic artifacts.[41]

The US sample included 16 bilingual English-Spanish speakers, of whom 12 completed the study in Spanish and 4 in English (see Appendix B). An additional 18 English speakers rounded out our US English sample (for n = 22). In Panama, all participants spoke Spanish and Ngöbere (most with bilingual fluency levels), so approximately half completed each set of tasks in Ngöbere (n = 13 in Exp. 1; n = 11 in Exp. 2) and the other half in Spanish (n = 10 in Exp. 1; n = 6 in Exp. 2). Language assignment was

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[41] We did not expect that language would affect the action prediction tasks (Experiments 1A and 2A), which rely on predictions of one or another outcome rather than interpretations of particular predicates. Action scenarios intentionally used neutral event descriptions that avoided the critical agency terms in question (i.e., no references to want, kin altruism, communicate, etc.).

sometimes based on considerations of language proficiency; otherwise participants were randomly assigned to a language condition. Language could not be randomly assigned in the US due to the small number of bilingual participants.

Results. There were no reliable language effects of Spanish versus English among US participants, or for Spanish versus Ngöbere among Ngöbe participants. This indicates that the attribution of capacities such as wanting, feeling, or communicating to plants is unlikely to be a linguistic artifact. These results must be interpreted with caution given our modest sample sizes and nonrandomized language assignment. Nonetheless, they provide preliminary evidence that agency attributions are not solely dependent on language for either Ngöbe or US participants.

10. Detecting multiple conceptual models

In this section we consolidate our findings from the above experiments by using cultural consensus modeling to address several critical questions. One outstanding question concerns the nature of conceptual divergence between US and Ngöbe views of agency. One could argue that the cultural mean differences in agency attribution do not decisively demonstrate two distinct conceptual models. For instance, Ngöbe attributions for the various agency capacities in Experiment 1B are not consistently near ceiling for plants as they are for animals, raising the possibility that Ngöbe respondents share the basic animal-oriented model of US participants but are simply more likely to endorse scattered capacities for plants. In other words, the mean differences between US and Ngöbe responses could represent variation from a single (universal) model of agency that is animal-oriented, rather than pointing to a distinct model where agency is equally a property of plants and animals. Another important question concerns the sources of individual variability that contribute to these differences both within and across cultures.

To answer these and related questions, we used a new bottom-up cultural consensus modeling method to identify whether multiple conceptual models of agency are latent in participant responses (collapsing across US and Ngöbe participants), and to explore between- and within-culture variations on these conceptual models. Our modeling is conducted on data from both capacity attributions and action predictions across the two experiments for a comprehensive assessment of agency frameworks. Our first objective was to determine if there are one or more consensus conceptual models present among our respondents. This is an important step beyond the cultural differences reported above because two groups can differ even while one group fails to converge on a consensus model (Le Guen et al., 2013). If more than one consensus is detected this will indicate that multiple models are present. Second, we are interested in the agency attribution profile of each consensus model, which can answer the key question of whether or not there is an alternative model that consistently endorses plant agency on par with animals. Third, we are interested in how participants cluster into the consensus models according to their actual cultural membership and individual characteristics, as well as how individual-level variables may predict competence within each model. This will enrich understanding of across- and within-group variability and point to individual factors that may influence one's conceptual model of plant agency.

10.1. Cultural consensus modeling

Cultural consensus modeling (CCM) (Romney et al., 1986) has been applied extensively in prior cultural research on biological cognition (Atran & Medin, 2008; Medin et al., 2007). Conceptually similar to factor analysis, CCM determines if a single underlying model exists, as well as whether patterns of residual agreement beyond the overall consensus suggest additional models that hold for subgroups in the sample. Each participant is assigned a cultural "competence," where higher scores on a factor loading indicate that an individual's responses are closer to the cultural consensus. CCM also calculates the consensus model "answer key" with a competency weighted consensus rating for each item, providing a more reliable approximation of the common truth than traditional data aggregation techniques (France & Batchelder 2015).

Recent advances in CCM provide a model-based way to derive multicultural consensus from continuous response data (Anders et al., 2014). This new Bayesian inferential approach to consensus modeling (Anders, 2013) offers a key advantage over prior CCM techniques by treating culture as a latent variable and using a bottom-up approach to identifying distinct consensus models and their members (rather than relying on known cultural membership as in traditional CCM methods). This confers a theoretical advantage over statistical models that treat culture as a fixed independent variable, by focusing on conceptual models and allowing cultural membership to remain latent. To emphasize this analytic distinction, we refer henceforth to "conceptual/consensus models" rather than "cultural models." CCTpack also introduces a new response precision parameter to assess whether some items are more difficult than others, unlike traditional CCM methods that assume all items are equally difficult.

10.2. Methods and procedure

Using the CCTpack R software package (Anders, 2013), we applied the Bayesian CCT model to the combined capacity attributions from Experiments 1 (5 individual capacities for each of 4 kinds) and 2 (4 plant social capacities) and action predictions from Experiment 2 only (4 plant social interaction predictions) (total k = 28). Experiment 1 action predictions were not included because they were confounded by experimental condition. The participant-level response data from all US and Ngöbe participants together (*N* = 47) were subjected to cultural consensus modeling for a 47 (participants) X 28 (items) matrix. For clarity, results are presented at the item level for plants but the kind level for the other nonhuman kinds (as in Figure 6).

In CCTpack, two posterior predictive checks are used to compare which model best fits the actual data. 1. To check that the consensus structure of the data is appropriately fit by the model (i.e., the appropriate number of consensuses), a scree plot of eigenvalues assesses the fit between the model-generated estimates and the actual structure of the data (see Anders, 2013 for details). 2. To check whether the item difficulty parameter should be treated as uniform (i.e., homogenous item difficulty) or variable (i.e., heterogeneous item difficulty), a variance dispersion index (VDI) reports how well the model captures differences across items due to response variability; these VDIs are compared and the model with better fit is selected (see Anders et al., 2014).

10.3. Results

10.3.1. Model selection and identification of latent conceptual models

The data were simulated using a series of models with 1, 2, and 3 consensuses, with and without heterogeneous item difficulty.

Item difficulty. The VDI check for item difficulty indicated that a model assuming homogeneous item difficulty fit the data, whereas a model with heterogeneous item difficulty failed to fit the data.[42]

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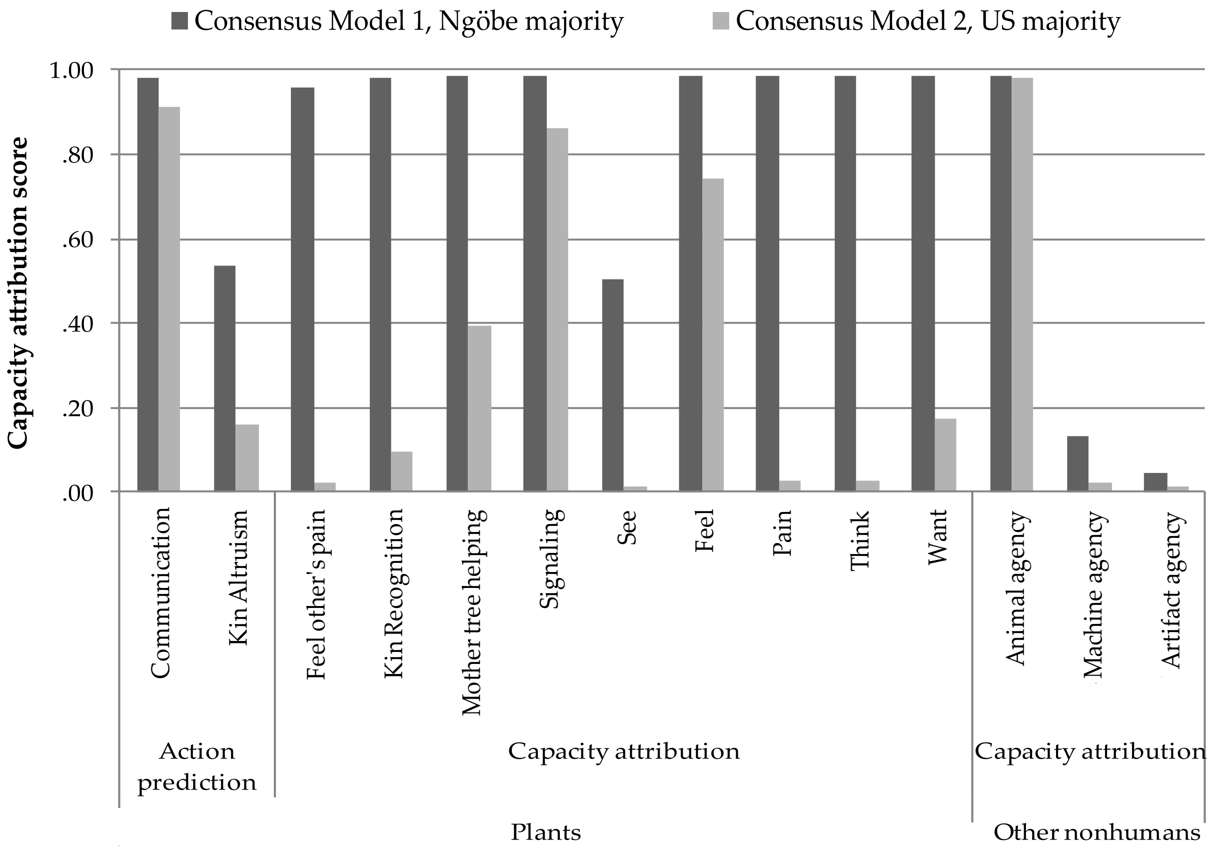
[42] A model that assumed heterogeneous items difficulty was unable to reach convergence of modeling chains for a successful fit to the data (Anders, 2014).

Figure 6. Consensus models for agency of plants and other nonhumans



*Total capacity attributions for other nonhumans are an average of 5 capacities: see, feel, feel pain, think, want

Consensus fit. The scree plots of eigenvalues showed that the first factor was substantially larger than subsequent factors, with a second factor evident but less pronounced. Posterior predictive checks showed that the data structure was well fit by both a one- and two-consensus model, but a three-consensus model failed to fit the data.[43] This suggests an overarching consensus accompanied by two subgroups. The overall consensus was expected due to the substantial agreement on capacity attributions for animals, machines, and artifacts. A two-consensus model would be expected to pick up additional variability concerning plant agency. In the past, we have consistently found a good overall consensus paired with systematic subgroup differences (Medin, et al., 2007). Thus, we selected a two-consensus model with homogeneous item difficulty.

10.3.2. Consensus Models

The model identified two consensuses latent in the agency rank responses (see Figure 6). With respect to the question of whether there are two different models for plant agency, the results are unambiguous. The first consensus model presents a strong and consistent endorsement of the nine plant capacities for social and intentional agency. Indeed, with the exception of seeing, capacity attributions to plants and animals are indistinguishable (at or near ceiling). With respect to action predictions, inferences

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[43] A 3-consensus model was unable to reach convergence of modeling chains (Anders, 2014), indicating that there were no detectable third components and/or too many degrees of freedom.

for kin altruism were lower than would be expected given that the associated capacities (kin recognition, mother tree helping) are strongly endorsed. This indicates that the kin altruism prediction scenarios may have tapped other considerations for these participants (e.g., resource sharing weighed against access to sunlight in the mother tree scenario). The second consensus model presents a highly selective endorsement of plant agency. Beyond a capacity to signal and feel, plants are not viewed as having much agency and are clearly less agentic than animals.

10.3.3. Consensus model membership

Consensus group membership. The model detected and clustered individual participants into the two consensus models in close correspondence with actual cultural membership. Members of the plant-oriented Model 1 were primarily Ngöbe respondents (9 of 11) whereas members of the animal-oriented Model 2 were primarily US respondents (28 of 36). The remaining members of each model were from the other cultural group.

Individual differences in consensus model membership. Ngöbe. The Ngöbe sample exhibited substantial clustering variability (9 clustered with Model 1, 8 with Model 2), which may speak to the presence of multiple models of agency that correlate with particular individual characteristics. Based on prior research, we anticipated that Ngöbe members of the plant-oriented Model 1 would lead more traditional community-based lifestyles than Model 2 members, as indexed by three demographic measures (Indigenous church membership, age, formal schooling). Consistent with our prediction, members of Model 1 were more likely to be members of the Indigenous church, whereas members of Model 2 were more likely to be Evangelical churchgoers or non-attendees, $F(1, 15) = 5.79$, $p = .05$, $\eta^2 = .28$. Model 1 members also tended to have fewer years of formal schooling, $F(1,15) = 3.33$, $p = .09$, $\eta^2 = .18$, and were more likely to be male, $F(1,15) = 3.33$, $p = .09$, $\eta^2 = .18$, but these trends only approached significance.[44]

In addition to individual characteristics, we also checked to see whether any task factors were associated with model membership. Importantly, task language (Ngöbere or Spanish) did not differentiate between members of Model 1 and 2. This provides further evidence that these conceptual models of agency are unlikely to reflect linguistic differences between Spanish and Ngöbere. However, Model 1 members were more likely to be in the culture-specific stimulus version of Experiment 1, $F(1, 15) = 6.48$, $p < .05$, $\eta^2 = .31$. As noted earlier, assignment to this version was incidentally correlated with other demographic factors, so the significance of this finding is unclear.

US. US participants clustered heavily into a single model (28 of 30 with Model 2), which limited analysis of differences between Model 1 versus Model 2 members due to the small sample (Model 1 $n = 2$). Unsurprisingly, we found no reliable differences in model membership by either individual characteristics or task language. On the other hand, it is a notable finding that US members converged so strongly on a single model of agency despite being the larger sample and being drawn from two distinct language samples.

Conceptual differences in cross-model membership. Given that a cultural majority emerged for each consensus model, we were interested in the responses of those individuals who were cross-clustered with the other consensus model (i.e., that of their non-majority culture). The agency attribution profiles of these subgroups could speak to what happens at the boundaries of each conceptual model. All differences reported below were significant at the $p < .05$ level in MANOVA's comparing agency attribution measures across the two models separately for each culture.

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[44] Note that age did not correlate with model membership among Ngöbe, suggesting that age is not a primary factor in these conceptual differences among our Ngöbe sample. This is a useful observation in light of any potential concerns regarding the age differences between our Ngöbe and US samples.

Ngöbe participants who clustered with the US-majority Model 2 ($n = 8$) diverged from their Ngöbe Model 1 counterparts in their lower attributions of agency to plants (on every capacity except mother tree helping), as well as their lower endorsement of machine agency capacities. However, they remained distinct from US members of Model 2 by being more likely to endorse a plant's capacity to feel another tree's pain. Ngöbe and US Model 2 members did not reliably differ on any other measures of plant agency, indicating a fair amount of convergence between this subgroup of Ngöbe participants and the US-majority model.

The two US participants who clustered with the Ngöbe-majority Model 1 differed from their US Model 2 counterparts in their higher endorsement of plant agency (for kin recognition, and all five intentional agency capacities: see, feel, pain, think, want). They remained distinct from Ngöbe members of Model 1, however, by being less likely to endorse plants' capacity to experience pain or feel another tree's pain.

These findings lend additional evidence for multiple models of agency among Ngöbe respondents. The focal model among Ngöbe respondents presents a strong recognition of plant agency, but this is accompanied by pronounced variation towards an animal-oriented model where plant agency is diminished. For their part, the rare US individuals who departed from their group's dominant animal-oriented model of agency moved towards an increased recognition of plant intentional (more so than social) agency.

Individual differences in competence. One unique strength of CCM is that it goes beyond sample means to assess each individual's level of competence on their consensus model, or how well they fit the consensus model to which they were assigned. We next analyzed individual differences associated with these competence scores. Analyses were run separately for Model 1 and Model 2 scores within each cultural group (Ngöbe or US).

For Ngöbe participants, we anticipated that greater competence on the plant-oriented Model 1 would correlate with more traditional community-based lifestyles, whereas competence on the US-majority Model 2 would show the inverse. However, no reliable relationships emerged between competence and lifestyle characteristics for Ngöbe clustered with either Model 2 ($n = 8$) or Model 1 ($n = 9$), likely due to modest sample sizes.

For US participants clustered with the US-majority Model 2, the only individual characteristic that reliably correlated with competence was, unexpectedly, gender, such that males were more competent than females ($r = .54$, $p < .01$). It is unclear why this may be the case.

Further investigation showed that competence among US participants exhibited interesting conceptual patterns. US members' competence on Model 2 was associated with *more* predictions for kin altruism but *fewer* predictions for communication, whereas neither inference task predicted US membership in Model 1 versus Model 2—instead, membership on Model 1 was associated with greater plant agency attributions. This suggests that plant agency concepts break down into separate components that may track different individual characteristics among US participants. We pursued this by exploring individual characteristics associated with plant agency measures among the entire US sample ($n = 30$). Interestingly, religious belief correlated with greater willingness to ascribe agency capacities to plants (specifically, thinking and wanting), $F(1, 25) = 4.65$, $p < .05$, $\eta^2 = .16$, whereas growing up in a nonurban environment correlated with greater predictions for plant social interaction (specifically, communication), $F(1, 25) = 4.16$, $p = .05$, $\eta^2 = .14$. These separate patterns for US religiosity and childhood residence suggest that knowledge of plant behavior may track separately from interpretive frameworks for understanding that behavior.

10.4. Cultural modeling: Discussion

Cultural consensus modeling allowed us to identify whether multiple conceptual models of agency are present among our respondents using a bottom-up modeling approach that treats culture as a latent variable. Two distinct consensuses were detected, confirming that there are two qualitatively distinct conceptual models of agency. One model endorses an animal-oriented view of agency where plants possess a very constrained set of capacities for signaling and sensation (endorsed by the majority of US respondents and nearly half of Ngöbe respondents). But an alternative model also stands, one that takes a decidedly different view where plants possess a robust suite of agency capacities on par with animals (endorsed by a majority of Ngöbe informants and two US respondents). These results provide evidence against the claim that all individuals share a basically animal-oriented model of agency, while also highlighting that multiple conceptual models are available within a given cultural context.

Investigation of the individual characteristics aligned with these models further illuminated the sources of variation underlying diverse conceptual stances. The results suggest that among Ngöbe respondents, the plant-oriented model of agency is supported by engagement with Indigenous cultural epistemologies. Among US individuals, religious belief and nonurban experience were correlated with distinct aspects of plant agency concepts. Religious belief was correlated with greater capacity attributions to plants, whereas nonurban experience correlated with greater predictions for plant social interactions. This suggests that epistemological orientations (e.g., religion) may influence interpretative frameworks for plants while familiarity with the biological world may inform inferences about actual plant behavior.

11. General discussion

11.1. Summary

Across two experiments using mixed methods, we found that Ngöbe were more likely than US individuals to ascribe a wide range of agency capacities to plants and to predict that plants will engage in complex social behaviors. Results from bottom-up modeling revealed that these cultural differences derive from two qualitatively distinct conceptual models of agency rather than variations on a single model. Furthermore, the present findings are unlikely to reflect cross-linguistic differences, as task language affected neither capacity attributions nor consensus models of agency.

Two key conclusions can be drawn from these results. First, the Ngöbe consensus model points to a framework that interprets plant and animal actions on closely corresponding terms. This challenges the domain-specificity claim that plants are universally conceptualized as insentient objects that belong to a different domain than animate agents. Second, the Ngöbe view correlates with insightful inferences about plant social behaviors that have only recently been observed by Western plant scientists (Mancuso & Viola, 2015). This suggests that the Ngöbe perspective on plants as active agents may afford insights into complex plant behaviors that are less accessible on the US view of plants as insentient, passive biological kinds.

Clearly, many Ngöbe informants conceptualize plants as agents in a way that US individuals do not. The critical question is how to understand the conceptual commitments at stake in these observed cultural differences. In what follows, we consider three possible accounts of the present findings in terms of (1) different degrees of ecological expertise, (2) extensions of universal folkpsychology concepts, or (3) culturally variable concepts of agency.

11.2. Ecological expertise

One might argue that Ngöbe inferences for plant social behaviors can be explained by their greater ecological knowledge as compared to US college students, rather than resulting from distinct conceptual frameworks *per se*. Certainly Ngöbe can be expected to have considerable knowledge of plants through their daily interactions with the surrounding forest ecology. However, Ngöbe informants' predictions for plant communication and kin altruism cannot be explained solely by expertise because these specific plant social interactions represent recent discoveries in Western botanical science. If sheer quantity of experience with plants led Ngöbe to observe subtle signaling and kin resource sharing behaviors, then this begs the question of why those insights long eluded Western plant scientists. We suggest that the Ngöbe conceptual framework provides a lens for expecting complex behavior which guides their inferences even in novel situations such as these. Converging evidence that cultural frameworks guide inferences for novel cases of nonhuman behavior comes from another study where we found that Ngöbe are more likely than US individuals to accurately infer cooperation between two animal predators that are unfamiliar to them (ojalehto, Medin, Horton, et al., 2015).

It is important to ask how ecological expertise and concepts of nonhuman agency may interact, but the answer is unlikely to be as simple as expertise versus conceptions. We see interpretative frameworks for plant agency (whether encoded in folktheories or scientific theories) as important conceptual devices for organizing knowledge and integrating new information (Hall, 2011; Narby, 2006), as well as guiding inference and explanation (Keller, 1983; Medin & Bang, 2014). From this perspective, conceptual frameworks necessarily involve feedback with many forms of cultural experience including ecological knowledge. It is informative to consider how Western scientists have brought their own intuitions to the study of plant behavior. For instance, initial findings for plant kin recognition were met with skepticism among plant scientists and some even declared (dubiously) that it would be "extraordinary" if the early claims could actually be substantiated (Klemens, 2008, p. 67). Those claims have since been substantiated to the satisfaction of many in the field (Bhatt, et al., 2011; Biedrzycki & Bais, 2010). Yet the initial skepticism serves to highlight how even experts' inferences concerning plant behavior may reflect prior assumptions—ecological expertise is not independent of cultural intuitions. Our results serve as a critical first proof that those cultural intuitions do differ.

Our findings align with broader interdisciplinary research programs demonstrating that Indigenous perspectives contribute novel insights into biological and ecological structure (Anderson, 2012; FORMABIAP, 2008; Narby, 2006; Pierotti, 2011; Pitman et al., 2011; Waldstein & Adams, 2006). Such observations and our own results raise important questions concerning the interactions between ecological expertise and cultural epistemologies as they relate to concepts of nonhuman agency and environmental cognition more broadly (e.g., ojalehto, et al., 2015; ojalehto et al., 2013). With cultural differences now established by the present experiments, further work may begin exploring how varying levels of expertise within each cultural context may (or may not) influence conceptions of natural agents.

11.3. Folkpsychology

Our results could be interpreted as showing that Ngöbe overextend a folkpsychological concept of mind to plants (e.g., Atran & Norenzayan, 2004; Barrett, 2000; Boyer, 1996, 2003). This overextension account would rest on the assumption that Western folkpsychology is a universal conceptual framework whose proper domain is restricted to animate agents, defined as humans and animals (e.g., Sperber & Hirschfeld, 2004; Wellman & Gelman, 1992). On this perspective, Ngöbe are incorrectly inferring human-like mental states on the part of plants. If the current results are interpreted in this way two questions follow. First, if the Ngöbe conception of plant agency affords useful insights into plant behavior then is it appropriate to characterize it summarily as a mistaken inference? Related to this, we must also consider why the US folkpsychological stance leads to the misguided rejection of actual plant capacities for social behavior.

Considering these questions, we propose that US attitudes about plants may be interpreted as an under-extension of agency concepts that are constrained by cultural beliefs about brains and nervous systems (for related points, see Marder, 2012; Marder, 2013). The idea that anthropocentric folkpsychology represents a selective narrowing of the agency domain would be consistent with several lines of evidence. First, based on infancy studies, it has been suggested that the extension of the concept "agent" is defined by principles of interaction (e.g., goal-directedness) and has no proper ontological domain (Gergely & Csibra, 2003; see also Lowder & Gordon, 2015). This has led some to propose that the core representational system for agency actually has no proper intuitive ontological domain: "Our tendency to apply psychological explanations to non-human phenomena…may not be due to an overextension of an (originally more restricted) psychological interpretational framework," but may instead reflect the proper application of a teleological stance (Csibra et al., 1999, p. 265). (We agree but hasten to add that a psychological framework need not be the only possible one for understanding teleological action.) Given that plants exhibit the critical cues for agency perception (e.g., goal-directedness, contingent interaction), they would also fall within the proper application of this teleological stance.

Furthermore, the evidence suggests that culture plays a role in acquiring an anthropocentric folkpsychology constrained to humans and animals. A large body of work in developmental psychology indicates that infants possess a core representational system for agency online by the end of the first year of life (Bíró & Leslie, 2007; Csibra & Gergely, 2013; Johnson, 2003; Johnson et al., 2007; Woodward, 2013). However, this is a skeletal representation system and it is only later on that children develop a rich conceptual framework for agency that includes causal principles tied to minds and mental states, where behavior is understood on folkpsychological terms (Johnson, 2000; Wellman, 2010). For US children, learning that psychological properties should *not* be extended to all actors who exhibit goal-directed behavior (such as plants or other inanimate nonhuman kinds) but rather selectively applied to humans and other animals requires extended learning into the grade school years (Opfer, 2002). This indicates that the exclusion of plants from the domain of agency may be a culturally acquired stance.

In short, the developmental evidence is consistent with the possibility that anthropocentric folkpsychology represents a culturally acquired lens on agency that narrows the domain to animates on the basis of a human prototype. The corresponding folkpsychological notions of minds and mental states may reflect a cultural model among Western researchers and participants (for similar conclusions in related domains, see Medin et al., 2015). This raises the possibility that the infant's representational system for agency—while widely seen as a precursor to folkpsychology among Western samples—may serve as a precursor to alternative folktheories of agency in other cultures. This is especially plausible when we consider that capacities which cue agency detection (goal-directed motion, contingent interaction) are not exclusive to entities with human-like brains but are also carried out by plants and other organisms (Chamovitz, 2012; Marder, 2012; Uexküll, 2010). Yet by focusing on the specifically psychological aspect of agency as it is assumed on Western folktheories, researchers have rarely considered the possibility that cultural folktheories of agency may be organized around other, non-psychological concepts (for a notable exception in the domain of folksociology, see Hirschfeld, 2006; Hirschfeld, 2013). Considering this possibility allows alternative accounts to be offered.

11.4. Folkcommunication

It is possible that the current findings point to a distinctive conceptual framework for agency that is available to Ngöbe informants. Specifically, we have argued that Ngöbe endorsements of plant agency can be understood in terms of folkcommunication, where the capacity for relational interaction is the grounds for inferring agency. This framework would properly apply to diverse actors including (at least) plants and animals. This account locates cultural variation at the level of conceptual organization of folktheories rather than in variable extensions of universal folkpsychological concepts.

Folkcommunication is at least as compatible with the data as an explanation based on overextensions of folkpsychology. Furthermore, folkcommunication carries the advantage that it makes fewer assumptions about mental-state concepts presumably held by Ngöbe, and avoids the explanatory paradox of why Ngöbe would consistently make "category errors" concerning plants despite having considerable ecological experience. On folkcommunication, plant agency attributions are seen as an empirically grounded recognition of communicative exchanges among diverse natural kinds.

We propose that folkpsychology and folkcommunication, while likely deriving from a common early-developing cognitive system for detecting agency (Csibra, et al., 1999; Johnson, 2003), follow distinctive meaning-making principles that ultimately lead to different domains. This need not imply that the two folktheories are mutually exclusive, such that US individuals have no access to folkcommunication, for instance. Indeed, our cultural consensus modeling results show that both models are present in the Ngöbe context and possibly in the US context as well. We speculate that either conceptual framework may be cultivated to a differing degree in various contexts. Even within a single individual, these folktheories could represent interpretive stances that focus on distinct properties of agency. On folkcommunication, the focus is on relational interactions as the primary quality of agency, and mental states may play a secondary role if any in agency judgments. By contrast, the folkpsychological lens trains attention to mental states as the primary property of agency and if communication figures in this model, it may be seen as a derivative property of the mental (Dennett & Haugeland, 1987).

Our account is roundly consistent with evidence from related domains to suggest that Western anthropocentrism leads to patterns of reasoning that differ from a more ecological orientation among Indigenous communities (Atran et al., 2005; Bang et al., 2007; ojalehto, et al., 2013; Waxman & Medin, 2007), and resonates with other research proposing that broad framework principles in the folkpsychological domain may recruit different bodies of socially learned knowledge across cultures (Meltzoff & Gopnik, 2013, see also Gelman, 2009). It is also well supported by a growing body of anthropological evidence on Indigenous folktheories of communication in ecosystems (see especially Kohn, 2013, 2015).

The current experiments are an initial foray and many questions remain. To date, folkpsychology has been virtually the only framework in town for thinking about agency, so it requires future work to clarify the inferential principles and explanatory constructs at work in folkcommunication. One line of investigation could target cultural differences in attributions of predicates and inferences that might distinguish between folkpsychology (e.g., internal individual states) and folkcommunication (e.g., interactive relational states). Cultural diversity may arise from differences in the relative salience given to these conceptual nodes and their extension to different classes of agents (e.g., plants, abiotic kinds, social groups, artificial intelligence).

12. Conclusion

Our research project sought to explore variability in concepts of nonhuman agency, specifically plant agency, and to generate new forms of evidence that can speak to the conceptual commitments at stake in animism. The experimental results show substantial cultural variation in concepts of plant agency and demonstrate that the Ngöbe perspective affords sophisticated insights into plant behavior. Our converging methods extend prior work by observing systematic differences in nonhuman agency attributions across cultures, establishing that these cultural differences extend to inferential reasoning, and showing that these cultural patterns arise from two distinct conceptual models of agency rather than variations on a single universal model. The differences observed between US and Ngöbe informants may arise from different extensions of a common folkpsychology, or from a distinctive theory of folkcommunication among Ngöbe informants. The present results are suggestive of the latter possibility but it remains for future research to disentangle these accounts.

At the very least, these findings raise the possibility that domain-specific conceptual knowledge may be organized in ways that are culturally variable. The anthropocentric stance on folkpsychology as the key organizing framework for agency may be a feature of Western cultural epistemologies rather than a universal cognitive principle. As an alternative, folkcommunication offers an ecologically oriented lens for attending to complex forms of interaction among nonhuman agents. The Ngöbe perspective serves as an invitation to revisit the widespread assumption among Western researchers that mentalistic folkpsychology is the universal intuitive prototype for agency—and that plants belong outside this domain. Pursuing the invitation to reconsider anthropocentric views of agency could advance cognitive theory while expanding Western understandings of nonhuman actors. The question of how humans conceptualize nonhuman beings in their ecological communities has never been more relevant than it is today.

Cognition beyond the human: cognitive psychology and the new animism

1. Introduction

Human life is caught up in the question of how to understand and relate with other beings. Navigating our ecological web of relations crucially involves inferences about the capacity of nonhumans to relate in, with, and towards their environments. Members of many Indigenous communities attend closely to the ways in which nonhuman kinds like plants, minerals, and ecological forces perceive, respond, and communicate with others (Hallowell, 1960; Harvey, 2005; Kohn, 2013). Within many Western communities, however, these nonhumans are regarded as passive natural kinds lacking agency. Investigating how these disparate stances on nonhuman kinds relate to cognitive systems, cultural worldviews, and engagement with nature is a long-standing concern across the cognitive sciences. Today, these questions are no longer theoretical. They carry urgent practical weight in the context of the global ecological crisis in which ecosystems are under tremendous stress as a result of Western industrialized ways of interacting with the rest of nature (Kahn, et al., 2010; Kidner, 2012; Mace, 2014). Our goal in this piece is to outline how cognitive psychology can contribute these inquiries by taking seriously the anthropological invitation to explore agency beyond the human.

We ground our approach in the new animism that insists that Indigenous views of nonhuman agency be taken seriously as modes of relating with the living world (Harvey 2005). Following Harvey, we use the term animism to refer to the recognition that “the world is full of persons, only some of whom are human, and that life is always lived in relationship with others” (Harvey, 2005, p. xi). Such lifeways often reflect broader cultural orientations known as relational epistemologies or relational ontologies (Medin et al., 2013). Here, we refer specifically to animism to highlight our concern with questions of nonhuman agency. Scholars of the new animism articulate how Indigenous engagement with nonhumans challenges Western ideas about nature-culture boundaries and offer conceptual tools for transforming fraught relationships between humans and their environments. Defining theories of this movement include perspectivism (Viveiros de Castro, 1998), relational epistemology (Bird-David, 1999), and the “anthropology beyond the human” (Kohn, 2013), among others. Such theories reflect a broader “turn to ontology” (Kohn, 2015) in anthropology that subverts the traditional Western distinction between human and nonhuman and attendant binaries such as culture and nature (Descola & Pálsson, 1996), subject and object (Viveiros de Castro, 2004), knowing and being (Ingold, 2010), and language and nonlanguage (Kohn, 2013). Fundamentally, all these theories can be seen as responses to the global ecological crisis and the need to transform human-nature relations (Kohn, 2015).

We explore the grounds for and consequences of one Indigenous animist perspective through a cognitive psychological lens. Animism is of interest to both anthropology and psychology and has generated fertile research programs in both disciplines. Yet the two bodies of scholarship rarely speak to one another (Beller et al., 2012; Seligman & Brown, 2010). If the common goal of social and behavioral sciences is to “identify and understand the range of human potential in forms of interaction with physical, biological and social environments” (Medin, in press), then there is much to gain from interdisciplinary collaboration to identify and potentiate new forms of human-environment interaction. Given the scope and urgency of our ecological crisis (UNEP, 2016), interdisciplinary collaboration is imperative. Our research combines anthropological theory with empirical cognitive psychology to investigate the conceptual commitments at stake in distinctive orientations to nonhuman agency. Based on long-term research with Indigenous Ngöbe partner communities, we argue that cultural differences in concepts of nonhuman agency reflect distinctive organization of social and ecological domains and trace how this relates to reasoning about ecological interactions and human-environment systems.

Our analytical lens for understanding the animacy of nonhuman beings is the concept of agency. We use a cognitive definition for the attribution of agency which entails the recognition that an entity can act and react. On this definition it is a shared property of entities that move, live, and think. But depending on one's perspective, not all moving things are necessarily alive (e.g., clouds), nor are all living things necessarily conscious (e.g., bacteria). In our research we investigate how these categories of agency are organized differently across cultural systems. Consequently we use the term agency rather than (potentially related) terms such as self, personhood, mind, or spirit. In our work it is important to distinguish between inferring that an entity can act in a particular way and the ontological properties (e.g., mind, self, biology) that are believed to underlie those actions. These ontological intuitions are precisely the terrain in which cultures may interpose distinctive concepts of human and nonhuman agents, which often results in ambiguity surrounding conventional ontological categories. For instance, the ontological boundaries of life and consciousness are contested issues in Western science and philosophy (Helmreich, 2009; Trewavas, 2016). This ambiguity provides space to exploit existing knowledge structures for new perspectives on what it means to relate with nonhuman agents.

We adopt a systems-level approach to understanding culture and concepts as interacting elements of a complex system and employ epistemological orientations as a framework for understanding how cultures organize knowledge, values, and behavior. Epistemological orientations refer to decisions, processes and practices that determine what is worthy of attention and in need of explanation, as well as the kinds of hypothesis that are likely to be considered and notions of what constitutes a good explanation. Taking a systems approach places us in the company of many anthropologists who define cultural phenomena in terms of circular, reciprocal, and coconstitutive processes. For instance, Kohn (2015) designates as "cultural" a system "in which relata are produced by and contribute to the system through which they relate—a system that achieves a kind of closure, totality, and separation by virtue of this special kind of relationality" (p. 314). Yet if the system achieves a kind of closure that separates it from other cultures, it also remains open to interaction—and the coordination of multiple perspectives within and between cultures is a topic of special interest that we address below.

In this article, the terms "Western" and "Indigenous" are used to refer to evolving and distributed but recognizable cultural orientations. The term Western refers to individuals (including researchers) who are members of urban, technologically dependent populations.[45] In our studies, this predominantly includes US college students but also European American foreign residents of Panama. Clearly, these samples represent diverse social identities and residences (e.g., urban, town, rural resorts), but they share in common Western post-industrial lifestyles, which have been shown to be an important factor in environmental knowledge and action (Shenton et al., 2011; Wolff et al., 1999). We use "Indigenous" to refer to cultural groups that identify as native to a land, focusing on native communities of the Americas. In the current studies, the Ngöbe community of Panama is the Indigenous study population. Ngöbe individuals live in a small-scale community where people personally interact with ecological systems on a daily basis, in contrast to the lifestyles of our Western samples. Just as Indigenous cultures are extremely diverse (Ramos, 2012), so too are Ngöbe individuals diverse in their life experiences, and investigating within-culture variation is one focus of this research.

The empirical research reported below involves long-term partnership with a Ngöbe community of Panama. The primary researcher, b.o., began fieldwork in the community in 2010 and has since spent

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[45] The Western cultural orientation can also be understood as "modernist" in the sense that Bird-David (1999) uses the term: "'modernist' signals neither the dichotomous opposite of 'primitive' nor the equivalent of 'scientific' but ideas and practices that dominated the Euro-American cultural landscape from the 17th to the 20th century" (p. S68).

more than 24 cumulative months living in and participating with the community. The Ngöbe people have resided for millennia in what is now Panama. The primary research community is located on a forested island off the Caribbean coast and numbers around 600 people. Here individuals live in a small-scale community and personally interact with the ecology through a subsistence relationship to the land and sea that includes agroforestry, fishing, and diving. Consequently, daily life is closely coordinated with the surrounding ecology (Gordon, 1982; Johannessen, 1970). In terms of formal infrastructure, the community hosts a local public school offering primary and partial secondary education taught in Spanish. The community also hosts two Christian churches and an Indigenous nativistic church. Ethnographic literature and participant observation indicates that the Ngöbe church teaches Indigenous philosophy and practices, and also represents a cultural and linguistic revitalization movement (Young, 1975).

2. Animist ontologies: Two disciplinary perspectives

Ontological anthropology

The move from the old to new animism can be told in large part as a shift from human-centered to ecology-centered perspectives. The old animism contended that Indigenous conceptions of nonhuman agents were misguided attributions of agency to nonhumans (see review in Harvey, 2005). Working from the analytic terms of their own cultural epistemologies, these anthropologists defined agency from a human reference point (a stance that is explicit in claims of anthropomorphism, e.g., Guthrie, 1980). Phenomena such as perception or communication were interpreted as psychological properties or qualities otherwise exclusive to humans (e.g., soul, human embodiment). On this basis, scholars of the old animism concluded that Indigenous attributions of agency to nonhumans were empirically unfounded and required explanation as a religious belief or category error.

Interwoven movements under the new animism and ontological anthropology have reconfigured the terms of analysis by establishing that animism is not a "failed epistemology" (Bird-David, 1999) or a "mistaken belief in an animated nature" (Kohn, 2015, p. 317) but a view that includes nonhumans in social relations and consequently cannot be theorized in terms of Western concepts of human-centered agency and a human-nature divide. In their concern for nonhuman beings, Indigenous animisms require us to abandon the human reference point and ask what it would mean to recognize and relate with nonhuman beings as agentive. Compared to Western epistemologies, Indigenous views reorganize the boundaries of nature itself and arrive at an ecology-centered view of agency.

An incisive analysis of how the Western human-centered stance on agency is uprooted and expanded by an ecology-centered stance comes through Eduardo Kohn's "anthropology beyond the human" (2013). Kohn's starting point is to acknowledge that the capacity to perceive and represent the world is not exclusively human but common to all life forms. Drawing on biological and systems science (notably Terrence Deacon, Charles Pierce, and Gregory Bateson), Kohn characterizes this shared representational capacity as a semiotic process whereby an organism uses signs to represent things in the world to itself. Semiosis can occur through multiple sign modes including indexical, iconic, and symbolic. Nonhumans do not use linguistic symbols but they do engage in sophisticated interactions with one another and their environments by means of iconic and indexical communication. In this sense, nonhumans inhabit a world that includes meaning and values just as do human worlds (see also Kauffman, 2008). However, Kohn argues that these ecological forms of meaning are rendered invisible by Western epistemologies that assume the only meaningful forms of representation are those specific to humans (i.e., symbolic representation).

Unlike Westerners, the Runa of Ecuador's Upper Amazon appreciate and work with the full range of semiotic interactions among natural kinds rather than being constrained to linguistic signs. Through close and sustained ethnography, Kohn develops his argument that the Runa see their environment as an "ecology of selves" teeming with diverse nonhuman subjects who are constantly sending, receiving, and interpreting signs (Kohn, 2013). This is not to deny that differences exist. Kohn argues that the Runa do attend to distinctions among different (and hierarchical) modes of communication among and between species, but acts of meaning exist on a continuum rather than dropping off an ontological divide between human intentionality and an unintentional "nature." The Runa perspective resists any fundamental separation between humans and nonhumans and engenders an experience of ecologies as social communities. There is a vital reciprocity in human relations with nonhuman beings. Not only are nonhumans agents who intentionally respond to their environments and others (including us) but they are also agents to whom we must respond. Working from this paradigm allows us to join the Amazonian Runa in their endeavor to understand "how humans communicate with a host of nonhuman beings in a world that is itself communicative but not symbolic or linguistic" (Kohn 2015, p. 314). Kohn argues that we can take up this perspective so that, like the Runa, "we too may learn another way to attend and respond to the many lives of those selves" that people ecologies (2013, p. 25).

Kohn's compelling conceptual move is to call out the peculiarly human-centric notion of representation that blinds Western epistemologies to meaningful forms of ecological interaction, in order to invite a broader perspective on empirically robust forms of communicative agency exercised by nonhumans. This semiotic analysis amplifies the observation that animism is not an "empirically unfounded" belief but rather a system of observation that invites Westerners (including researchers) to take a new perspective on what it means to be an agent capable of responding to the world (see also Bird-David, 1999). Using the terms of ontological anthropology, the animist approach offers a lens onto general properties of reality that is just as compelling as the Western approach—or perhaps more so, if our goal is to develop new ways of relating to our ecosystems. This stance forms the basis for the hypotheses we test in our cognitive research.

Cognitive psychology and intuitive ontologies

Cognitive psychologists approach the study of ontology through the notion of intuitive ontologies. Intuitive ontologies are thought to be fundamental, untutored ways of organizing knowledge about the world according to domains (Hirschfeld & Gelman, 1994; Wellman & Gelman, 1992). The proposal is that these intuitive cognitive domains "carve nature at its joints," enabling learning and thought to be guided by domain-specific cognitive processes that automatically discriminate between, say, an inert physical object and an animate agent. Specifically, researchers have outlined three intuitive ontological domains and corresponding conceptual frameworks for understanding the entities and causal forces belonging to those domains: folkpsychology, folkbiology, and folkphysics. On this account, the actions of animate agents like humans or other animals are explained in terms of mental states like beliefs and desires—a conceptual framework known as folkpsychology (e.g, Erickson, et al., 2010). By contrast, it is proposed that the actions of other kinds of actors like plants or clouds are explained by appeal to non-intentional biological processes (folkbiology) or physical forces (folkphysics). For instance, people would activate different folktheories to interpret what causes movement toward the sun by a cloud versus a plant (folkphysics versus folkbiology), and both would be interpreted differently from what causes a person to move toward the sun (folkpsychology) (Gutheil, et al., 1998; Opfer & Gelman, 2001; Opfer & Siegler, 2004). This domain-specific epistemology, then, presents a worldview in which entities in the natural world can be adequately described in terms of physical and biological causes without recourse to intentionality or sociality—properties that are considered exclusive to humans and perhaps some other animals. We could argue that this is a culturally constructed anthropocentric model of psychological agency that may extend agency to some "higher level" animals such as mammals, but excludes entities such as plants, minerals, or celestial bodies that do not share similar forms of agency to humans (see also Waxman & Medin, 2007).

This domain-specific account is widely regarded as a universal feature of cognition (Sperber & Hirschfeld, 2004). However, this particular delineation of intuitive ontological domains has been formulated by Western psychologists and most of the evidence in support of it (especially biology versus psychology) has come from Western study populations (Carey, 2009; Gutheil, et al., 1998; Keil, 1995; Opfer, 2002; Opfer & Gelman, 2001), as well as some industrialized Eastern cultures (Hatano & Inagaki, 1994; Inagaki & Hatano, 2004). By selectively attending to those kinds of agency unique to humans, folkpsychology adopts an anthropocentric perspective that focuses heavily on propositional mental representations made available by language (Kohn, 2013). Important questions of nonhuman agency are largely rendered invisible on a perspective where humans are the prototypical agents. The Western domain-specific view neglects to conceptualize how other forms of life experience perceive, respond, and relate to their worlds. By contrast, individuals practicing animist epistemologies have systematically investigated how humans live together with, represent, and are represented by other life forms (Kohn, 2013). Ethnography with Indigenous communities provides ample evidence to suggest that the Western anthropocentric folkpsychology is culture specific, motivating investigation into an alternative conceptual framework for agency "beyond the human" (Bateson, 2000; Bird-David, 1999; Bird-David & Naveh, 2008; Harvey, 2005; Ingold, 2006, 2011; Kohn, 2007, 2013; Pierotti, 2010; Santos-Granero, 2012).

We propose that alternative partitionings of intuitive ontological domains may provide a better match for conceptual patterns in different cultures (ojalehto & Medin, 2015a). Building on the anthropology of animism (especially Kohn), we argue that folkcommunication is more apt than folkpsychology in the Ngöbe communities where we work, and possibly other Indigenous communities. Under folkcommunication, we posit that agency is understood as a relational capacity where the actions of agents are explained in terms of relational states such as signaling or social interaction rather than mental states like beliefs and desires. Reasoning in terms of folkcommunication versus folkpsychology would entail substantial differences in organization of conceptual domains across cultures. This perspective leads to an alternative account of cultural variability in nonhuman agency concepts than those currently offered by domain-specificity theory. Furthermore, it allows us to consider how Indigenous folktheories allow new ways to perceive and attend to ecological interactions.

An important implication of our proposal is that intuitive ontological domains reflect and reinforce broader cultural epistemologies. If so, then clarifying what is cultural in Western researcher's own theories of domain-specific cognition can shift our views about cognitive priors. In the interest of interdisciplinary conversation, it is worth expanding on this point as it pertains to claims about a universal folkpsychology. Several interdisciplinary scholars have argued that cognitive psychology has already provided evidence to establish that the domain-specific organization of domains including folkpsychology is universal (Atran & Norenzayan, 2004; Boyer, 1996). This claim rests on research showing that infants spontaneously interpret certain events in terms of agency by expecting that an object will exhibit "behavior [that] is directed at the world" (Johnson, 2003, p. 554). The strongest cues to agency detection in infancy are goal-directedness and contingent interaction (for more extensive reviews, see Carey, 2009, pp. 157-213; Gelman & Opfer, 2002; Johnson, 2003; Poulin-Dubois, et al., 2009; Rakison & Poulin-Dubois, 2001; Saxe et al., 2004). Both cues provide examples of "non-random relatedness between the agent and its environment...that imply that the object producing the behavior can both detect and respond to its environment" (Johnson et al., 2007, p. 9). Researchers conclude that infants possess a core representational system for agency online by the end of the first year of life. However, the infant's knowledge of agency is rudimentary and presumably involves little or no appreciation of mental states (Carey, 2009). It is only later in development that children develop a rich conceptual framework for agency that includes causal principles tied to minds and mental states, where behavior is understood in mentalistic terms (i.e., folkpsychology) (Johnson, 2000; Wellman, 2010). Thus, the agency representation system in infancy is distinct from the later developing intuitive theory of folkpsychology in Western cultures (Bíró & Leslie, 2007; Leslie, 1994). Nonetheless, the infant's representational system for agency is generally thought to be a precursor to folkpsychology among Western psychologists.

But what holds for Western communities need not hold for all communities. The infant's representational system for agency may serve as a precursor to alternative folktheories of agency in other cultures. This is especially plausible when we consider that the cues to agency detection (goal-directed motion and contingent interaction) are common to all living systems and not only those with human-like brains. A striking observation from developmental psychology is that infants will attribute agency to any kind of entity—bouncing balls, faceless blobs, animated shapes, and animals or humans—as long as it engages in dynamic actions characteristic of those agency cues (Bíró & Leslie, 2007; Csibra & Gergely, 2013; Johnson, 2003; Johnson, et al., 2007; Woodward, 2013). This suggests that infants use an "agency-from-action" inferential system where agency is computed based on "patterns of interaction among entities" rather than selective processing of particular ontological kinds (e.g., animates) (Carey, 2009, pp. 188, 193). This has led some psychologists to propose (in contrast to the mainstream domain-specificity account) that the core representational system for agency actually has no proper intuitive ontological domain: "Our tendency to apply psychological explanations to non-human phenomena (see Piaget, 1929; Heider & Simmel, 1944) may not be due to an overextension of an (originally more restricted) psychological interpretational framework," but may instead reflect the proper application of a cognitive stance for recognizing teleological action (Csibra, et al., 1999, p. 265).

In the same spirit, we argue that the infant's representational system for agency provides a common foundation upon which cultural epistemologies build in distinctive ways. Different folktheories may organize knowledge about agency in distinctive ways depending on whether they adopt a human-centered or ecological perspective on the kinds of agency that are meaningful. It follows that the separation of human and nonhuman agents into different intuitive ontological domains may represent a feature of Western cultural epistemology, not a cognitive prior.

3. A cognitive psychological perspective on the new animism

In order to capture cognitive variability in ways of relating with the nonhuman world, cognitive psychology, like anthropology, needs theories that go beyond the human to consider nonhuman agency. Drawing on the new animism in ontological anthropology, we investigate the cognitive consequences of animist epistemologies with respect to the organization of social and ecological domains. We structure our investigations according to two key hypotheses following from the new animism. First, we expect that Ngöbe individuals will recognize agency across a broader spectrum of natural nonhuman kinds than do Western individuals, who will be more likely to attribute agency to human-designed information processing artifacts. We propose that these distinct cultural patterns of agency attribution reflect diverse principles for inferring agency on the basis of an ecocentric theory of folkcommunication or an anthropocentric theory of folkpsychology. To test this further hypothesis, we use converging empirical methods to assess underlying principles for inferring agency and to probe how they guide expectations concerning actual ecological interactions.

The comparative studies reported below focus on Indigenous Ngöbe adults in Panama and US college students, with select comparisons to European Americans residing in Panama. This line of work takes place within a larger research program exploring how epistemological orientations that view humans as part of nature (or apart from nature) influence conceptual organization and reasoning processes relative to the living world (Atran & Medin, 2008; Bang et al., 2007; Herrmann, et al., 2010; Medin & Bang, 2014b; Medin et al., 2006; Unsworth et al., 2012; Waxman & Medin, 2007). In partnership with several native communities including the Menominee of Wisconsin, urban Native Americans in Chicago, and the Itza' Maya of Guatemala, this research has consistently shown that cultural epistemologies organize folktheories of the natural world in ways that carry important consequences for ecological reasoning, environmental decision making, and ecosystem health. Against this background, we specifically investigate folktheories of agency as one conceptual resource for cultivating sustainable human-nonhuman relations under broader systems of cultural epistemology.

Agency attribution experiments

To test our first key hypothesis that Ngöbe and US individuals differ in their willingness to ascribe agency to nonhuman kinds, we have adapted methods developed by Western psychologists in a series of experiments (Gray, et al., 2007; Opfer & Gelman, 2001). In these experimental tasks, participants are presented with images of a range of entities including humans (e.g., elderly woman, infant), nonhuman animals (e.g., chimp, frog, bird), plants (e.g., banana, manioc), abiotic kinds (e.g., sun, ocean, rocks), and complex artifacts (e.g., robot, computer). For each entity, participants judge whether it can exercise a given capacity (e.g., thought, communication, morality, hunger, desire) in a series of predicate attribution probes (e.g., "Can plants think?"). In Panama, participants complete these tasks in a face-to-face interview in a local house in the Ngöbe village. In the US, tasks are completed either in interviews or computer surveys on the university campus. Experiments are conducted in Spanish or Ngöbere in Panama, and in English or Spanish in the US (for further details, see original studies in ojalehto, Medin, & Garcia, 2015; ojalehto et al., submitted-a, submitted-b).

As a formalized method for eliciting informants' beliefs about nonhuman agency, these agency attribution experiments should offer convergent evidence to the in-depth field interviews conducted by anthropologists. Accordingly, we predicted that Ngöbe would be more likely than US participants to attribute agency to plants and abiotic kinds on the basis of those natural kinds' capacity to interact with the environment. By contrast, we predicted that US participants would be more likely than Ngöbe informants to attribute agency to complex artifacts due to their human-designed information processing capacities. Confirming this, across several experiments we have consistently found that Ngöbe individuals are more likely to attribute agency capacities to plants and abiotic kinds than are US individuals (ojalehto, et al., submitted-a, submitted-b). For their part, US individuals are more likely than Ngöbe to attribute agency to complex artifacts.

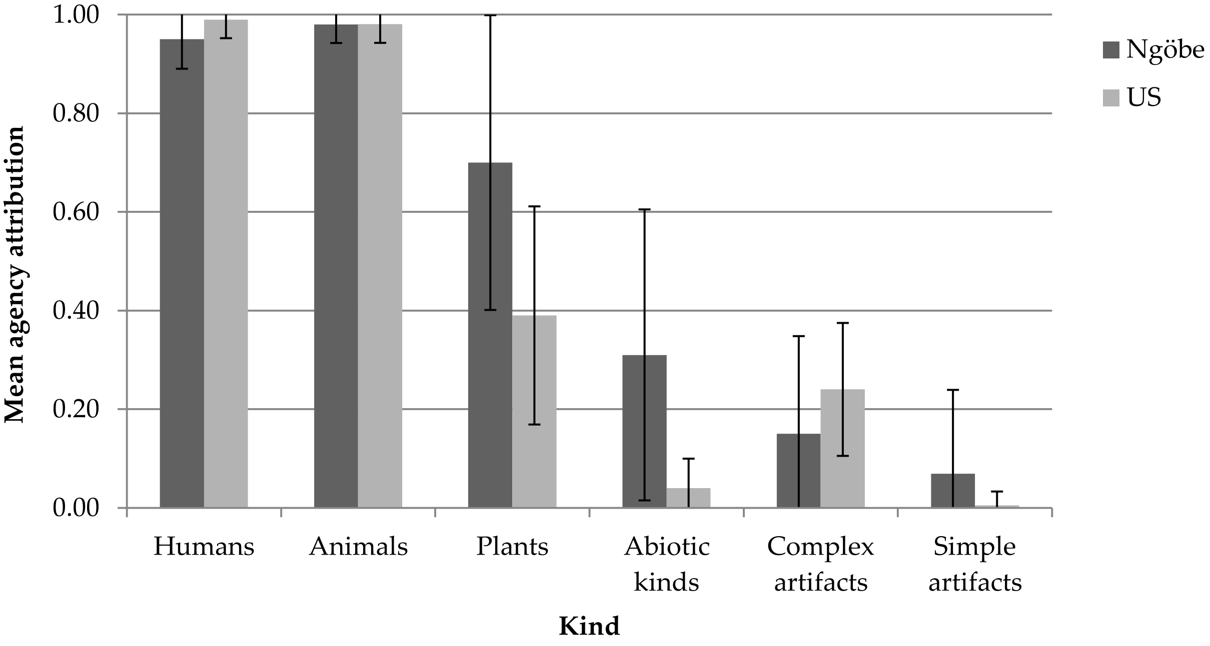
A closer look at the cultural profiles of agency attribution for nonhuman kinds further supports the idea that these reflect anthropocentric or ecocentric models (see Figure 1). Ngöbe participants attribute greater agency to plants and abiotic kinds than to complex artifacts, privileging ecological forms of agency above human-created forms. Plants in particular are ascribed agency at levels near that of animals, suggesting a model that recognizes agency as a shared property of vegetal and animal life forms. In contrast, US participants attribute greater agency to complex artifacts than to natural abiotic kinds, privileging human-designed agency over ecological forms of agency. When it comes to plants the picture is nuanced. US participants view complex artifacts as having greater cognitive capacities than plants (e.g., thought, memory) but view plants as having more experiential capacities than complex artifacts (e.g., hunger, fear). This may reflect distinct notions of what plants "do" (e.g., have biological states) and what artifacts "do" (e.g., have representational states). This distinction did not hold for Ngöbe, who were more likely to ascribe both cognitive and experiential capacities to plants than to complex artifacts.

Another important observation concerns the stark cultural differences in attributions of animacy (life and movement) to abiotic kinds. The vast majority of Ngöbe participants affirmed that the sun and ocean were animate. In a ranking task that asked participants to order entities according to their capacity to be alive, the sun and ocean were ranked above all other kinds by fully half of Ngöbe participants. The fact that the sun and ocean were ranked so prominently in Ngöbe models of animacy suggests their prototypical status as animate forces. The Ngöbe framework for agency may be grounded in a view of life as a graded force where powerful abiotic kinds like the sun or ocean are prototypes. By contrast, US participants almost never attributed animacy to abiotic kinds. Furthermore, their rankings for life followed a binary split: plants, animals, and humans were almost always ranked as having the same capacity for life, while all other kinds were excluded. On the US view, an entity is either alive or not. But our results suggest that the Ngöbe perceive a gradient in the life force of various natural kinds.

The results thus far present systematic cultural differences in agency attribution that are roundly consistent with anthropological reports. Yet several questions remain. One concern is that differences in agency attribution may reflect different semantic mappings for agency terms across English, Spanish, and/or Ngöbere. To explore potential language effects we have conducted these experimental tasks in two languages within each cultural group (US: Spanish and English; Panama: Spanish and Ngöbere). If attribution patterns differ across languages within a cultural group (e.g., for Spanish versus Ngöbere among Ngöbe participants), this would suggest the observed differences in agency attribution reflect linguistic differences more so than conceptual differences. However, we have found no reliable language effects of language in either group. This indicates that the attribution of capacities such as wanting, feeling, or communicating to nonhumans cannot be due solely to language. Instead, they appear to reflect distinct cultural ideas of what those very terms mean.

This raises the question: on what grounds do US and Ngöbe individuals attribute these agency capacities to entities? Building on the anthropology of animist ontologies especially as articulated by Kohn, we propose that Ngöbe attribute agency on the basis of a folktheory of communication where the

Figure 1. Agency attributions for each kind by culture



relevant constructs revolve around relationships, interactions, and signs rather than mental causes for action (e.g., Kohn, 2013). To assess this, we developed a coding scheme to analyze participants' verbal explanations for the presence of constructs associated with each hypothesized cultural folktheory (for details, see ojalehto, Medin, & Garcia, 2015). For instance, we predicted that US explanations would contain more references to humans as the prototype for agency (e.g., chimps can think because "they're very similar to human minds") and that they would focus on having a brain as a criterion for agency (e.g., plants can't think because they don't have brains). On the other hand, we predicted that Ngöbe explanations would focus on relationships as constitutive of agency (e.g., "The sun communicates with water in the moment of rising"), and that they would focus on observable interactions as a criterion for inferring agency (e.g., "Plants can think because they grow toward sunlight"). Each participant's interview transcription was analyzed for the frequency of reference to each coding category.

The coding results presented two distinct sets of explanations for agency. Ngöbe predominantly explained their agency attributions by referring to observable interactions and relationships, consistent with an interpretation of agency as a communicative capacity. Many Ngöbe informants also explained that agency was a pluralistic capacity that is exercised by diverse human and nonhuman entities in unique ways (e.g., animals "have their distinct forms to wait, express, know"). This contrasted with US explanations that primarily interpreted agency in terms of a psychological property characterized by unobservable mental states underlying actions. US explanations also tended to treat humans as the prototype and often reflected a *scalae naturae* model where organisms are hierarchically ordered on a scale from simple to complex (i.e., human) agency. Anthropocentric framings were significantly less pronounced in Ngöbe explanations. This coding analysis extends our prior agency attribution results by showing that Ngöbe and US individuals take different stances on the relevant prototypes and causal principles for inferring agency—namely, as a communicative capacity shared by many nonhuman kinds, or as a psychological capacity exclusive to humans or other animals with brains.

Collectively, these results are consistent with our proposal that US and Ngöbe folktheories of agency follow distinctive inferential principles that ultimately lead to different intuitive ontological domains. US individuals take an anthropocentric stance on the psychological causes of action, presumably using knowledge about the kinds of entities that have a brain or nervous system as a fundamental constraint on folkpsychology. Ngöbe do not share this constraint, which frees them to attend to forms of agency exercised by diverse natural entities. Presumably, using communicative principles as the basis for inferring agency provides a framework for viewing plants, animals, abiotic kinds, and other nonhumans as agents actively relating to their environments. These findings contribute to the anthropological literature by providing systematic evidence for the broad ecological scope of agency attributions among Ngöbe informants, illuminating their explanatory basis, and showing that these attributions hold across both native Ngöbere and Spanish. However, our findings thus far are based on verbal reports that rely heavily on specific predicate attributions (e.g., "can think"). One concern is that explicit verbal reports do not always align with underlying conceptual commitments, as other cultural research has shown (Astuti, 2001; Astuti, et al., 2004). For instance, people's stated beliefs can diverge from their inferences about novel scenarios and some aspects of conceptual organization are simply unsuited to explicit reflection and report (e.g., you may be hard-pressed to answer if we asked whether you organize your knowledge of species taxonomically or ecologically). Responding to these concerns, stronger evidence that cultural folktheories of agency differ would come from experimental methods that go beyond verbal attributions to assess other cognitive dimensions.

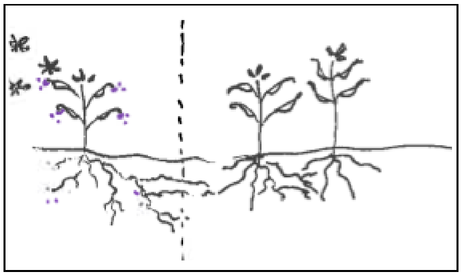
Inferential reasoning experiments

In a further series of experiments, we sought new forms of evidence to bear on the question of culturally distinct folktheories of agency. Cognitive experimental methods offer tools to ask questions that cannot be readily posed in field interviews and explicated by informants, or made apparent in ethnographic observation. We mobilized these experimental tools to assess underlying principles for inferring agency and to test how those principles guide expectations for actual ecological interactions.

First, we investigated the implicit inferential principles involved in attributions of agency by employing the cognitive experimental method of a framing manipulation (ojalehto, et al., submitted-b). This task used the same agency attribution method of prior studies but introduced a new experimental framing of the capacity probes, in addition to the original framing. In the original framing designed by Western researchers, agency predicates are presented with no grammatical object (e.g., Is x capable of feeling hunger?), which implicitly treats the capacity as a property of the individual entity. Our coding analysis of Ngöbe explanations suggested that a more culturally fluent way of reasoning about agency capacities is to include the object(s) of the interaction (e.g., Is x capable of feeling hunger for food or nutrients?). Accordingly, in the relational framing we presented each agency predicate with grammatical objects that place the subject in relation to other entities, implicitly treating the capacity as a relational property. US and Ngöbe participants were randomly assigned to either the original framing condition or the new relational framing condition. If relational principles are central to inferring agency on the Ngöbe folktheory, then the relational framing should facilitate greater agency attributions to nonhumans as compared to the original framing. By contrast, US participants should show no effect of framing condition if they interpret these predicates as mental states that are fixed properties of individual entities with brains (and not properties that arise out of relationship). The results showed that Ngöbe were indeed more likely to attribute agency to nonhuman kinds in the relational condition as compared to the original condition. US responses did not differ across the two experimental conditions. These results provide a new form of evidence that relational principles are central to how Ngöbe (but not US) individuals reason about agency, in line with our proposed folkcommunication framework.

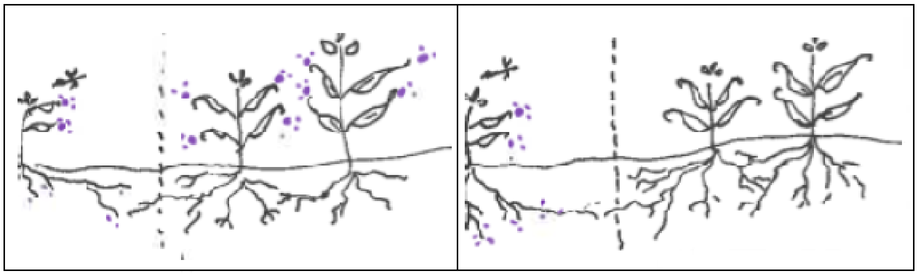
If these cultural differences reflect distinct folktheories of agency, then they should not only be evident in capacity attributions (i.e., *saying* that a plant can communicate) but should also be reflected in inferential reasoning about the actual behavior of nonhuman agents (e.g., *predicting* that a plant will engage in communicative behavior). More specifically, the Ngöbe folktheory should encourage a broader stance for observing and expecting complex forms of interaction and relationship among nonhumans than the US folktheory. To test this hypothesis, we designed an experiment to elicit predictions of plant behavior (ojalehto, et al., submitted-a). Plants are a good test case because they occupy a contested category in Western science and philosophy (Chamovitz, 2012; Hall, 2011). Traditionally, Western scholars have viewed plants as passive objects rather than active agents and favored explanations of plant activity in terms of automatic reactions and mechanistic processes (Hall, 2011; Trewavas, 2002). For instance, Darwin's claim that plant phototropism is an inductive behavior (not a mechanical process) on the part of plants was hotly contested among botanists in the 1800s (see Julius von Weisner (1878) (cf Chamovitz, 2012; Whippo & Hangarter, 2006). Contemporary debates in plant science center on recent findings that demonstrate complex social capacities of plants, including communication and kin resource sharing (Bhatt, et al., 2011; Biedrzycki & Bais, 2010; Brenner, et al., 2006; Dudley & File, 2007). These findings were unexpected in the Western biology community where the prevailing view held that plants have limited capacities to perceive and discriminate the complexities of their (social) environment (see also Kimmerer, 2013). Yet there is now mounting evidence to suggest that basic forms of awareness, memory, and sensory perception are present among plants—indeed, some scientists argue that plant behavior cannot be understood without appealing to these capacities (Chamovitz, 2012; Trewavas, 2002, 2003). Nonetheless, the evidence remains debated and some plant scientists flat out reject the possibility of plant sentience (Alpi, et al., 2007). It is plausible that these debates are tied to broader Western cultural conceptions of plants as passive organisms. If so, this would provide a test bed for our hypothesis that cultural folktheories of agency may lead to divergent expectations for actual behavior.

Drought scenario



1a. Here are three plants of the same species. Aboveground, a wall separates the left plant from the two on the right, but the roots are connected. Insects have arrived and are irritating the plant on the left. As a result, the plant has released chemicals to defend itself. The chemical is released through both leaves and roots.

1b. What will happen to the two plants on the other side, after the left plant releases defensive chemicals? (Assume the insects have not arrived on the right side of the wall yet.)



2a. The other two plants will also release chemicals to defend themselves.

2b. The other plants will remain in the same state as before, without releasing chemicals.

We exploited the ambiguity surrounding these recent scientific findings to investigate the role that cultural folktheories play in guiding intuitive expectations for actual plant behavior in novel reasoning scenarios. Novel scenarios presumably elicit inferences based on conceptual knowledge rather than simple fact retrieval, allowing us to investigate the inferential principles privileged on different folktheories. We hypothesized that the Ngöbe perspective on plants as active, experiencing agents would afford insights into social plant behaviors that are less accessible on the US view of plants as insentient, passive biological kinds. Participants were presented with four line drawn image sequences depicting plants engaged in behaviors characteristic of communicative signaling and kin-selective resource sharing (see Figure 2; for details see original report in ojalehto, et al., submitted-a). Critically, in this prediction task participants were not directly asked whether plants can communicate or share resources with kin. Instead, they were presented with the images and a neutral description of the situation faced by two or more root-connected plants (neutral because agency-relevant predicates such as communicate or think were not used). Then participants predicted what would happen. In each scenario, they chose between two possible outcomes designed to reveal whether the participant inferred the capability to communicate or recognize kin.

To get a sense of the task, consider the two communication scenarios. These situations involved two to three root-connected plants signaling in response to either an impending drought or an insect plague, and participants had to predict whether this would prompt an anticipatory adaptive response in the receiving plant (modeled on experimental results reported in Falik, et al., 2011; Heil & Karban, 2010). Specifically, participants predicted whether or not the receiver plant(s) would already be in a prepared state prior to the arrival of the threatening event. In addition to communication we also presented two kin altruism scenarios. These involved resource sharing between two plants, one between two sibling plants and the other between a mother tree and her seedling (modeled on experimental results and observations reported in Dudley & File, 2007; Simard, 2009; Wilkinson, 1998). Participants predicted whether or not the more mature plant would modify its resource consumption such that the less mature plant would benefit. If the Ngöbe folktheory views plants as active agents, then this should facilitate expectations for complex interactive behaviors on the part of plants and Ngöbe should be more likely than US participants to predict that plants will communicate and share resources with kin.

Results showed that Ngöbe were more likely than US participants to predict both plant communication and kin altruism. Furthermore, analysis of explanations showed that Ngöbe were more likely to interpret plant communication in terms of social goals (i.e., signaling to another plant for that plant's benefit), whereas US participants tended to interpret it as a byproduct of individual survival goals and biological mechanisms (e.g., automatic chemical processes that only incidentally warned another plant). These findings suggest that even where cultural predictions sometimes align, as for plant communication, individuals may infer behavior on the basis of distinct reasoning principles. These findings extend the observed cultural differences in agency attribution experiments by suggesting that different ways of interpreting plant agency carry cognitive consequences for inferential reasoning about actual plant behavior in novel reasoning scenarios. The majority of Ngöbe informants' predictions aligned with recent findings in botanical science**.**

One intriguing implication of the Ngöbe folktheory of agency is that it may also encourage expectations for complex forms of social interaction *across* different nonhuman species. Western ecological theory has tended to see one kind of interaction—competition—as the driving force of ecosystems (e.g., Holt & Polis, 1997, p. 745), and competition is the default assumption in many relationships between species (Minta et al., 1992; Palomares & Caro, 1999). But more recently, research has begun to highlight widespread positive interactions (e.g., cooperation, commensalism) in ecosystems (Bruno et al., 2003). Observers have suggested that the competitive model reflects Western cultural values (Todes, 2009). Suggestively, Native scholars have pointed out that recognizing cooperation among nonhuman species is often linked to appreciation of those species' social capacities, e.g., for communication (Pierotti, 2011). This scientific ambiguity in the interpretation of interspecies interactions provides another test bed for assessing folktheories of nonhuman agency across cultures. Specifically, different cultural understandings of nonhumans as social agents may also support distinct views of the cooperative or competitive nature of ecological interactions.

We tested this using an illustrated nonfiction storybook (with text removed) to elicit US and Ngöbe participants' interpretations of an ambiguous hunting relationship between two predators, a coyote and badger (ojalehto et al., 2015). Coyotes and badgers are an interesting case study because the two hunt cooperatively (Kiliaan et al., 1991; Minta, et al., 1992). Interestingly, their association also involves behaviors not directly related to hunting activities, including play, sustained nasal-nasal and body contact, and resting together. However, the illustrations in the book (like naturalistic observations generally) were ambiguous with respect to the nature of their hunting relationship. This provided a test case for assessing whether cultural folktheories afford divergent inferences about an interspecies interaction. Notably, we expected this particular interspecies interaction to be novel for both groups, either due to geographic unfamiliarity with these species (Ngöbe participants) or to general lack of ecological knowledge (U.S. participants). As in the plant interaction experiments above, using a novel reasoning scenario requires participants to base their inferences on conceptual knowledge encoded in folktheories rather than simple fact retrieval.

Participants looked through the entire storybook and then were asked to narrate what was happening. If the Ngöbe folktheory of nonhuman agency recognizes social capacities including cooperation, and/or if the competitive frame is a Western cultural lens, then U.S. participants should prefer competitive interpretations whereas Ngöbe participants should prefer cooperative interpretations. As predicted, the majority of Ngöbe inferred that the two predators were cooperating, whereas most US college students inferred that the two predators were competing. Further probes suggested that these models of ecological interaction correlate with recognition of social agency in nonhuman animals (e.g., beliefs that coyote and badger could communicate and act morally). These findings lend further evidence to show that folktheories of agency can support different readings of actual interspecies relationships. Our results suggest that Ngöbe folktheories accommodate a wider range of social roles for animals, including capacities for communication and morality that pertain to recognition of ecological dynamics such as cooperative interaction. Once again, the Ngöbe perspective aligns with ecological science on interspecies cooperation. These findings also align with anthropological reports of Indigenous views of animal social and cognitive capacities (e.g., Harvey, 2005).

In summary, results from multiple experiments show that cultural folktheories embed distinct inferential principles for attributing agency, and these principles guide inferences about actual plant and animal behaviors. Furthermore, the Ngöbe view consistently aligns with recent scientific advances showing that communication and cooperation are key drivers of ecological structure, suggesting that Ngöbe perspectives offer unique affordances for understanding ecosystem dynamics.

4. Culture and Concepts: Multiple perspectives on human-nature relations

The interdisciplinary project of the new animism invokes deep questions of culture, cognition, and environments. Often underlying these questions is some form of the universalist-relativist debate, which cannot escape assumptions about what culture is. Anthropologists and cognitive scientists debate what is at stake in animism with respect to various discipline specific goals ranging from epistemologies to metaphysics. For our part, we are concerned with how Indigenous views of nonhuman agency afford ways to perceive ecological communities, and what this says about the possibilities for human interaction with nature. Our explicit value orientation is that Indigenous insights can and should be taken up in a broader context. In this sense we assert with Kohn (2015) that animist ontologies are not “a description of how the world is, or how one kind of person thinks, but a call for a form of thinking, available to anyone, that is able to see possible ways of becoming otherwise” (pp. 320-21). To aid this process, careful attention must be given to researchers’ stances on the nature of cultural and conceptual differences, as these ideas partially determine our ability to see and learn from variability. In this section, we argue that cognitive psychology can contribute to these efforts by theorizing cultural differences in terms of conceptual organization under a view of cultures as complex systems. This allows us to characterize cultural variability in terms of multiple perspectives, pointing toward practical ways to mobilize Indigenous concepts in a broader context.

Revisiting animism and cognitive universals

Our research motivates reconsideration of the discussion between anthropologists and cognitive psychologists concerning cognitive variability versus universality in the domain of animism (e.g., Guthrie, et al., 1980; Lloyd, 2010; Lloyd, 2007; Sperber & Hirschfeld, 2004). In stark contrast to the ontological turn, one influential line of cognitive anthropology has taken a universalizing stance on the cognitive priors that underlie animist beliefs (Atran & Norenzayan, 2004; Boyer, 1996). The explanation offered by these accounts is that attributions of agency to nonhuman kinds such as plants represent a “category error” by extending mentalistic attributions beyond the proper intuitive ontological domain of animates (Atran & Norenzayan, 2004; Boyer, 1996). These “overextensions” are attributed to a natural tendency to generate counterintuitive concepts, which may be due to religious beliefs (e.g., belief in tree spirits) (Barrett, 2000; Boyer, 2003) or to divergent sets of explicit cultural knowledge (e.g., mistakenly assuming that plants have minds). These accounts read the cognitive psychological literature on domain specificity as providing evidence that the Western delineation of intuitive domains into folkpsychology, folkbiology, and folkphysics is universal. Implicitly these accounts also assume that the epistemological orientation to human-nature relations that these domains encode is universal. In asserting that the Western organization of conceptual knowledge is universal, these theories are placed in the old animism framework whereby they must explain why some cultures appear to violate these (presumed) natural conceptual constraints. Namely, if the Western folkpsychological concept of mind is universal and properly constrained to animates, then the problem is to explain why cultures vary in how far they extend the concept to nonhumans. These overextension accounts are consistent with prevailing sentiments in the Western cognitive science community, where domain specificity is widely regarded as a universal feature of cognition (Gelman & Legare, 2011; Sperber & Hirschfeld, 2004).[46]

We depart from these accounts by arguing that this particular organization of intuitive ontological domains reflects Western cultural epistemology rather than a universal feature of cognition. Epistemological orientations to human-nature relations are organized differently across cultures and likewise intuitive ontological domains are structured in distinctive ways across cultures. The evidence outlined above, we have argued, is consistent with the idea that presumed overextensions of folkpsychology actually reflect different concepts of agency as a communicative or psychological phenomenon. By proposing folkcommunication as an alternative to folkpsychology, we no longer rely on Western formulations of intuitive ontological domains to characterize Indigenous epistemologies. Instead, we argue that culture specific folktheories reflect distinctive ways of organizing conceptual knowledge about social and ecological domains.

These two accounts frame the epistemological status of Indigenous animisms differently. Overextension accounts claim that animism represents some form of conceptual "slippage" away from universal intuitive ontologies, whether this is seen as a natural propensity, a religious belief, or a failed inference. On folkcommunication there are no longer (apparent) contradictions to explain as nonhuman agency attributions represent an empirically grounded recognition of the diverse interactive forms of agency that structure ecosystems (including humans).

These two accounts also stake different claims about underlying cognitive structures. Overextension theories take a strong stance on universal cognitive domains and their constituent concepts (e.g., folkpsychology and a concept of mind) and locate cultural variability at the level of extensions of concepts (e.g., overextensions of mind to plants). The implicit assumption is that culture can be seen as "input" to universal cognitive priors, reflecting a presumed dissociation between the contents and processes of thought. In contrast, we maintain that how conceptual contents are organized is critical to the meanings they come to acquire, and that this feedback unfolds in interaction with broader cultural epistemologies. We take a systems-level view in which culture affects both the contents and the processes of thought, and vice versa. This step complicates the traditional separation between higher-level beliefs associated with culture and basic cognitive functions associated with the mind. In studying how intuitive ontological domains reflect and reinforce broader cultural epistemologies, our goal is to deepen understanding of conceptual diversity and how it may be channeled for the development of multiple perspectives on human-nature relations.

Multiple perspectives on variability

By theorizing cultural differences in terms of distinctive modes of conceptual organization, we also assume that these are open systems constituted through relationships, and dynamic in the sense of continually responding to the agents and contexts of which they are part. This dynamism is evident in the ways that cultural sensibilities and cognitive patterns change across time as well as in the plurality of

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[46] Not coincidentally, developmental differences within Western cultures are also explained on overextension accounts whereby children begin with a "promiscuous" theory of folkpsychology that misconstrues nonhuman agency on mentalistic terms and is only later "appropriately" restricted to animate kinds (Carey, 1985; Kelemen, 2004; Piaget, 1971). Perhaps these accounts help to understand how children in Western contexts develop cultural competence (but see ojalehto et al. 2013). Yet when non-Western adults assert that natural kinds like plants can perceive, respond, and communicate, such assertions have likewise been interpreted within the Western domain-specificity framework where such capacities are seen as psychological ones (Casler & Kelemen, 2008; Wellman, 1998).

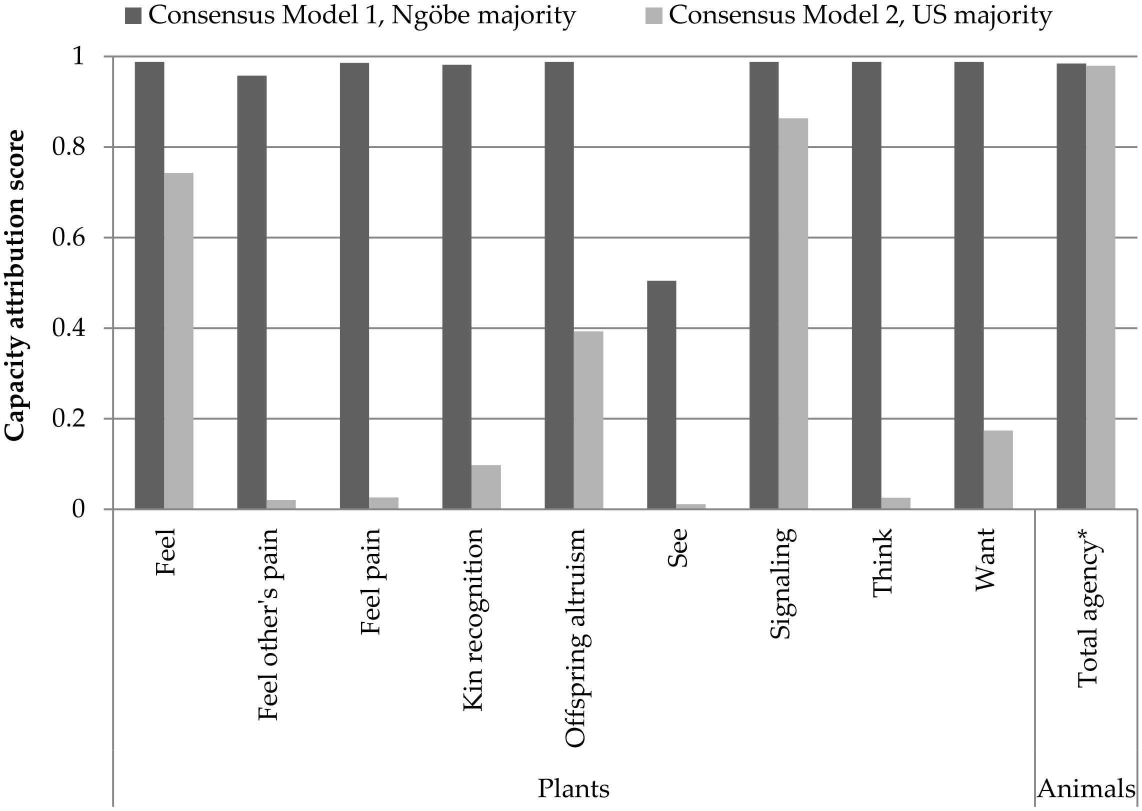
worldviews within a given culture in a single epoch (Iliev & ojalehto, 2015; Lloyd, 2007). It follows that exploring multiple levels of variability should be an objective of cultural work. In particular, attention to within-group variability can offer insight into the distributed, evolving nature of cultural knowledge at both the individual and group levels. Our research makes this an explicit objective by using cultural consensus modeling to explore patterns of variability and similarity both within and across cultures.

Cultural consensus modeling (CCM) is a mathematical technique used by anthropologists for measuring the degree to which individuals share a consensus within a domain (Romney, et al., 1986). Conceptually similar to factor analysis, CCM determines if a single consensus model exists among a group of informants, as well as whether patterns of residual agreement beyond the overall consensus suggest additional models that hold for subgroups in the sample. Furthermore, one unique strength of CCM is that it goes beyond sample means to assess each individual's level of "competence" on their consensus model, where higher scores indicate that an individual's responses are closer to the consensus model. Such analyses can reveal nuanced variations in conceptual models and the individual characteristics associated with those models to inform how concepts and culture interact (e.g., for an example of intergenerational change see Le Guen, et al., 2013). CCM has been applied extensively in prior cultural research on biological cognition (Atran & Medin, 2008; Medin, et al., 2007). In our own research program we have leveraged this tool to illuminate the cognitive, individual, and cultural factors that align with more or less anthropocentric or ecocentric models of agency.

With respect to conceptual models of agency, we have found evidence that multiple models are available within the Ngöbe community and that individuals may themselves hold multiple perspectives. In the experiments on nonhuman agency concepts reviewed above (ojalehto, et al., submitted-a, submitted-b), we have used a bottom-up cultural consensus modeling approach to identify consensus models while treating culture as a latent variable (Anders, et al., 2014). The results indicate that there are multiple conceptual models of agency available in the Ngöbe community. The more pronounced consensus model reflects an ecocentric approach where both plants and abiotic kinds are ascribed a range of agency capacities. Yet a sizeable minority of Ngöbe informants clusters with the US model of anthropocentric agency, although they still ascribe more agency to abiotic kinds and less agency to complex artifacts than do US participants. Furthermore, we consistently find individual differences suggesting that these consensus models reflect engagement with cultural epistemologies. Among Ngöbe informants, for instance, competence on the ecocentric model of agency correlates with greater engagement in Ngöbe cultural discourses (e.g., being a member of the Indigenous church) and less involvement with non-Ngöbe cultural discourses (e.g., less formal schooling). Such findings underscore how conceptual behavior is embedded in systems of knowledge and practice.

One important application of this approach is that it allows us to identify whether cross-cultural differences represent variation from a single (universal) model or two qualitatively distinct models of agency. Standard data aggregation techniques only present mean differences between groups (as in the agency attribution means from Figure 1) and cannot reveal systematic patterns of variability that may underlie those mean differences. For instance, on the basis of mean results in Figure 1, one could argue that Ngöbe and US individuals share a basically anthropocentric model of agency (high attributions for humans and animals) but that Ngöbe are simply more variable in their judgments about specific plant capacities. On the other hand, there may be two different models among Ngöbe informants and the mean data collapse across these. To test this, we again used bottom-up modeling to identify consensus models based on measures of plant and animal agency attribution in the plant social interaction experiment described above (ojalehto, et al., submitted-a). The model detected and clustered individual participants into two consensus models, with members of Model 1 primarily Ngöbe (9 of 11) and members of Model 2 primarily US (28 of 36). The results were unambiguous. The Ngöbe-majority consensus Model 1 presented a strong endorsement of plant agency across all the capacities measured (see Figure 3). Indeed,

Figure 3. Consensus models for agency of plants and animals



*Animal total agency is an average of 5 capacities: see, feel, feel pain, think, want

with the exception of seeing, capacity attributions to plants and animals are indistinguishable. The US-majority consensus Model 2 presented an animal-centered view of agency where plants were less agentic than animals. We conclude that Ngöbe informants do not simply deviate from the anthropocentric model of agency. More than half of Ngöbe endorse a decidedly different model of agency where plants are capable of social and intentional agency on par with animals.

It is plausible that Ngöbe are generally aware of these distinct models and may shift between perspectives. Suggestive evidence for this proposal comes from the experimental condition discussed earlier involving two different framings of agency probes. The relational framing facilitated greater agency attributions among Ngöbe participants than the original individual framing. We propose that this occurred because relational capacities are important to inferring agency on folkcommunication, and the framing invited Ngöbe participants to reason from this ecocentric stance on agency. With respect to US folkpsychology, other research has shown that US attributions of mindfulness to nonhuman animals vary according to more or less human-centered framings (Bastian et al., 2012). Folktheories of agency, like cognitive processes more generally, are responsive to contextual cues and individuals may modify their perspectives depending on their goals in a particular situation.

The US samples in our experiments have consistently reached strong convergence on a single dominant model of anthropocentric agency. Interestingly, we found that competence on this model was associated with more years of university schooling. This may suggest that university schooling (possibly psychology-specific, given that these participants were drawn from a psychology subject pool) strengthens the dominant cultural model of agency. We also observe small numbers of US participants who cluster with the Ngöbe ecocentric model of agency on the basis of their agency attribution to plants.

Standing amid the diversity is the question of what is shared. One conclusion from cultural consensus modeling is that we share the propensity to work with multiple conceptual models. This offers an important resource to draw on in the process of cultivating new perspectives on human-nature relations.

5. Conceptual tools for the place of humans in nature

Engaging seriously with animisms can inspire and inform the development of new conceptual resources to confront our global ecological crisis (Kohn, 2015). There is growing consensus among native scholars, ecological scientists, and social scientists that Indigenous knowledge systems can and do contribute to effective natural resource management (Kimmerer, 2013; ter Steege et al., 2013; Whyte, 2013). The challenge is to specify how perspectives from animistic ontologies may be mobilized for new environmental orientations in contexts such as Western consumerist societies. There is a tension between the simplistic exportation of isolated elements, on the one hand, and rejecting the possibility of any interchange, on the other. We propose that a productive starting point is to consider that both individuals and groups can hold multiple conceptual perspectives, and that these perspectives (like any cognitive process) are elements of broader cultural systems that include practices, values, and ecologies. Concepts offer one entry into these complex cultural systems; change in these nodes may interact with change at other levels of the system. Here, we outline how cognitive psychology can participate in this project by identifying the conceptual tools offered by Indigenous epistemologies, and suggesting how they can be made available for new ecological orientations in diverse cultural contexts. Our goal is to highlight where multiple perspectives can inform one another and motivate ways to move beyond an anthropocentric model where humans stand apart from nature.

The research reviewed above directly contributes to this goal by identifying the conceptual resources that allow Ngöbe to perceive their ecologies as social domains. We theorize different cultural orientations in terms of conceptual organization, which offers a tractable way to understand how Indigenous insights can contribute to Western sensibilities without necessarily implying that entire ontological worldviews must be shifted. Westerners may struggle to see a plant as sentient (on their cultural interpretation of that term), but this is not required in order to adopt a folkcommunication lens that recognizes how the interactive capacities of plants enable them to respond to one another in genuinely social ways. Folkcommunication could supplement existing Western folktheories to provide multiple levels of analysis to coordinate in observing and understanding ecosystem dynamics. Being able to access multiple ontological levels within a system and to see how they interact is critical to developing understanding of complex systems (Wilensky & Resnick, 1999). For instance, our findings indicate that an appreciation of nonhumans as agents who actively perceive and relate could encourage individuals to develop expectations for complex behavior on the part of plants and other organisms. Holding the expectation creates opportunities to observe the behavior of living organisms in ways that would rarely be glimpsed on a purely anthropocentric model of agency. By introducing a means to perceive the social aspect of ecologies, folkcommunication can challenge the Western organization of intuitive conceptual domains that separates humans from nature toward a more integrated view of social and ecological domains.

Our findings further suggest that taking an ecocentric stance on agency via folkcommunication could prompt attention to positive social interactions among plants, animals, and presumably humans. Drawing on these conceptual tools could expand Western intuitions about nature “red in tooth and claw” and foster new ways of attending to interspecies dynamics in ecologies. This is important because accurate readings of interspecies relations are necessary for effective natural resource management, as in wildlife conservation policies that support the natural affinity between two carnivorous predators rather than mistakenly assuming intraguild competition (Linnell & Strand, 2000). But it is also important for the intuitions people bring to bear on understanding ecosystems and humans' place within them. Psychological research has suggested that U.S. undergraduates may take a zero-sum approach to conservation by viewing the needs of humans and animals as in competition (Markowitz et al., 2013). Similarly, one consistent finding in our research is that Ngöbe are more likely than US participants to infer cooperation and communication among nonhuman agents. This echoes findings among other Indigenous communities in Central and North America (Atran & Medin, 2008). Consequently, one important step will be to challenge the Western competitive folk model of nature to open ways to perceive how cooperation between species (including humans) is not only possible but plausible.

Recognizing plant agency also opens the possibility to recognize that plants interact with humans. Within the realm of human-plant interactions, cultivating knowledge of and engagement in positive reciprocal relationships is paramount. Robin Wall Kimmerer (2013), a Native ecological scientist and writer, recounts that she once opened an undergraduate course on ecology by asking her students to list negative human-environment interactions. A slew of hands went up. Then she asked them to list positive human-environment interactions. The room was silent. This imbalance needs to be redressed if we are to develop new and fuller ways of interacting with our environments, for positive interactions with nature are critical to ecological sustainability as well as positive personal relations with the living world. Here at Northwestern University, a team of scholars has experimented with this approach by organizing a local maple-tapping project each winter. Led by Native Americans from Chicago, students are introduced to the historical relationship between humans and maple trees on this land, and participate in the process of drilling taps, collecting sap, and boiling it into syrup. Bringing students into relationship with the living beings on their own campus equips them to recognize a maple tree (no small feat given the tree blindness among US college students) (Wolff, et al., 1999) and personally appreciate its unique properties for sustaining human and other animal lives.

Additionally, apprehending nonhumans as agents with a capacity to experience their environments and interact with others could also create a larger scope for moral concern. Research across the cognitive sciences has shown that our intuitive recognition of other kinds as agents helps to shape their role in our social and moral communities (Banaji & Gelman, 2013). It follows that recognizing the agency of nonhumans may encourage individuals to see how environmental dilemmas are also social ones that concern proper ways of relating with nonhuman others. Such a perspective is needed in Western societies. Among Westerners, reasoning about environmental dilemmas tends to be instrumental and lacks any inherent social dimension—the only social aspect of environmental dilemmas concerns derivative effects on human societies (Kortenkamp & Moore, 2001, 2006). This makes sense under an anthropocentric folkpsychology that views nonhumans as insentient, asocial objects. Unfortunately, it may also foster a human-centered perspective on the morality of environmental decision making. Consistent with this, evidence suggests that Western individuals tend to reason about environmental dilemmas in terms of anthropocentric considerations (human welfare, interests, aesthetics, and timeframes) more so than biocentric considerations (nature's intrinsic value or rights) (Kahn & Lourenço, 2002; Kellert, 1993; Kortenkamp & Moore, 2001, 2006). An ecocentric concept of agency could provide a necessary complement to the Western narrative of human-centered agency and extend moral consideration to relationships with nonhumans. The affirmation of a reciprocal relationship motivates careful consideration of potentially harmful interactions. For instance, when learning about plant relatives in a community education program, Native American students in Chicago only took specimens from plants when necessary to make medicine for community members (Bang & Medin, 2010). Many

Indigenous communities share a practice of offering thanks to plants before taking their life (FORMABIAP, 2008), removing strips of bark (Anderson, 1996), or maple tapping.

Finally, Ngöbe frameworks may offer tools for reframing Western cultural models of the place of humans in nature. The very notion of an ecosystem—including whether the ecological is distinct from the social (see Mace, 2014) and whether or not human beings are a part of them—may be culturally dependent (Medin & Bang, 2014a; Medin, et al., 2013). As a case in point, Western depictions of ecosystems very rarely include human beings (Medin & Bang, 2014a). As a consequence of this model that separates humans from nature, research among Westerners finds evidence for a general lack of ecological knowledge and a tendency towards oversimplified reasoning about humans as the dominant causal force in ecosystems, where nonhuman perspectives are deemphasized (White, 1992; Wolff, et al., 1999). By contrast, our research with Ngöbe and other indigenous communities documents sophisticated ecological reasoning that includes complex models of plant-animal relationships, emphasis on human-nature interdependence, and attention to nonhuman perspectives (Medin, et al., 2013). Learning to attend to the deep interconnectedness between social and ecological domains could serve as a critical scaffold for new approaches to environmental thought and action among Westerners.

4. Conclusion

Human-nonhuman relationships are at the forefront of interdisciplinary conversations about environmental futures. In this article we have synthesized insights from ontological anthropology and cognitive psychology to advance understanding of conceptual systems involved in animistic ontologies. Building on anthropological theory of the new animism, our empirical research documents how Ngöbe individuals take an ecocentric view of agency via folkcommunication and traces how this conceptual lens affords insightful perceptions of plant and animal interactions. Not only does folkcommunication appear to heighten attention to positive ecological interactions such as cooperation and communication, it may also expand intuitions concerning the possibilities for human interaction with nature.

Incorporating predictions drawn from ethnographic surveys of Indigenous societies has allowed us to ask new questions about the universal intuitive ontological domains proposed by mainstream psychological theory. Ethnographic observation can reveal potentially culture-specific assumptions embedded in psychological theories and empirical cognitive methods can make those assumptions available to testing. Illustrating this interplay, our findings make visible and challenge the anthropocentric lens in Western theories of agency as a folkpsychological domain. In so doing, our comparative cultural analysis speaks to anthropological debates by suggesting that Ngöbe concepts of nonhuman agency derive from a distinct theory of folkcommunication rather than overextensions of Western folkpsychology, as some cognitive anthropologists have claimed.

Cognitive psychological methods can enrich anthropological theories by providing forms of data that are not available through ethnographic observation alone. As a starting point, our results affirm the centrality of relationships and communication in Ngöbe reasoning about the living world, and echo the broader anthropological claim that Indigenous and Western epistemologies organize concepts of human-nature relations differently. Cognitive theory offers a specific framework for theorizing these differences in terms of conceptual organization, leading to the proposal that US and Ngöbe folktheories differentially privilege psychological or communicative principles as a basis for inferring agency. This claim can be refined through experimental testing to identify how these folktheories guide distinctive forms of reasoning about actual instances of interspecies interaction. By administering these tasks to community samples, we were able to measure the systematic application of these principles among Ngöbe community members and to identify multiple conceptual models within the community. Such outcomes illustrate how integrating anthropological and psychological insights can foster research approaches that avoid some potential pitfalls of either discipline acting in isolation (Astuti & Bloch, 2012).

We hope this project serves as an invitation for further dialogue between anthropology and cognitive psychology on shared research problems. With anthropologists, we recognize the need for more effective interchange between Indigenous and Western epistemologies in order to address urgent challenges of cultural and ecosystem survival. Interdisciplinary projects can coordinate multiple perspectives on cultural variability to better understand how Indigenous conceptual resources can be mobilized for new environmental orientations in a broader context. It is difficult to imagine a more important objective than finding sustainable ways to relate with our ecological communities.

Conclusion

How do we come to know and relate with nonhuman beings? Based on the findings presented here, this process varies considerably across cultures. Integrating theory and methods from psychology and anthropology, this work has demonstrated that folktheories afford qualitatively distinct views of nonhuman agency across Ngöbe and US communities. Ngöbe take an ecocentric stance on agency, recognizing diverse forms of agency among nonhuman natural kinds on the basis of those entities' ability to interact with their environments. US individual take an anthropocentric stance on agency by inferring agency on the basis of psychological properties unique to humans and similar animals.

By attending to the perspectives of Indigenous Ngöbe partners, these findings offer a unique vantage point on culture and concepts as well as ecosystems. With respect to culture and concepts, this research offers a new view of conceptual organization for social and ecological domains. On this account, domain-specificity theory has colored our understanding of cognitive diversity by embedding a Western epistemological stance on human-nature relations into purportedly universal cognitive domains. Our findings show that Ngöbe are in a position to recognize the social dimension of ecological interactions for a more integrated view of human-nature relations.

With respect to ecosystems, the consequences of the Ngöbe framework are potentially far-reaching. Concepts of ecological interaction may shape environmental cognition and action in ways that ultimately (re)shape ecologies themselves. For instance, if cultural frameworks invoke distinct perspectives on the social reality of ecological interactions, then this may influence the environmental tradeoffs that people are willing to entertain and even extend to distinct notions of what is at stake in environmental dilemmas. This dissertation marks the beginning of a larger project to learn how Indigenous perspectives can open new avenues for understanding the living world and our place in it. Given Indigenous communities' long-term success in balancing human and ecological welfare (Anderson, 1996; Nakashima et al., 2012), the international community could surely benefit from Indigenous approaches to knowing, valuing, and interacting with nature. Who is at stake? We all are.

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Appendices

Appendices for Study Series 1: Grounding principles for inferring agency

Appendix A: Experiment 1

A1. Methods and procedure

The present task was adapted from the original mind-perception survey in several ways: (1) Response method was ranking rather than pairwise comparisons; (2) Items included plants and abiotic kinds in addition to selected original items; (3) Only a subset of capacity probes was used; and (4) Verbal explanations were elicited.

Stimuli: Two special agents (God, deceased human) were included in the stimuli but not reported here as they are irrelevant to the current question. Stimuli also included a frog in the US but not in Panama (only 2 Ngöbe participants saw the frog), so this item is excluded from ranking results. (Note: Four US interviews had either or both rain and rock as missing items. These were treated as missing but the rank order still included them in the tie for last.)

Rankings: To keep interviews of reasonable duration, each participant ranked 2-4 capacities. The number of capacities ranked did not differ significantly across groups (Ngöbe M = 2.81, US M = 3.18, t(20) = -1.05, *ns*). Each capacity was ranked by a similar number of Ngöbe and U.S. respondents, $\chi 2$ (1, N = 22) from 0.00 to 1.70 for each capacity, all ns. The order for the capacity probes was random, except that *communication* usually appeared first in Panamanian interviews because pilot work suggested its centrality for Ngöbe. (Note: 8 of 11 Ngöbe saw Communication first; 4 of 11 US students saw Communication first. This difference in distribution is not significant. The other 4 capacities were presented in random order for both groups.)

Explanation probes. Participants generally provided one explanation per entity (e.g., chimp) or kind (e.g., all animals), with number of explanations provided for a given capacity ranging from 2 to 19. Average length of explanation did not vary by culture (Ngöbe M = 11.17 words, SD = 2.30; US M = 12.04 words, SD = 2.01, t(20) = .-.94, ns); nor did the average number of explanations provided by individual participants (Ngöbe M = 20.18, SD = 10.19; US M = 19.64, SD = 8.39, t(20) = .14, ns).

Bilingual protocol

Probe stem, for Communication: I will ask you to decide which thing is more capable of [conveying thoughts or feelings to others]. Please look at all the things here, then rank them in order of top to bottom, from those who are most capable of [conveying thoughts or feelings to others], to those who are least capable." *Voy a pedirle que decida, ¿Cual cosa es más capaz de [expresar pensamientos o sentimientos a los demás]? Por favor, mire a todos los cosas aquí, y ordénelos desde los más capaces [de expresar pensamientos o sentimientos a los demás] hasta los menos capaces.*

Desire. Which thing is more capable of longing or hoping for things? *¿Cual cosa es mas capaz de desear o esperar las cosas?*

Thought. Which thing is more capable of thinking? *¿Cual cosa es mas capaz de pensar?*

The remaining bilingual probes were identical to the Protocol used in Appendix B2 (without the relational condition).

A2. Detailed results: Agency attributions

Other effects. As expected, there were also significant main effects of culture and kind on both inclusions and rankings. Overall, Ngöbe included more entities in their agency ranks ($M = 0.66$, $SD = 0.20$) than did US participants ($M = 0.45$, $SD = 0.15$), $F(1, 20) = 7.82$, $p < .05$, $\eta^2 = .28$. Overall mean ranks also differed slightly (Ngöbe: $M = 8.88$, $SD = 0.22$; US: $M = 8.66$, $SD = 0.16$), $F(1, 20) = 6.69$, $p < .05$, $\eta^2 = .25$. They are not exactly equal across groups because mean ranks are aggregated by kind, leading to a weighted mean rank. Overall mean rankings are identical when averaged across the 16 items individually for an unweighted average of 8.5. There were main effects for kind on both inclusions, $F(3.24, 64.87) = 61.48$, $p < .01$, $\eta^2 = .76$, and rankings, $F(3.47, 69.35) = 114.41$, $p < .01$, $\eta^2 = .85$. Humans and animals were included more than the other three kinds, (*ps* < .05), with humans ranked highest followed by animals (*ps* < .05), and then the three non-animal kinds, which did not differ from one another (these differences are noted with subscripts in Table 1 in the main text).

A3. Coding scheme for explanations

Table A1: Inter-rater reliabilities for coding variables

	Inter-rater reliability tests	
Coding variable	**Alpha**	**ICC***
Framings of Agency		
Human-centric framing	0.81	0.69
Scalar framing	0.81	0.69
Social relations framing	0.92	0.85
Ecological relations framing	0.88	0.79
Agency Constructs		
Internalized indicators	0.86	0.76
Interactive indicators	0.83	0.70
Consciousness criteria	0.87	0.77
Directedness criteria	0.77	0.62
Individual Processes	0.88	0.79

* All ICC tests are significant, p < .01, with 232 degrees of freedom

A4. Detailed Results: Explanatory frameworks for agency

Explanation corpus: The final data set included a total of 429 explanations from 20 participants across the five agency capacities and five kinds. *Agency capacities:* The cultural distribution of explanations provided for each capacity did not vary by culture (overall explanations per capacity: Thought, 64; Communication, 151; Morality, 62; Hunger, 79; Desire, 73). *Entity kind:* The number of explanations provided for each kind did not differ by culture. There was a reliable main effect of kind, $F(1,18) = 15.77$,

$p < .01$, $\eta^2 = .47$, with more explanations provided for animate kinds (M = 14.20, SD = 6.40) than inanimate kinds (M = 7.25, SD = 5.14). There was no interaction of culture by kind.

Coding capture. Coding capture refers to the portion of the total explanatory content provided by individuals that was captured by the coding scheme. There was no main effect of culture on coding capture (Ngöbe M = 18.20%, SD = 5.10%; US M = 16.07%, SD = 3.41%, $t(18) = 1.10$, ns), indicating that the coding scheme successfully captured modes of reasoning relevant to both groups.

Detailed results for key coding constructs.

Relational framings of agency: Broken down by social and ecological relations. Overall, Ngöbe relied on relational framings of agency (social + ecological) significantly more often than US participants. The same cultural trend held separately for social relations, $F(1,18) = 4.78$, $p < .05$, $\eta^2 = .21$, and non-significantly for ecological relations, $F(1,18) = 2.95$, $p = .10$, $\eta^2 = .14$. Our coding system followed the Western sense of "social" so the distinction between social and ecological depended on the grammatical subjects (animate or inanimate). Thus, it is unsurprising that there was a main effect of kind $F(1,18) = 6.50$, $p < .05$, $\eta^2 = .27$, such that explanations for animate kinds had more social relational content (M = 3.52%, SD = 3.13%) than explanations for inanimate kinds (M = 1.62%, SD = 2.15%). And vice versa, inanimate explanations had more ecological relational content (M = 5.26%, SD = 4.29%) than animates (M = .90% SD = 1.47%), $F(1,18) = 19.79$, $p < .01$, $\eta^2 = .52$. No interactions of culture by kind were found for either category.

Appendix B: Experiment 2

B1. Methods and procedure

Items: Simple artifact: In Panama, the simple artifact was a handmade net bag. In the US, it was a standard (industrially-manufactured) tote bag. This difference between the two artifacts had no discernable effects on results—capacity attributions to the bag were uniformly low for both Ngöbe and US participants.

Counterbalanced probe orders: (Order A) Move, morality, fear, memory, communication, hunger, pain, live; *(Order B)* Move, pain, hunger, communication, memory, fear, morality, live.

Experimental condition: In the relational condition, each capacity probe identified an object (or objects) of the agency predicate (e.g., can x feel hunger for *food or nutrients*?). Each probe was always presented with the focal objects noted in the protocol below; other objects were occasionally used if further examples were needed. Every participant in the relational condition heard the initial probe for a capacity in the relational format. However, the total number of relational probes given by the experimenter during the rest of the ranking process varied across participants due to interview dynamics (e.g., some participants sorted rapidly, requiring fewer experimenter probes overall and thus receiving fewer relational probes).

Demographic items: Religiosity: In addition to reporting church attendance, participants responded to three belief questions drawn from the original mind-perception survey of Gray et al. 2007: 1) I consider myself to be strongly religious [or spiritual] / *Yo me considero muy religioso [o espiritual];* 2) I believe that God exists / *Yo creo que Dios existe;* 3) I believe that people whose bodies are dead continue to live on spiritually / *Yo creo que las personas cuyos cuerpos están muertos, siguen viviendo espiritualmente. Experience with nature:* In addition to reporting their place of primary residence in childhood (urban, suburban, rural), participants responded to the following questions about experience with nature: 1) Do you [your parents] have a farm or garden? / *¿Tiene[n] [sus parientes] una finca o un jardín?* 2) In general, I would say that my experience with planting, farming, or harvesting is: [5-point response scale] / *En general, yo diría que mi experiencia con la siembra, la finca, o la cosecha es:* 2) In general, I would say that my experience with hunting and fishing is: / *En general, yo diría que mi experiencia con la caza y la pesca es:* (same scale) 3) Do you have a pet now [have you ever in your life]? *¿Tiene una mascota, ahora [en tu vida]?*

B2. Bilingual protocol

Instructions: In this task, we will ask you different kinds of questions. There are no right or wrong answers; please respond with your thoughts.

> *En esta tarea, te vamos a preguntar diferente tipos de preguntas. No hay respuestas correctas ni incorrectas. Puedes responder como piensas.*

Practice task: Okay, let's start by practicing some questions to see the task goes. First, we'll practice ranking. The example is size. So the question is: Decide which of these is the biggest.

> *Vamos a empezar con unas preguntas de practica para ver cómo va ser la tarea. Primero vamos a practicar clasificación. El ejemplo para practicar es el tamaño. Entonces, la pregunta es: ¿Cuáles cosas son más grande?*

Bilingual Questions, for Original & [Relational] Conditions

General question stem: Which things are most capable of [X]? Please consider each thing and rank them in order of top to bottom, from those who are most capable of [X], to those who are least capable. If some of them are equal, you can put them together in the same row. If some of them don't have any capacity to do [X] at all, you can leave them out.

> *¿Cuáles cosas son mas capaz de [x]? Por favor, mira todas las cosas aquí, y ordénelas desde arriba hacia abajo las que son más capaces de [x] hasta las menos capaces. Si algunas son iguales, puedes ponerlas en el mismo puesto. Si algunas de ellas no tienen ningún capaz de [x], puedes ponerlas afuera.*

(i) Move: Which things are most capable of moving? *[Same across both conditions]*
Cuales de las cosas son mas capaz de moverse? [Same across both conditions]

1. Morality: Which things are more capable of telling right from wrong (or good and bad) and trying to do the right (or wrong) thing? [*Relational condition:* to others (of their kind)?]
Bueno y Malo: ¿Cuáles cosas son mas capaz de reconocer lo bueno y lo malo y de tratar de hacer lo bueno (o lo malo) [Relational condition: *a los demás (entre ellos)?]*

2. Fear: Which things are more capable of feeling afraid or fearful? [*Relational condition:* e.g., of enemies or plagues?]
Temor: ¿Cuales cosas son mas capaz de sentir temor o miedo? [Relational condition: e.g., de los enemigos, or las plagas?]

3. Memory: Which things are more capable of remembering things? [*Relational condition*: e.g., where food, water, or their home/nest is?]
Memoria: ¿Cuales cosas son mas capaz de recordar las cosas? [Relational condition: e.g., donde está su comida, agua, o su hogar/nido?]

4. Communication: Which things are more capable of expressing feelings? [*Relational condition:* to others (of their kind)?][47]
Comunicación: ¿Cuáles cosas son más capaz de expresar sentimientos? [Relational condition: a los demás (entre ellos)?]

5. Hunger: Which things are more capable of feeling hungry? [*Relational condition*: e.g., for food or nutrients?]
Hambre: ¿Cuales cosas son mas capaz de sentir hambre [Relational condition: e.g., por comida o nutrientes?]

6. Pain: Which things are more capable of feeling physical pain?[48] [*Relational condition*: e.g., from being hurt or sick?]
Dolor: ¿Cuáles cosa son mas capaz de sentir dolor físico [Relational condition: e.g., de ser lastimado o enfermo?]

(ii) Live: Which things have more capacity to be alive? *[Same across both conditions]*
Vivir: Cuales cosas son mas capaz de estar vivos?

B3. Participants

Don't know responses. These were treated as missing data. For inclusions, this was appropriate given that composite variables (by kind and dimension) reflect a simple mean. For the weighted rank system, however, too many missing data points led to ranks that were not strictly comparable across participants. This is because the weighted rank for each participant was calculated from the total number of items ranked, such that the lowest item (an exclusion or a last place rank) would be ranked "12" for a participant who ranked only 12 entities (leaving out two 'don't knows') but "14" for one who did rank all the entities (regardless of whether all 14 were included or not). Most Ngöbe participants (6 of 8) who gave a "don't know" response did so only once (for a single item on a single capacity ranking), so it did not appreciably affect their aggregated ranks by kind or dimension. However, two Ngöbe participants systematically gave "don't know" responses for the sun and the ocean across multiple capacities, so their aggregate rank scores did not fit the [1,14] scale and were excluded from analysis.

B4. Detailed results for preliminary analyses

Probe order. The six agency capacities were presented in one of two counterbalanced orders, the same for both cultural groups. A series of analyses on the focal outcome measures (with culture and task order as between-subjects factors) confirmed that there was no effect of probe order on agency attributions, as measured by rates of inclusion. Similarly, there was no effect of probe order on mean ranks among Ngöbe. However, probe order did affect mean ranks for US participants: the place of plants versus complex artifacts is flipped across the two probe orders, and this is reflected most strongly on the cognition dimension (there is no effect of probe order for experience). US participants were more likely to

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[47] The original mind-perception survey item read "conveying thoughts or feelings to others," but this probe has two predicates that may tap different conceptions, so we chose a single predicate (presumably the more inclusive one) with "conveying feelings to others."

[48] The original mind-perception survey item read "experiencing physical or emotional pain," but this probe has two parts so we again chose a single predicate (presumably the more inclusive one) with "feeling physical pain."

rank complex artifacts above plants on the probe order that presented Morality first, as compared to when Pain was presented first. This effect was of small enough magnitude that the overall cultural attribution profile still ranked complex artifacts well above plants on the cognition dimension (as reported in the main text).

B5. Detailed results for focal analyses

Overall analysis: As expected, there was a main effect of culture for inclusions, $F(1, 54) = 19.61$, $p < .001$, $\eta^2 = 0.27$, such that Ngöbe had higher rates of inclusion overall ($M = .53$, $SD = .14$) than US participants ($M = .44$, $SD = .06$). This cultural main effect was moderated by kind and (separately by) condition and dimension as described in the main text. There was no main effect of culture for ranks.

Cultural models of agency

Cultural agency attribution profiles by mean rank

Appendix Table B1. Mean ranks for agency[a] by culture

	Mean ranks[b]						
	Ngöbe		**US**			**Overall**	
	(n = 22)		(n = 35)			(N = 57)	
Kind[c]	*M*	*SD*	*M*	*SD*	*U*-test	*M*	*SD*
Humans	2.90_a	(0.91)	2.87_a	(0.62)	*ns*	2.88_a	(0.73)
Animals	5.04_b	(0.98)	4.28_b	(0.39)	184.5**	4.57_b	(0.77)
Plants	8.36_c	(1.29)	9.39_c	(0.89)	172***	8.99_c	(1.17)
Abiotic kinds	9.49_d	(1.47)	11.01_d	(0.31)	72.5***	10.42_d	(1.19)
Complex artifacts	10.99_e	(0.70)	9.61_c	(1.12)	92.5***	10.14_d	(1.19)
Simple artifacts	11.63_f	(0.76)	11.13_e	(0.35)	235.5*	11.32_e	(0.60)

[a] Agency is a composite measure of memory, communication, morality, hunger, pain, and fear.

[b] Lower numbers indicate higher ranks (1 - 14); excluded items scored as tied for last.

[c] Main effect for kind: Means in the same column not sharing the same subscript differ significantly at $p < .05$ in Wilcoxon signed-rank tests.

Note: * Indicates $p < .05$; ** $p < .01$; *** $p < .001$.

Experimental Condition

Experimental Condition: Inclusions. There was a main effect of condition, $F(1, 54) = 10.08$, $p < .01$, $\eta 2 = 0.16$, with higher rates of inclusion in the relational condition ($M = .50$, $SD = .14$) as compared to the original condition ($M = .45$, $SD = .05$). But this main effect of condition was moderated by culture, such that agency attributions only varied by condition for Ngöbe participants.

Details for US inclusions by experimental condition: Original: $M = .45$, $SD = .04$; Relational: $M = .43$, $SD = .07$; condition: $F(1, 33) = 1.16$, $p = .29$, $\eta^2 = .03$; condition by kind, $F(2.22, 73.25) = 1.58$, $p = .21$, $\eta^2 = 0.05$.

Conceptual dimensions: mind-perception

Note on results reporting for conceptual dimensions by each culture: Where appropriate, degrees of freedom are adjusted using Huynh-Feldt estimates due to violation of assumption of sphericity for kind (US inclusions: $\chi^2(14) = 147.75$, $p < .001$, $\varepsilon = 0.42$) (Ngöbe inclusions: $\chi^2(14) = 78.62$, $p < .001$, $\varepsilon = 0.53$) and kind by dimension (US inclusions: $\chi^2(14) = 153.8$, $p < .001$, $\varepsilon = 0.47$) (Ngöbe inclusions: $\chi^2(14) = 51.73$, $p < .001$, $\varepsilon = 0.62$).

Cross-cultural differences on agency attribution to each non-animal kind: Mean ranks also differed in the same direction for each non-animal kind across both experience and cognition, as predicted.

Conceptual organization of agency concepts

Correlations. We also conducted a series of pairwise correlations between each of the eight individual capacities for each kind, considering each cultural group separately. These results told a roundly similar story to that of the aggregate conceptual dimensions reported in the main text.

B6. Cultural Consensus Modeling

Technically, ranking data (as opposed to normal continuous data) violates the axiom of conditional independence given that a response for one item influences the ranks available for another item. In such a case, the posterior checks can be considered approximations rather than exact indicators. However, this does not mean the model used is problematic. In fact others have used a Thurstonian model for rankings identical to the method used here (Lee et al., 2012; Lee et al., 2014), except that the CRM, which detects latent truths, extends this model to multiple cultures and also accounts for response biases and item difficulty. Additionally, the more ranks one uses (e.g., items) the less severe the violation of conditional independence; hence, we used the item-level data with 14 items rather than kind-level data with 5 kinds. As one final note, CCTpack includes two participant response bias parameters as a default setting (this measures the tendency to use the extremes as opposed to the middle of the scale). We did not include response bias parameters in our modeling simulations due to constraints from too many degrees of freedom.

Appendices for Study Series 2: Folkpsychological and folkcommunicative perspectives on plants

Appendix A: Experiment 1

A1. Experiment 1A: Supplementary methods and materials

Culture-specific stimuli for plants and machines were provided in Panama, as follows:

> Plant item (Benefit Present condition): Here is a plant that grows on the ground. This kind of plant depends on sunlight to grow and live. The seedling is starting to grow in the shade, here. The sunlight is over there. When this plant grows, will it keep growing straight forward in the shade, or will it grow over to where the sunlight is?
>
> *Aquí hay una planta que crece en el suelo. Esta planta necesita luz del sol para poder crecer y vivir. La semilla esta empezando a crecer aquí, en la sombra. La luz del sol esta justo ahí. ¿Cuándo esta planta crezca, se mantendrá creciendo recto debajo del sombra, o crecerá hacia donde está la luz?*

For machines, we used line drawings of three familiar machines (motorboat, radio, and chainsaw) to replace the original novel machines ($N = 10$). Otherwise, all aspects of the machine stimuli were conserved (i.e., locomotion, goal objects). (Culture-specific machine items are available from the first author upon request.)

A2. Experiment 1B: Supplementary methods and materials

Question probes for capacity attributions as translated into each study language (English, Spanish, and Ngöbere) are provided below, using as an example item the plant growing toward sunlight. Each probe was phrased in relation to the goal object (e.g., can a plant see, want, feel, or think about the sun?), with the exception of pain, which specified a form of harm (e.g., cutting a plant). As such, each capacity attribution represented an interpretation of that entity's specific goal-directed action presented in the task. This method follows that used in Opfer & Gelman's original study, with the exception of wanting (which was phrased with the object "anything" rather than the goal object).

Can the plant see the sunlight?
¿La planta puede ver la luz del sol?
Ngwina trö törö köteri gwane, dba töin iye ya? (*Si hay luz del sol adentro, ella puede ver la luz?)*

Can the plant feel the sunlight when it touches it?
¿La planta puede sentir el sol cuando la toca?
Ngwina trö törö köteri gwane, dba doin iye ya? *(Si hay luz del sol adentro, ella puede sentir la luz?)*

If it's cut, can the plant feel pain?
¿Si se corta, esta planta puede sentir dolor?
Mö we dö ködrete jödrònbidi gwane, dba nme tare iye ya? *(Si usted la puyas con algo, ella puede sentir dolor?)*

Can the plant think?
La planta puede pensar?
Dba töbike? *(Ella puede pensar?)*

Can the plant want the sun?
¿La planta puede querer el sol?

Ngwina trö törö köteri gwane, dba tönme iye ya? (*Si hay luz del sol adentro, ella puede querer la luz?)*

A3. Experiment 1B: Supplementary results

Missing item response. Due to experimenter error, six US participants were presented with the "want" question for only 2 of 3 plants. Their average "want" attributions to plants were collapsed over 2 rather than 3 items (this was warranted as responses were uniform for both plant items for all 6 participants).

Results. In addition to the cultural differences reported in the main text, we found the expected main effects and interactions (as evident in Figures 1 and 2 presented in the main text); descriptive statistics are provided in Table A1 and tests are reported in Table A2. *Main effects*: There were main effects of kind (animals > plants > machines > artifacts, all *ps* < .01) and of capacity (feeling and wanting were the most frequent attributions, *ps* < .01, and pain more than seeing, *p* < .01). *Condition:* As expected, BP/BA condition had no effect on psychological attributions for either group.

Interactions: In addition to cultural differences in capacity attribution to plants (see main text), cultural differences of lesser magnitude also emerged for the three other kinds. *Animals:* Ngöbe were more likely than US participants to attribute seeing to animals. Inspection of US explanations indicated that situational features of task scenarios prompted infrequent denials that an animal could see the goal object (one was in the animal's mouth; another was inside a log). *Machines:* Ngöbe were more likely than US participants to attribute pain and wanting to machines. *Artifacts*. Ngöbe were also more likely than US participants to attribute feeling and wanting to artifacts. These cultural differences were minor in the absolute sense, and attributions to machines and artifacts were low even among Ngöbe.

Ngöbe culture-specific plant stimulus: Among Ngöbe participants, capacity attributions to plants unexpectedly differed across the two stimulus versions, such that participants were more likely to attribute agency capacities to the culture-specific item depicting an outdoor ground vine ($M = .86$, $SE = .09$) than the original study item from Opfer & Gelman (2001) depicting an indoor potted plant ($M = .45$, $SE = .08$), $F(1, 21) = 11.44$, $p < .01$, $\eta^2 = .35$). As we found for Exp. 1A goal-directed action predictions, however, this effect held for all three plant stimuli (not just the item that differed across versions), so other factors (e.g., participant schooling and church membership) contribute to the observed difference.

Table A1: Mean attributions of agency capacities by culture and kind for Experiment 1B

Psychological capacity / Culture	Animals		Plants		Machines		Artifacts		Capacity Total	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Feel										
Ngöbe	.97	*.10*	.84	*.36*	.33	*.37*	.23	*.31*	.59	*.29*
US	.98	*.08*	.69	*.32*	.16	*.31*	.02	*.08*	.46	*.20*
Total	.98	*.09*	.75	*.34*	.23	*.35*	.11	*.23*	.52	*.25*
Want										
Ngöbe	1	*.00*	.78	*.37*	.35	*.41*	.13	*.28*	.56	*.26*
US	.95	*.12*	.37	*.47*	.13	*.30*	.01	*.06*	.36	*.24*
Total	.97	*.10*	.54	*.48*	.22	*.36*	.06	*.19*	.45	*.28*
Pain										
Ngöbe	.97	*.10*	.71	*.44*	.16	*.35*	.10	*.25*	.49	*.28*
US	1	*.00*	.08	*.22*	.00	*.00*	.01	*.06*	.27	*.07*
Total	.99	*.06*	.34	*.45*	.07	*.23*	.05	*.17*	.36	*.23*
Think										
Ngöbe	.83	*.39*	.46	*.50*	.09	*.29*	.07	*.24*	.36	*.36*
US	.94	*.24*	.16	*.36*	.08	*.24*	.00	*.00*	.30	*.21*
Total	.89	*.31*	.29	*.45*	.08	*.26*	.03	*.16*	.32	*.29*
See										
Ngöbe	1	*.00*	.26	*.41*	.04	*.21*	.04	*.21*	.34	*.21*
US	.91	*.21*	.01	*.06*	.05	*.19*	.00	*.00*	.24	*.11*
Total	.95	*.17*	.11	*.29*	.05	*.20*	.02	*.13*	.28	*.20*
Kind Total	.95	*.13*	.43	*.37*	.14	*.27*	.06	*.16*	.39	*.23*
Overall psychological attributions *(composite scores averaged across 5 capacities)*									Total	
Ngöbe	.95	*.08*	.61	*.33*	.19	*.25*	.12	*.22*	.47	*.18*
US	.96	*.07*	.26	*.20*	.08	*.18*	.01	*.02*	.33	*.08*
Total	*.96*	*.08*	*.40*	*.31*	*.13*	*.22*	*.05*	*.15*	*.39*	*.15*

Table A2: Table of effects for Exp. 1B: Culture, kind, and capacity attributions

Effect	*F* test	Post-hoc
Culture	*F*(1, 54) = 15.26*** η^2 = .22	Ngöbe (*M* = .47) > US (*M* = .33)
Kind	(3, 162) = 388.53*** η^2 = .88	Animals (*M* = .95) > Plants (*M* = .43) > Machines (*M* = .14) > Artifacts (*M* = .06)
Capacity attribution	*F*(4, 216) = 40.78*** η^2 = .43	(Feel, Want > Pain, Think, See) (Pain > See) Feel (*M* = .52), Want (*M* = .45), Pain (*M* = .36), Think (*M* = .32), See (*M* = .28)
Culture Kind	*F*(3, 162) = 13.09*** η^2 = .20	Plants: Ngöbe (*M* = .61) > US (*M* = .26) Artifacts: Ngöbe (*M* = .12) > US (*M* = .02)
Culture × Capacity	*F*(4, 216) = 4.36* η^2 = .08	Feel: Ngöbe (*M* = .59) > US (*M* = .46) Want: Ngöbe (*M* = .56) > US (*M* = .36) Pain: Ngöbe (*M* = .49) > US (*M* = .27) See: Ngöbe (*M* = .34) > US (*M* = .24)
Kind × Capacity	*F*(12, 648) = 16.04*** η^2 = .23	Animals > All other kinds: for all 5 capacities Plants > Machines, Artifacts: for 4 capacities (not See) Machines > Artifacts: for Want
Culture × Kind × Capacity	*F*(12, 648) = 4.59*** η^2 = .08	*(see separate tests for each kind below)*
Animals:		
Culture × Capacity	*F*(4, 216) = 2.96* η^2 = .05	See: Ngöbe (*M* = 1) > US (*M* = .91)
Plants:		
Culture × Capacity	*F*(4, 216) = 5.57** η^2 = .09	Feel: Ngöbe (*M* = .84) > US (*M* = .69) Want: Ngöbe (*M* = .78) > US (*M* = .37) Pain: Ngöbe (*M* = .71) > US (*M* = .08) See: Ngöbe (*M* = .26) > US (*M* = .01)
Machines:		
Culture × Capacity	*F*(4, 216) = 3.40* η^2 = .06	Want: Ngöbe (*M* = .35) > US (*M* = .13) Pain: Ngöbe (*M* = .16) > US (*M* = .00)
Artifacts:		
Culture × Capacity	*F*(4, 216) = 4.97** η^2 = .08	Feel: Ngöbe (*M* = .23) > US (*M* = .02) Want: Ngöbe (*M* = .13) > US (*M* = .01)

* *P*-value > .05, ** *p*-value > .01, *** *p*-value > .001

Appendix B: Language

B1. Language protocol

Primary probes were always presented in the assigned interview language but participants were free to respond in their preferred language; nearly all responded in the assigned interview language (including the US text-based responses, and Panama verbal responses).

B2. Supplementary language results

Among US participants, there were no reliable effects of Spanish versus English for any of the experiments. Among Ngöbe participants, no language effects were observed for Spanish versus Ngöbere on the capacity attribution tasks (Experiments 1B and 2B), where any cross-linguistic differences could have been relevant as an alternative account of observed cultural differences.

Unexpectedly, Spanish-Ngöbere language differences were found among Ngöbe participants for the goal-directed action prediction task (Experiment 1A). Participants predicted more goal-directed actions for plants (across both BA and BP conditions) and animals in Ngöbere than Spanish (*Plants:* $F(1, 19) = 6.46$, $p < .05$, $\eta^2 = .25$; Ngöbere $M = .72$, $SD = .28$; Spanish $M = .44$, $SD = .40$) (*Animals:* $(1, 19) = 4.67$, $p < .05$, $\eta^2 = .20$, Ngöbere $M = .97$, $SD = .10$; Spanish $M = .73$, $SD = .42$). Predictions for machines and artifacts did not differ. This is the one study where we did not predict (or find) cultural differences between US and Ngöbe samples, so the observed language effects are incidental to our primary cultural hypotheses. In any case, they do not alter the overall findings reported for Experiment 1A. We do not think this indicates that Spanish instructions were unclear to participants, because action predictions did not differ for machines or artifacts by language.

The observed effects of language may point to other factors. Both language and stimulus version were correlated with demographic characteristics in our sample: participants in the Ngöbere condition tended to be older and to have fewer years of formal schooling, while participants in the familiar plant stimulus version had less schooling (correlated with stimulus version $r = -.62$, $p < .01$) and were more likely to be members of the Indigenous Ngöbe Church ($r = .59$, $p < .01$). The multiply correlated factors in our sample make it difficult to isolate a single factor in explaining the observed differences for predictions of plant goal-directed actions.

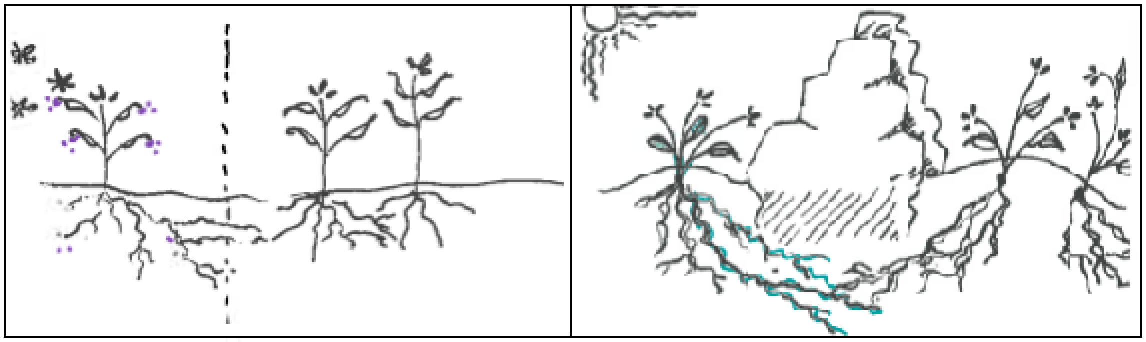
Appendix C: Experiment 2

C1. Participants, pilots and protocol development

Development of the action prediction scenarios and capacity questions involved piloting with several participants. Additionally, some participants did not complete the interview, either leaving blank survey responses (in the US) or finishing early to avoid exhaustion in longer interviews (in Panama). Altogether including pilots, 22 Ngöbe and 32 US individuals participated in Experiments 2A and 2B. Given that many items that pilot participants saw were nearly identical to the final items, we also conducted all analyses reported here on the full participant sample including pilots. All findings hold across both sample sets.

C2. Experiment 2A: Supplementary methods and materials

Communication scenarios



Insect scenario

Drought scenario

(i) Insect communication scenario

Here are 3 plants of the same species. There is an above-ground wall separating the plant on the left from the two plants on the right. The leaves of the individual plants can't touch each other, but the roots are connected. Some insects have arrived and are irritating the plant on the left. As a result, the plant has released chemicals to defend itself from the insects. The chemical is released through both the leaves and the roots. What will happen to the two plants on the other side of the wall, after the left plant releases defensive chemicals against the insects? (Assume that the insects have not arrived on the right side of the wall yet.) (1) The other two plants will also release their chemicals to defend themselves. (2) The other two plants will remain in the same state as before, without releasing chemicals.

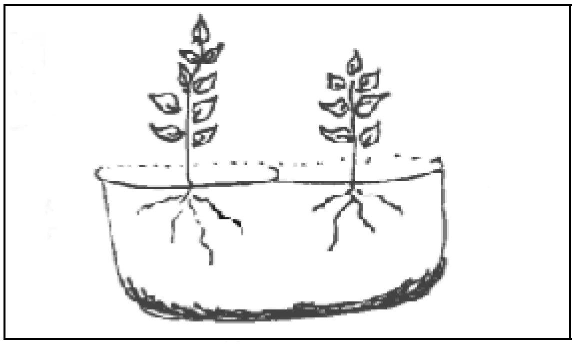
Aquí hay 3 plantas de la misma especie. Hay una pared encima del suelo separando la planta a la izquierda de las otras dos plantas a la derecha. Las hojas de las plantas individuales no pueden tocarse las unas con las otras, pero las raíces si están conectadas. Han llegado unos insectos a molestar la planta a la izquierda. A consecuencia, la planta ha echado unos químicos para defenderse de los insectos. Los químicos son descargados por medio de las hojas y las raíces. ¿Qué va a pasar con las dos plantas al otro lado de la pared después que la planta a la izquierda echo químicos defensivos contra los insectos? (Asume que los insectos todavía no han llegado al lado derecho de la pared.) (1) Las otras 2 plantas van a echar el químico para defenderse de los insectos también. (2) Las otras 2 plantas se van a quedar igual como siempre, sin echar químicos.

(ii) Drought communication scenario

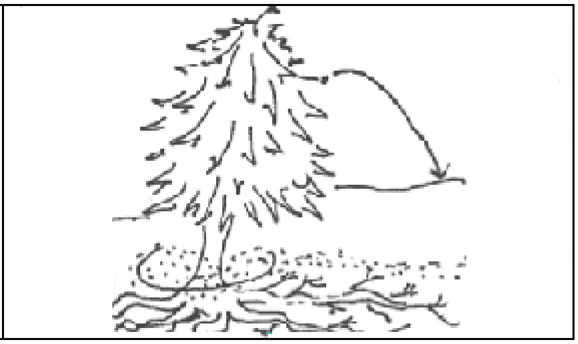
Here are three plants of the same species. These plants have long roots that extend to great depths because they live in an arid area where water is located deep underground. There is one plant growing by itself on the left side of a huge rock cliff. It is connected to the middle plant via roots that travel beneath the rock, but it is not connected to the third plant on the far right. The climate on the left side of the cliff is a bit different from the climate on the right side. Currently, there is a severe drought on the left side. In order to defend itself from the drought, the left plant undergoes a change in its body that allows it to conserve its water use. The drought has not yet reached the other side of the cliff, but it will arrive there in three weeks with even more intensity. What will happen to the other two plants when the drought arrives on the right side of the cliff? (1) They are both going to die because neither of them were prepared beforehand. (2) Only the plant that was connected will survive because it was prepared beforehand.

Aquí hay tres plantas de la misma especie. Estas plantas tienen raíces muy largas que alcanzan una profundidad porque viven en un área seca donde el agua está profundamente debajo del suelo. Hay una planta que está creciendo sola al lado izquierdo de una roca grande. Esta planta está conectada a la planta en medio por medio de las raíces que recorren debajo de la roca, pero no está conectada a la tercera planta que está a la derecha. El clima a la izquierda de la roca es un poco diferente del clima al lado derecho de la roca. Ahorita, hay una sequía grande al lado izquierdo. Para defenderse de la sequía, la planta a la izquierda hace un cambio en su cuerpo que la permite conservar su uso de agua. La sequía todavía no ha alcanzado el lado derecho de la roca, pero va a llegar en tres semanas con más intensidad. ¿Qué va a pasar con las otras dos planta cuando llegue la sequía al lado derecho de la roca? Que pasara cuando la sequía llegue donde ellas? (1) Ellas dos van a morir porque ninguna de ellas estaban preparadas. (2) Solo la planta que estaba conectada va a sobrevivir porque ella estaba preparada antes.

Kin Altruism Scenarios



Sibling scenario



Mother tree scenario

(iii) Sibling kin altruism scenario

The two plants in this pot are of the same species, but are unrelated (not biological kin). If one of the plants is stronger than the other and can more quickly extend its roots, it will capture all the nutrients until the other plant dies. This frequently occurs among unrelated plants. Now we have two plants that are related: they are biological kin. One of the plants (on the left) is stronger than the other and can extend its roots faster than its sibling (on the right). What will happen in this case with the two plants that are biological kin? (1) The stronger plant will extend its roots in all directions and take all the nutrients until its sibling dies. (2) The stronger plant will share the nutrients with its sibling and both will survive.

Estas dos plantas en la maceta son de la misma especie, pero no están relacionadas (no son descendentes de la misma planta). Si una de las plantas es más fuerte que la otra y puede crecer sus raíces en todas partes más rápidamente, puede capturar todos los nutrientes hasta que la otra planta se muera. Esto pasa con frecuencia entre plantas que no son relacionadas. Ahora tenemos dos plantas que son relacionadas: son descendentes de la misma planta. Una de las planta (a la izquierda) es más fuerte que la otra y puede extender sus raíces más rápido que su hermano (a la derecha). ¿Que pasara en este caso con las dos plantas que son descendentes de la misma planta? (1) La planta más fuerte va a crecer sus raíces en todas direcciones y capturar todos los nutrientes hasta que su hermano muera. (2) La planta más fuerte va a compartir los nutrientes con su hermano y los dos van a sobrevivir.

(iv) Mother tree kin altruism scenario

Here is a large tree that is growing in the mountains. After reproducing, it releases one of its seeds. Where will the seed grow better? (Suppose that there is the same amount of sunlight and nutrients in both locations.) (1) Near its mother's roots. (2) Farther away where there are no roots from its mother.

Aquí hay un árbol grande que está creciendo en la montaña. Después de haber reproducido, el árbol descargo una de sus semillas. Dónde va crecer mejor la semilla? (Supone que hay la misma cantidad de luz del sol y nutrientes en las dos posiciones.) (1) Cerca de las raíces de la mama. (2) Más lejos donde no hay raíces de la mama.

C3. Supplementary results on plant interaction predictions

Plant communication: Separate analyses of each prediction scenario showed that this cultural difference held for both communication in response to insects (Ngöbe *M* = .94, *SD* = .24; US *M* = .70, *SD* = .47), t(44.80) = 2.33, *p* < .05, d = 0.70, and communication in response to drought (Ngöbe *M* = .94, *SD* = .25; US *M* = .70, *SD* = .47), t(43.98) = 2.25, *p* < .05, d = 0.68. *Kin altruism:* Separate analyses of each prediction item showed that Ngöbe were far more likely to predict sibling resource sharing (*M* = .82, *SD* = .39) than US participants (*M* = .30, *SD* = .47), t(45) = 3.91, *p* < .001, d = 1.16, but there was no difference in predictions for mother tree, t(43) = -0.03, *p* = .98 (Ngöbe *M* = .35, *SD* = .49; US *M* = .36, *SD* = .49).

C4. Experiment 2A: Supplementary details on coding analysis

Table C1: Coding categories for explanations of plant social action predictions

Code	Domain / Example explanations
Other-directed goal	
	Communication
	“They were communicating underground and telling the other tree, they were warning it that it has to save some water.” (Ngöbe, Drought)
	“The plants worked synergistically, together, so that they could all be protected.” (US, Insects)
	Kin altruism
	“Because the mom is giving her food to eat…as if the mom is giving her some help to grow.” (Ngöbe, Mother tree)
	“The mother tree will help its baby via roots.” (US, Mother tree)
Individual goal	
	Communication
	“Maybe they feel the chemical defense on the other side and that’s why they think that it is better that they prepare too.” (Ngöbe, Insects)
	“They sense the chemicals and it’s a natural response to survive. The roots were very close.” (US, Insects)
	Kin altruism
	“It will be next to its mom and it will grow better because if you put it apart, then it will starve.” (Ngöbe, Mother tree)
	“It can take nutrients from its mother to help it grow instead of having to completely fend for itself.” (US, Mother tree)
Mechanistic	
	Communication
	“Because it will be spreading its roots, its leaves, its flowers. It is strong. (Ngöbe, Insects)
	“Its roots will likely have been changed due to the other plant. It's not ‘preparing itself’, it's responding to a simple stimulus from another plant to change.” (US, Drought)
	Kin altruism
	[No] [1] “The territory where the roots are, the mother tree, is already too dry. The nutrients that are there are not strong enough for a new seed to grow.” (Ngöbe, Mother tree)
	“The roots help stabilize the young tree.” (US, Mother tree)

[1] All explanations are for positive action predictions, except this case where none was available because no Ngöbe respondent provided a mechanistic explanation for kin altruism.

Coding reliability. Two independent coders judged a subset of explanations (representing over 30% of the corpus of explanations) for interpretations of plant interactions. Inter-rater reliability on the assignment of explanatory codes was high for both communication explanations (Kappa = .81, $p < .001$; percent agreement = 88%) and kin altruism explanations (Kappa = .76, $p < .001$; percent agreement = 88%).

Detailed coding results. Kin altruism: Explanation data was available from US participants for the mother tree scenario but not the sibling plant scenario, so we do not report coding analyses for kin altruism explanations in the main text. Nonetheless, the results from available explanation data roundly supported our overall thesis, as reported here. *Mother tree.* Among participants who predicted that the seedling would grow better closer to its mother ($N = 16$), we found that only Ngöbe construed the interaction as one involving the mother's goals for her seedling, as indicated by a reliable cultural difference on the 2 x 3 chi-square analysis, χ^2 (1, $N = 16$) = 5.88, exact, 2-sided $p < .05$ (using the N-1 chi-square test). Ngöbe were more likely to refer to social goals than either individual goals or biological mechanisms. In contrast, US participants predominantly explained the mother-tree interaction in terms of biological mechanisms or individual goals. *Sibling plants:* Ngöbe explanations for sibling sharing were analyzed, and these showed the same pattern of social goal interpretations as for the other prediction scenarios.

C5. Experiment 2B: Supplementary methods and materials

Question probes for social capacity attributions as translated into each study language (English, Spanish) are provided below, with accompanying stimuli indicated in brackets.

> *Signaling.* Do you think that plants can communicate with and send signals to one another?
> *¿Tú crees que las plantas pueden comunicar o mandar señales entre ellas mismas?*
> [Insect communication illustration]
>
> *Kin recognition.* Do you think that plants can recognize who their kin are?
> *¿Tú crees que las plantas pueden reconocer quiénes son sus descendentes?*
> [Sibling plant illustration]
>
> *Mother help*. Do you think that a mother tree can help its baby tree via roots?
> *¿Crees que la mama puede ayudar él bebe árbol por medio de sus raíces?*
> [Mother tree illustration]
>
> *Feel other's pain.* [This item was presented after an initial question, "Can this tree feel pain when you cut it?"] Now suppose that there are other trees from the same species growing around this fallen tree. Can they feel the tree's pain even though they themselves were not cut?
> *Ahora supone que hay otros árboles de la misma especie creciendo alrededor de este árbol que ha caído. ¿Ellos pueden sentir el dolor del árbol, aunque ellos mismos no fueron cortados?*
> [Photograph of a chainsaw-fallen tree and stump]

C5. Experiment 2B: Supplementary results

In addition to the cultural differences reported in the main text, there were several main effects and interactions, as would be expected (evident in Figure 5 presented in the main text). *Main effects*: There was a main effect of capacity, $F(3, 126) = 8.43$, $p < .001$, $\eta^2 = .17$. Plant signaling was most often endorsed ($M = .81$, $SD = .44$) and reliably more so than either feel other's pain ($M = .41$, $SD = .31$) or kin recognition ($M = .56$, $SD = .50$), ps < .05. The capacity for a mother to help offspring ($M = .66$, $SD = .50$) was more often endorsed than feel other's pain, $p < .05$. Capacity attributions for feel other's pain and kin recognition did not reliably differ.