Cross-cultural evidence of cognitive adaptations for social exchange among the Shiwiar of Ecuadorian Amazonia

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On the basis of evolutionary game theory, it was hypothesized that humans have an evolved cognitive specialization for reasoning about social exchange, including a subroutine for detecting cheaters. This hypothesis led to a specific prediction: Although humans are known to be poor at detecting potential violations of conditional rules in general, they should nevertheless detect them easily when the rule involves social exchange and looking for violations corresponds to looking for cheaters. This prediction was subsequently confirmed by numerous tests. Evolutionary analyses further predict that: (*i*) in humans, complex adaptations will be distributed in a species-typical fashion; and (*ii*) aspects of cognitive organization relevant to performing the evolved function of an adaptation should be more buffered against environmental and cultural variation than function-irrelevant aspects. Here we report experiments testing whether social exchange reasoning exhibits these properties of adaptations. Existing tests of conditional reasoning were adapted for nonliterate experimental subjects and were administered to Shiwiar hunter–horticulturalists of the Ecuadorian Amazon. As predicted, Shiwiar subjects were as highly proficient at cheater detection as subjects from developed nations. Indeed, the frequency of cheater-relevant choices among Shiwiar hunter-horticulturalists was indistinguishable from that of Harvard undergraduates. Also as predicted, cultural variation was confined to those aspects of reasoning that are irrelevant to social exchange algorithms functioning as an evolutionarily stable strategy. Finally, Shiwiar subjects displayed the same low performance on descriptive conditionals as subjects from developed nations. Taken together, these findings support the hypotheses that social exchange algorithms are species-typical and that their evolutionarily stable strategy (ESS)-relevant subroutines are developmentally buffered against cultural variation.

reciprocation | cooperation | economics | game theory | evolutionary psychology

Although zoologically rare, social exchange has evolved in a variety of species, from vampire bats to baboons, indicating that some species have evolved the adaptations necessary for engaging in this behavior whereas others have not (1, 2). Evidence that social exchange behavior has been an ancient and enduring characteristic of our own species can be found throughout the ethnographic record, and both paleoanthropological research and its presence in chimpanzees suggest that this particular form of social interaction may be older than the genus *Homo* (3–8). Selection pressures favoring social exchange exist whenever one organism (the provisioner) can change the behavior of a target organism to the provisioner's advantage by making the target's receipt of a provisioned benefit *conditional* on the target acting in a required manner. This mutual provisioning of benefits, each conditional on the other's compliance, is what is meant by social exchange or reciprocation (9, 10).

Evolutionary biologists have shown through game-theoretic techniques that adaptations for social exchange can be favored and stably maintained by natural selection, provided they include design features that (*i*) enable them to detect cheaters (i.e., those who do not comply or reciprocate), and (*ii*) cause them to channel future benefits to reciprocators, not cheaters[d] (11–14). These analyses prompted the hypothesis that the human neurocognitive architecture includes *social contract algorithms*: a set of circuits that were specialized by selection for solving the intricate computational problems inherent in adaptively engaging in social exchange behavior. Among these is a subroutine for cheater detection (9, 15, 16).

A *social contract* specifies a situation in which an individual must satisfy a requirement of some kind (often at some cost to him- or herself), in order to be eligible to receive a benefit from another individual or group. Cheating is a violation of a social contract in which the benefit is illicitly taken (i.e., without satisfying the requirement upon which provision of that benefit was made conditional) (9, 15, 16).

Conditional Reasoning. Because conditionally delivered behavior requires conditional reasoning for its regulation, methods drawn from the study of conditional reasoning have been used to conduct a series of experiments testing for the presence of social contract algorithms and their predicted properties. The hypothesis that the brain contains social contract algorithms (the *adaptive specialization hypothesis*) predicts a sharply enhanced ability to reason adaptively about conditional rules when those rules specify a social exchange. The null hypothesis is that there is nothing specialized in the brain for social exchange: This hypothesis predicts no enhanced conditional reasoning performance specifically triggered by social exchanges as compared with other contents.

The Wason selection task (17–19) is a test of conditional reasoning in which subjects are asked to identify possible violations of a conditional rule of the form *If P then Q* (see Fig. 1*a*). As predicted by the adaptive specialization hypothesis, when the conditional expresses a social contract and detecting a violation corresponds to detecting a cheater, subjects perform very well—65–80% of subjects answer correctly (15, 16, 20–24). In contrast, the hypothesis that high performance on social exchange conditionals is a byproduct of a general cognitive ability to reason well about all conditionals has been repeatedly falsified: A large literature shows that people are very poor at detecting violations of conditional rules when the conditional describes almost any other state of the world. A correct response (*P and not-Q*) on such rules is typically elicited from only 5–30% of subjects tested (15–19). People reason poorly even about conditionals that are almost identical to social contracts, but that lack even one of their key defining features (15, 16, 20–24).

Abbreviation: ESS, evolutionarily stable strategy.

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[d]These features are necessary for the adaptations causing the behavior to be an evolutionarily stable strategy or ESS (14). For the application of the game-theoretic constraints to cognition, see ref. 9.

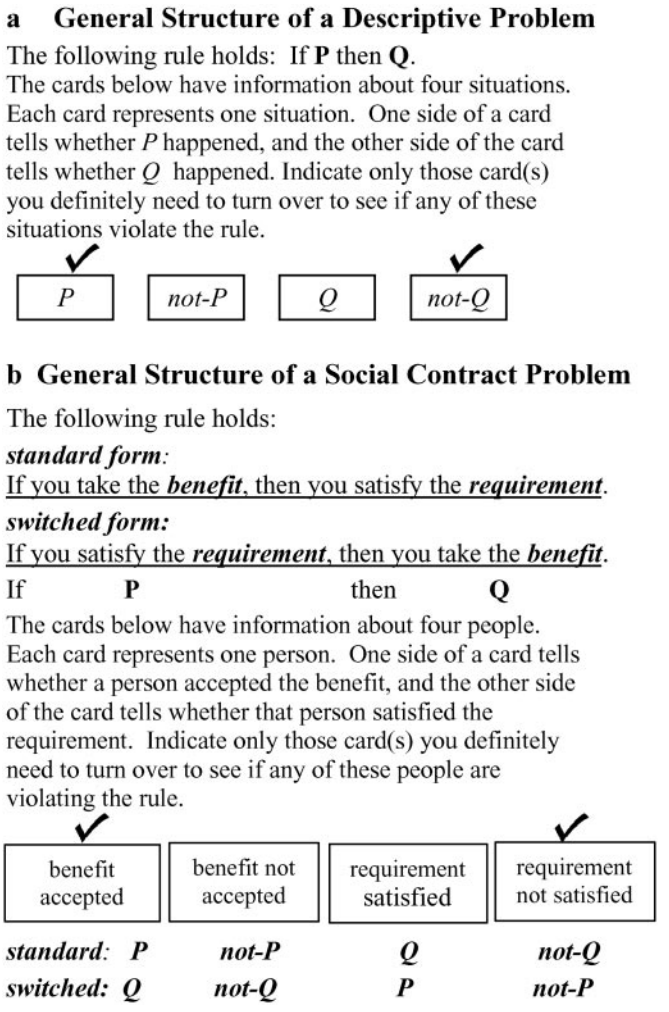

Fig. 1. The Wason selection task. The conditional rule (If *P* then *Q*) always has specific content (see *Methods* for examples). (*a*) The general structure of the task in logical terms. Check marks indicate the logically correct card choices. (*b*) The general structure of the task when the content of the conditional rule expresses a social contract. It can be translated into either logical terms (*P*s and *Q*s) or social contract terms (benefits and requirements). Here, check marks indicate the correct card choices if one is looking for cheaters. The benefit term appears in the antecedent (*P*) in the standard form, and in the consequent (*Q*) in the switched form.

Variants of the null hypothesis—that people's facility at cheater detection is a byproduct of some more general cognitive ability—have been empirically tested in many ways (15, 16, 20–26). For example, the accompanying article (25) reports that focal brain damage can selectively impair social exchange reasoning while leaving intact other cognitive abilities (including conditional reasoning about closely parallel rules). This discovery provides support for the hypothesis that social exchange reasoning is an adaptive specialization, rather than the expression of some more general cognitive ability.[e] Similarly, it has been shown that cheater detection is not a byproduct or special case of the activation of logical reasoning (15, 16, 20–23). As in the experiments reported here, a generic social contract can be expressed in a number of ways: e.g., "If you take the benefit, then you (must) satisfy the requirement" (standard form) or "If you satisfy the requirement, then you (may) take the benefit" (switched form). Subjects routinely check for cheating by choosing the cards that represent a person who has accepted the benefit and a person who has not satisfied the requirement, regardless of the logical category these choices fall into. Specifically, by detecting cheaters, subjects produce an adaptively correct response that incidentally corresponds to the logically correct answer (*P and not-Q*) on standard social contracts, but that corresponds to a logically incorrect answer (*Q and not-P*) on switched social contracts (15, 16, 20–23). (See Fig. 1*b*).

Ontogeny and the Logic of Cross-Cultural Tests. If the algorithms that produce social exchange reasoning are an evolved adaptation, their development should be buffered against disruption by cultural or environmental variability, with acquisition caused by mechanisms selected for that function (as in the case of language[f]) (27–30). In contrast, the null hypothesis is that all apparent cognitive specializations are the product of a few general-purpose, content-independent acquisition processes acted on during ontogenesis by differentiated local cultural and physical environments (31, 32)[g]. Contrary to the predictions of this general-purpose acquisition hypothesis, performance on conditional reasoning problems that do not involve social contracts (or other evolutionarily significant domains) remains at low levels even when the rules tested are culturally familiar[h] (15–19), or when subjects are trained, taught logic, or given incentives to perform well (17–19, 33). Even more striking, however, is that, contrary to the general-purpose acquisition hypothesis, subjects perform just as well on their very first exposure to culturally unfamiliar social contracts as they do on culturally familiar ones, so that there is no evidence for improvement even with a lifetime of exposure (15, 16, 20–24).

Still, the key divergence between the two explanations involves the predicted distribution of specialized reasoning skills or abilities across the human species (20, 21). Social contract algorithms are predicted to be cross-culturally universal, because complex adaptations in long-lived species with open population structures, such as humans, will almost always be distributed in a species-typical fashion (34).[i] Similarly, selection favors buffering the functional aspects of adaptations against environmental disruption—a selection pressure that is absent from functionally irrelevant aspects of adaptations, which are therefore more free to vary (34). In contrast, skills acquired through more general-purpose inductive processes are distributed across cultures in a more variable fashion: this is true even when adaptations play some part in building them [e.g., counting; lexically distinguishing yellow from black, white, and red; (35–39)[j]]. If social exchange reasoning is acquired by means of more general-purpose processes, then it might be absent from many cultures, its features might vary in widely divergent settings, and, in particular, they need not exhibit the narrow properties necessary for it to constitute an evolutionarily stable strategy (ESS). Indeed, under the null hypothesis there is no reason to expect ESS-relevant aspects of social exchange reasoning to be less variable than

[e]For an opposite dissociation, where social exchange reasoning is preserved but more general cognitive abilities are impaired (in schizophrenia), see ref. 26.

[f]Functionally specialized acquisition mechanisms buffer development by solving problems of combinatorial explosion in environments that do not uniquely determine an outcome when analyzed by more general inductive procedures (27, 28).

[g]For discussion of acquisition views, see refs. 29 and 30.

[h]That familiarity *per se* does not facilitate logical reasoning on this task is uncontroversial at this point (15–19).

[i]This condition holds if the adaptation is complex—that is, its genetic basis depends on the simultaneous presence of specific alleles at several different independent loci. The more loci involved, the more likely the adaptation in question is ancient and species-typical. Almost all cognitive adaptations will require, for their specification, more than a few loci, and so will be complex in this sense. (Also, adaptations for cheater detection are not predicted to be expressed facultatively.)

[j]Although counting systems vary widely, there are adaptations that make them possible and place certain constraints on them (35, 36). The same is true for color terms (37–39).

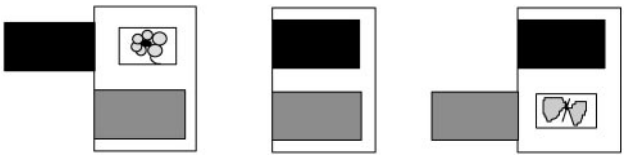

Fig. 2. Wason selection task modified for nonliterate subjects: Schematic representation of the ''cards.'' Both doors are closed on the middle card. Opening the top door reveals a photo representing either a true or false antecedent (e.g., the presence of a particular flower). Opening the bottom door reveals a photo representing either a true or false consequent (e.g., the presence of a butterfly).

ESS-irrelevant ones, because general-purpose acquisition machinery has not been designed to distinguish between them.

Although cognitive experiments supporting the hypothesis that there is a reasoning specialization for cheater detection have been conducted in a number of different societies, these sites were all in developed nations (e.g., U.S., Hong Kong, U.K., Germany), and all involved literate subjects (20–24, 31). Although each instance is informative, the evidence for species-typicality gains strength in proportion to the diversity of subject populations tested, and cannot be considered strong if the only populations tested are from modern market economies. For this reason, we chose as our study population the Shiwiar of Ecuadorian Amazonia, a group of hunter–horticulturalists whose way of life is as different from life in industrialized societies as any that presently exists, and one that in several key respects more closely reflects the kind of social environment in which humans evolved. The focus of research was to test whether the Shiwiar would exhibit the same subtle patterns of reasoning as all other tested populations do, despite major differences in cultural, social, and physical environments.

Methods

Shiwiar Participants. Shiwiar in the study area have no everyday direct contact with outsiders (see *Appendix*). The rivers the Shiwiar live along become unnavigable long before they reach the frontiers of colonization, and there are no roads. They depend on hunting (often with blowguns), fishing, gardening, and foraging for their livelihood. Relatively few Shiwiar speak Spanish, and Shiwiar, a non-Indo-European language, is the language of daily life. Traditional ties of kinship and affinity dominate social relationships mediated by gossip, witchcraft, and the threat or use of violence, and the Shiwiar continue to interpret the world through a culturally distinctive worldview. Although it is impossible now to find a group of people who are not subject to some influence from the industrialized world, Shiwiar in the study villages are at the far end of this spectrum. To the extent that they have been influenced by the outside world, it has been largely a material influence, such as the gradual adoption of some nonindigenous crops, and the acquisition of various tools and artifacts.

Stimuli and Procedures. Fig. 2 depicts how we modified the Wason task for use with nonliterate subjects (see *Appendix*). Each subject was presented with a descriptive problem, a standard social exchange problem, and a switched social exchange problem. The rules were embedded in a story context. All of the problems had unfamiliar content and study participants had no direct or prior experience with the rules. The order of the problems was reversed for half of the subjects.

Predictions

For well-established reasons (40, 41), experimentation under field conditions injects higher levels of error variance into results than are obtainable under well-controlled laboratory conditions.[k] Nevertheless, if social contract algorithms are an evolved adaptation, and hence a reliably developing species-typical feature of the human neurocognitive architecture, then:

(*i*) Shiwiar subjects should show the same strong propensity to select the cards that correspond to detecting cheaters as subjects do in developed nations.

(*ii*) To the extent that cultural variation is exhibited, it should be differentially found in card selections that are irrelevant to performing the function of the adaptation—that is, to detecting cheaters. Only cheater-detecting choices reflect the operation of evolved algorithms necessary to make social exchange an evolutionarily stable strategy, and so only those are predicted to be developmentally buffered against cultural variation and other sources of perturbation.

(*iii*) For social contracts, social exchange categories (benefit accepted/requirement met) are hypothesized to be a deeper representational format than logical categories (antecedent = P/consequent = Q). For these problems, Shiwiar card choices should parallel each other when the cards are analyzed in terms of their role in social exchanges, but not when analyzed in terms of their logical role in the propositional calculus (which differs for the standard and switched forms).

Results

If mechanisms specialized for cheater detection are universal features of the human cognitive architecture, then one would expect Shiwiar to say ''yes'' to the *benefit accepted* and *requirement not satisfied* cards. Errors of omission—failing to choose either of these cards—would suggest a failure to understand what events are relevant to detecting cheaters, and would therefore be very damaging to the hypothesis. Such errors were rare. The *benefit accepted* card was chosen by 86% of subjects on both social contracts (chance = 50%; $p = 0.00013$). The *requirement not satisfied* card was chosen by 86% of subjects for the standard social contract ($p = 0.00013$), and by 81% for the switched social contract ($p = 0.0011$). These figures are almost identical to those from a comparable study done at Harvard (15, 16): 75–92% of the Harvard undergraduates tested chose the cheater-relevant cards in response to parallel problems (see Fig. 3[l]). Shiwiar made more correct cheater detection selections in two cases, Harvard students in the other two, and the average difference between these populations in cheater detection card choices was just 1 percentage point, favoring the Shiwiar.

In other words, like Harvard undergraduates, Shiwiar subjects almost always chose the cards necessary for detecting cheaters. This

[k]Experimentation under field conditions injects higher levels of error variance into results than are obtainable under well-controlled laboratory conditions. More significant than factors such as added distractions, interruptions, and language difficulties is the extreme cultural strangeness of experimental testing itself, with its unfamiliar necessity of adhering to formal, abstract, and seemingly arbitrary behavioral and communicative constraints. Shiwiar subjects had no prior experience with experimental test-taking situations. This situation introduces confusion into the communicative pragmatics inherent in the task situation, and error variance into results. Restricting one's responses to the question *explicitly* asked, and ignoring information (such as who may be exhibiting generosity to whom) that is relevant to real life but not to a test problem, is a skill one learns in classrooms and courtrooms. Presumably, this is why schooling affects how people reason about problems involving hypotheticals (40) (such as those posed by Wason tasks). In virtually every other social context, when a question is asked, the pragmatic implication is that the asker does not already know the answer, and would like to be told whatever information might be relevant to solving his problem (41). Thus we predicted that Shiwiar performance would reflect two factors: (*i*) their lack of familiarity with the culturally specific pragmatics of Western testing situations (such as the task demand to ignore interesting information), which would cause cheater-irrelevant cards to sometimes be selected, and (*ii*) the presence of a species-typical cheater detection mechanism, which would cause a strong propensity to select cheater-relevant cards.

[l]The Harvard data (15, 16) were chosen for purposes of comparison because (*i*) these problems most closely paralleled the ones given to the Shiwiar, (*ii*) it was the most complete parallel data set, and (*iii*) this comparison placed the hypothesis in greatest jeopardy. Shiwiar look even more similar to subjects from developed nations when other data sets are used.

PSYCHOLOGY

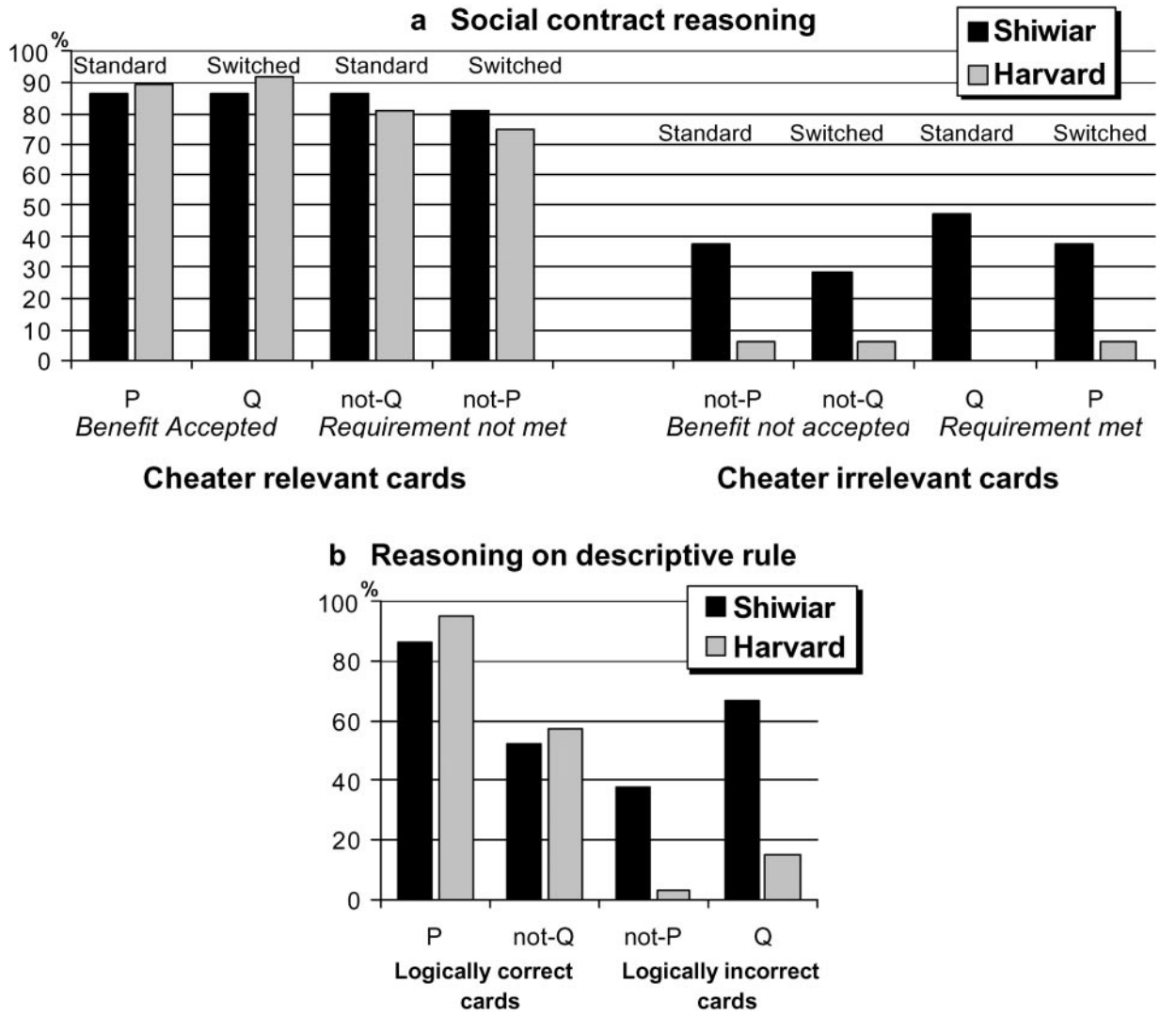

Fig. 3. Individual card selections: Comparison of the performance of Shiwiar subjects with that of Harvard undergraduates. (*a*) Performance on social contracts. (*b*) Performance on descriptive rules.

result was not because of a nonspecific tendency to choose all cards. Although the surface content of the three problems differs, all express conditional rules of the form *If P then Q*. Therefore, card choices can be classified by *logical* category, and compared across problems (e.g., *P* is cheater relevant for a standard social contract, but not for a switched one; see Fig. 1, Table 1). Holding logical category constant, each card in a social contract was chosen significantly more often when it was relevant to cheater detection than when it was not (*P*: 86% vs. 38%; *not-P*: 81% vs. 38%; *Q*: 86% vs. 48%; *not-Q*: 86% vs. 29%; range of values: $0.0045 > p > 0.00018$; $0.69 > r > 0.54$[m]). Additionally, for both social contracts, the number of subjects choosing cheater irrelevant cards (*benefit not accepted*; *requirement satisfied*) was below chance, although not always significantly so (see Table 1[n]). In every case, however, selection frequencies were in the predicted direction (above 50% for cheater-relevant cards and below 50% for cheater-irrelevant cards). The probability of obtaining this pattern by chance alone is only 1 in 256 ($2^{-8} = 0.004$).

Table 1. For social contracts (SC), frequency of card choices follows social contract category, not logical category; Shiwiar subjects ($n = 21$)

Card category	Standard SC	Switched SC	Descriptive
Social contract category			
Benefit accepted	18	18	
Benefit not accepted	8	6	
Requirement met	10	8	
Requirement not met	18	17	
Logical category			
P	18	8	18
Not-P	8	17	8
Q	10	18	14
Not-Q	18	6	11

Cheater-relevant cards: *Benefit accepted* corresponds to *P* for standard version, *Q* for switched. *Requirement not met* corresponds to *not-Q* for standard version, *not-P* for switched.

[m]Paired *t* tests: For *P*: $t^* = 4.16$, $r = 0.68$, $p = 0.00024$; for *not-P*: $t^* = 3.21$, $r = 0.58$, $p = 0.0022$; for *Q*: $t^* = 2.89$, $r = 0.54$, $p = 0.0045$; for *not-Q*: $t^* = 4.28$, $r = 0.69$, $p = 0.00018$.

[n]The frequency of choosing the *benefit not accepted* card was significantly below chance ($p = 0.02$) for the switched social contract, and for all other irrelevant card choices in the predicted direction, but not significantly so (i.e., $p > 0.05$). For the descriptive problem, only the *P* card was chosen more often than chance.

Thus cheater-relevant cards were overwhelmingly and selectively chosen by Shiwiar subjects. When they made errors, these were disproportionately on cards irrelevant to cheater detection, through sometimes exhibiting an interest in additional cards—errors of curiosity. As predicted by the hypothesis that functionally important aspects of an adaptive specialization should be more buffered against disruption, the Harvard and Shiwiar subjects did not differ in their propensity to choose ESS-relevant, cheater-detection cards. Also as predicted, these populations differed more in their propensity to choose ESS-irrelevant cards than ESS-relevant ones: the magnitude of this difference was more than 6 times greater for ESS-irrelevant cards.

We also scored responses by using the most stringent scoring criterion: an answer was counted as correct only if the subject chose the two necessary cards *and no others*. Although this very strict scoring criterion penalizes errors of curiosity [and, given task pragmatics, non-Western subjects (40)[k]], it is nevertheless relevant: Finding that this exact pattern is the modal response, despite error variance due to task pragmatics, would further militate against the hypothesis that Shiwiar are choosing the correct cheater-detection cards merely because of an indiscriminate interest in all cards. In contrast, if Shiwiar construe the world in a way that is incommensurate with Western conceptions, or have reasoning mechanisms that embody very different principles, or even answer randomly, then there is no reason to expect the stringent pattern to occur more often than chance.[o]

Sixty-two percent of Shiwiar subjects produced this pattern in response to at least one of the two social contracts (chance = 12%; $p = 2.0 \times 10^{-7}$, $h' = 1.106$). It was also the modal response if one considers each social contract problem individually: this pattern was elicited from 47.6% of Shiwiar subjects for the switched social contract and from 33.3% for the standard one (chance = 6.25%[p]). Each of these proportions is much higher than chance, and the effect sizes are large by conventional standards ($p = 1.54 \times 10^{-6}$, $h' = 1.018$; $p = 0.00044$, $h' = 0.726$, respectively).

Another way of assaying for the presence of domain-specific social contract algorithms is to see whether the social contracts elicited a different pattern of responses than the descriptive problem. Table 1 shows that the response profile for the descriptive problem does not match that for either social contract: Like American subjects, Shiwiar treat descriptive rules differently from social contracts. The same is true if one compares responses by using the stringent scoring criteria. No Shiwiar answered *Q and not-P* to the descriptive problem, but 47.6% produced this otherwise unusual pattern in response to the switched social contract ($t^* = 4.26$, $p < 0.00025$, $r = 0.69$). *P and not-Q*, the logically correct response for a descriptive problem, is also the correct cheater-detection response for a standard social contract. Yet more Shiwiar subjects gave this response to the standard social contract than to the descriptive problem (33.3% vs. 14.3%, $t^* = 1.71$, $p = 0.052$, $r = 0.38$[q]). By conventional standards, the first effect size (0.69) is large and the second (0.38) is medium; these Shiwiar effect sizes are not significantly different from those for the Harvard students.[r] [The descriptive problem did not elicit the logically correct answer (*P and not-Q*) more often than chance (14.3%, $p = 0.14$), and it elicited *Q and not-P* less often than chance (0%; $p < 0.05$)[s].]

Most importantly, the response profiles in Table 1 reveal which problems the Shiwiar were construing as similar, and what dimensions they were using to do so. When sorted by social contract category (i.e., benefits and requirements), the two social contracts elicited response profiles that are almost identical. But when sorted by logical category, the selection frequencies for standard and switched social contracts are notably at variance with one another (and neither profile matches the descriptive rule). This means (*i*) Shiwiar minds construed the two social contract problems as similar to each other and different from the descriptive problem, and (*ii*) for social contract problems, a social contract categorization scheme captures dimensions that are psychologically real for Shiwiar subjects, whereas a logical categorization scheme does not. The same result obtains for the Harvard undergraduates (15, 16).

Conclusions

The function of a cheater-detection subroutine is to draw attention to potential cheaters, regardless of whatever else in the situation might be of interest. If this subroutine is a reliably developing, species-typical feature of the human mind, then Shiwiar should overwhelmingly choose the cards necessary for detecting cheaters on social contracts. They did. Indeed, Shiwiar hunter–horticulturalists and Harvard undergraduates had identical response profiles for these ESS-relevant cards.

This finding is consistent with the prediction that responses necessary for social exchange to function as an ESS will be developmentally buffered against cultural variation. It is difficult to imagine two populations that differ more than Shiwiar villagers and Harvard students in their exposure to Western-style schooling, word problems, the institution of science, or the concept of an experimental situation—factors that are known to affect performance in cross-cultural studies of cognition. The extreme cultural unfamiliarity of the test situation should introduce error into the Shiwiar data, thereby lowering their performance ceiling. Yet this effect appears only when one looks at the propensity to choose cards with information that, while interesting, is irrelevant to detecting cheaters (errors of curiosity). ESS-relevant choices were culturally uniform; ESS-irrelevant choices were free to vary with the cultural situation.

In short, Shiwiar performance on reasoning problems involving social exchange is what was predicted on the hypothesis that social contract algorithms are a reliably developing, universal feature of the human cognitive architecture, functioning as an evolutionarily stable strategy. Such a universal competence, if it exists, would serve as one of the cognitive foundations for human economic activity, as well as certain other cooperative dimensions of human sociality.

Appendix

Subjects. Twenty-one male and female Shiwiar individuals ranging from 16 to approximately 60 years of age participated in the experiment. Verbal consent was obtained to carry out this study from all individuals who participated, as well as from village leaders and other appropriate authorities.

Shiwiar live in a remote area, and have little direct contact with outsiders. What contact they have is possible primarily by

[o]A yes/no judgment for each of four cards results in $2^4 = 16$ combinatorial possibilities; hence the probability of choosing all and only the correct cards by chance is $1/16 = 6.25\%$. The probability of getting at least one of two social contracts right by chance is $[1 - (15/16)^2] = 12\%$.

[p]This result is very robust to changes in assumptions about what counts as chance. Suppose, for example, that people everywhere think that one particular card needs to be chosen for any conditional rule, regardless of content. If it happened to be one of the cards that a person looking for cheaters would choose, then 8 of the 16 combinatorial possibilities would be eliminated, and 12.5% of subjects would answer correctly by chance. Nevertheless, such an arbitrary doubling of the value of chance does not affect the conclusions: cheater detection among Shiwiar would still be higher than chance at the $p < 0.01$ level.

[q]Given $n = 21$ and a medium effect size of 0.38, the probability of finding a difference that is significant at the 0.05 level is only 34% (42). Increasing sample size to increase the power of the test was not an option: we tested everyone in the village who was willing (to get 80% power, $n = 80$).

[r]Significance test for differences in effect size uses Fisher's *z* transformation of *r* (43).

[s]*Q and not-P* is the correct response if one is looking for cheaters on a switched social contract, but for a descriptive conditional, it is both logically incorrect and almost never produced by subjects from developed nations.

means of missionary emergency medical airlift on small dirt airstrips cut in the forest with machetes and axes. These flights typically do not enter a given village for months on end and in smaller villages may not be made for periods as long as a year. Missionaries are not resident in study villages and Shiwiar leaders prohibit the presence of most outsiders.

Task and Stimuli. The Wason task was modified for use with nonliterate subjects (see Fig. 2). First, we used actual cards to present the experimental stimuli and presented content information visually in photographs instead of in writing. Second, instead of having information presented on two sides of the card we presented the information about the antecedent and consequent in two photos on one side of the card. These photos were covered by "doors," which could be opened to reveal a photo. In every experiment, the photo depicting the antecedent appeared on top, while the photo depicting the consequent appeared on the bottom. Third, we presented subjects with one card at a time. That is, they were presented with one photo and asked whether they needed to see the covered photo on the same card to know if that card broke the rule being tested. When the subject gave his/her response, the experimenter presented the next card until all four alternatives were presented. All of this was done to reduce memory load, given that this is a verbally administered version of what is usually a written task.

Translation of Instructions. Because no Shiwiar speak English, protocols were first translated into Spanish. The method, along with the Spanish versions of the switched social contract and descriptive rule, were then pretested on 33 13- and 14-year-olds at a Quito junior high school with results similar to those found among U.S. college populations (social contract: 61% correct; descriptive: 12% correct). The protocols were then translated from Spanish to Shiwiar by a bilingual assistant, and recorded onto a cassette tape, with independent translation back into Spanish serving as a check on the accuracy of the Shiwiar version.

Procedures. Subjects were presented instructions and experimental content in Shiwiar from a cassette tape. Before testing, subjects were familiarized with the task as follows. Each subject was presented with a Wason selection task employing a descriptive rule: *"Chinki keakau nakumkamau yakinini, turasha yurank naranja nukamkamau nunkanini"* ("If there is a red bird in the drawing on top, then there is an orange on the drawing below"). All photos on six cards were shown to the subject. The experimenter emphasized that on top there was always one class of item, in this case different colored birds, and on the bottom there was always a different class of item, in this case different kinds of fruit. The cards were then covered and shuffled, and the test was run to familiarize the subject with the test and to test subjects' understanding of the procedures. No feedback about correct versus incorrect responses was given.

After this instruction set, each subject was presented with another descriptive problem, a standard social exchange problem, and a switched social exchange problem. The rules were embedded in a story context. All of the problems had unfamiliar content and study participants had no direct or prior experience with the rules. The standard social contract was a social contract law "If you eat mongongo nut [described as an aphrodisiac], then you must have a tattoo on your chest" [described as a mark denoting married status]. The switched social contract was a personal exchange "If you give me a basket of fish when you return from fishing, then you may use my motorboat." (Residents of the study villages have seen boats with outboard motors, and consider them desirable, but no one there owns one.) The descriptive problem was "If there is a green butterfly in the picture on the top part of the card, then there is a red flower in the picture on the bottom part of the card." The order of the problems was reversed for half of the subjects.

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