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Developmental Continuity in Teleo-Functional Explanation: Reasoning about Nature Among Romanian Romani Adults

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Teleo-functional explanations account for objects in terms of purpose, helping us understand objects such as pencils (for writing) and body parts such as ears (for hearing). Western-educated adults restrict teleo-functional attributions to artifact, biological, and behavioral phenomena, considering such explanations less appropriate for nonliving natural entities. In contrast, children extend explanations of purpose to the nonliving natural domain. This cross-cultural study explores whether apparent restrictions in"promiscuous teleology" occur as a function of age and development, generally, or scientific literacy, more specifically. Using methodology from Kelemen (1999b), two groups of adult Romanian Roma from the same community selected explanations for properties of biological and nonbiological natural entities; one group had little or no science training, the other was formally schooled. Compared to their schooled peers and to Western-educated American adults, nonschooled Romani adults were more likely to endorse purpose-based explanations of nonbiological natural entities. Findings challenge assumptions of fundamental conceptual discontinuities between children and adults.

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INTRODUCTION

"*Why (does it get dark at night)?*" "*So that people can go to bed*" (Piaget, 1972, p. 294).

On the basis of statements like the previous one, Piaget claimed that children are "artificialists" who draw on their own intentional experience to conclude that things are made by people for a purpose. He argued that children fall prey to this belief because of a "precausal" inability to conceive of physical causes that leaves them profoundly confused about the natural world. In essence, they conflate natural and human-made phenomena until maturation plus informal and formal learning lead them to outgrow and replace this misconception with a more veridical and differentiated worldview.

Piaget's proposal of course amounts to the suggestion that there is a fundamental difference in the way children and adults construe the natural world, and much developmental work has taken place since he made these claims to challenge his position. For example, there is now a wealth of findings to suggest that children are unlikely ever to be "precausal." Violation-of-expectation studies find that children represent and use their knowledge of physical causes from infancy (Baillargeon, 1993; Van de Walle & Spelke, 1996) and marshal this tacit knowledge quite explicitly during the preschool years (e.g., Bullock & Gelman, 1979; Chandler & Lalonde, 1994; Schultz, 1982). Furthermore, a body of research indicates that infants and young children both distinguish between natural objects and artifacts (e.g., Gelman & Wellman, 1991; Massey & Gelman, 1988; Pauen, 2002) and recognize that people tend to make artifacts but not natural entities (Gelman & Kremer, 1991; Kelemen & DiYanni, 2005; for an alternative perspective see Evans, 2000). Finally, work specifically focused on children's teleo-functional tendency to reason about objects and events in purpose-based terms has raised questions as to whether children ever really evidence a broad bias to view phenomena in terms of purpose, lending support for the conclusion that there is never any real discontinuity with adults' selective teleo-functional construal of nature (Keil, 1992, 1995; Greif, Kemler Nelson, Keil, & Gutierrez, 2006). This paper reviews the evidence for this latter position, and in a study of Romani adults examines support for a related but slightly different claim: We argue that although Piaget's interpretation may have been faulty, contemporary studies do indeed yield evidence that children have a generalized bias to view objects and behaviors in terms of a purpose. Where Piaget may have been wrong is in arguing that this tendency ever entirely goes away.

Teleo-Functional Thought: Selective or Promiscuous?

In the context of reasoning about the natural world, Western-educated adults often appear to distinguish between living and other natural entities through selective application of teleo-functional explanation (Keil, 1992; Kelemen, 1999a). This fact has led some scholars to argue that teleo-functional explanations are intimately linked to biological understanding and may even form the innate basis of a universal theory of biology (Atran, 1994, 1995; Keil, 1992; Springer & Keil, 1989). Keil (1992, 1995) has suggested that children possess a "naïve" biological theory derived from recognition that biological parts serve purposes for living things (e.g., hands are for grasping) but parts do not serve purposes for nonliving things (e.g., a mountain's outcropping is not"for" anything).

This suggestion that an autonomous teleo-functional stance is an innate primitive of human cognition—and that it forms the developmentally invariant core of a universal, naïve biology—is a strong one. Importantly, such a "biological teleology" proposal predicts that at any developmental time-point, teleo-functional intuitions should be highly selective. That is, when thinking about the natural world, children and adults alike should consider only the adaptively valuable properties of biological entities (e.g., antlers or lungs) as having functions—not whole biological organisms (e.g., cows) or any aspect of nonbiological natural entities (e.g., rocks or points on rocks). Furthermore, the kinds of functions intuitively invoked should more generally concern self-serving ends relevant to survival rather than the other-serving functions more typical of artifacts (e.g., antlers should only be considered as existing for an animal's self-serving need such as protection, not for an other-serving need such as scratching another animal).

Several studies motivated by these predictions have yielded evidence for the view. For example, Keil found preliminary evidence that from 3 years of age, children will functionally distinguish an artifact from a living thing by identifying a biological part (e.g., a barb on a rose) as "self-serving," but a parallel part on an artifact (e.g., a barb on barbed wire) as "other-serving" (cited as study in progress, Keil, 1995). Greif, Kemler Nelson, Keil, & Gutierrez (2006) recently found that when encouraged to ask questions, preschool children are more likely to query "what does it do?" about computer displays of unfamiliar animals parts and artifacts than about unfamiliar whole animals. Most relevant of all to the proposal of an intuitive selective teleo-functional construal of nature, Keil (1992; also 1995) found that elementary school children prefer teleo-functional explanations for living rather than nonliving natural objects' properties. Specifically, he presented children with a teleo-functional and a physical explanation of a property (e.g., greenness) of either a living thing (e.g., a plant) or a nonliving natural kind (e.g., an emerald). Kindergarten children were at chance, but second graders were more likely to choose the purpose-based explanation with the living thing (e.g., "it's green because it helps there be more of them") and the physical explanation with the nonliving thing (e.g., "it's green because tiny parts mix together to give them a green color").

These results lend support for the notion of a selective teleo-functional construal. However, a confound between animacy and function in the teleo-functional phrases of this last and most pertinent of the studies make the findings less clear (see Kelemen, 1999a, and Matan & Carey, 2001, for discussion). Furthermore, other evidence counters the conclusion that children's teleo-functional construal of nature is "biological" and selective. For example, following Keil (1992), Kelemen (1999b, Study 2) asked American children to choose between more neutrally phrased teleo-functional and physical explanations of the properties of various unfamiliar living and non-living natural entities. The nature of the teleo-functional explanations varied; some described "self-serving" functions that were quasi-biological in having self-beneficial "adaptive" effects (e.g., "the rocks were pointy so that animals wouldn't sit on them and smash them") and some described "other-serving" functions that were more social and artifactlike insofar as they benefited external agents (e.g., "the rocks were pointy so that animals could scratch on them when they got itchy"). The results found that whereas American adults only endorsed physical explanations for nonliving natural object properties (e.g., "the rocks were pointy because bits of stuff piled up for a long time") and only self-serving teleo-functional explanations for the properties of living things (e.g., "Cryptoclidus had long necks so that they could move easily through the water"), 6- and 7-year-old first graders and 8-year-old second graders favored teleo-functional explanations of any kind for both living and nonliving natural object properties.[1] By 10 years of age, this "promiscuous teleology" showed signs of increased selectivity with children endorsing only self-serving teleo-functional explanations with biological properties. Nevertheless, even at this age, children's preference for physical explanations of nonliving natural objects was no different than chance. This overly broad application of teleo-functional explanation was all the more interesting because it occurred despite the fact that just prior to testing, participants received a short tutorial in which the use of purely physical-causal explanation was unambiguously modeled (Kelemen, 1999b, Study 2). Indeed, a further replication found that "promiscuous teleology"

[1]In the case of second graders, the preference for other serving teleo-functional explanations of biological properties was not quite above chance.

actually increased among American 7- and 8-year-olds when modeling during pretrial training was made even more explicit (Kelemen, 2003).

In addition to these results, this tendency has also been found elsewhere: with British elementary children despite the relative absence of ambient religiosity in British popular discourse (Kelemen, 2003); in studies using different methods (e.g., open-ended questions, Kelemen & DiYanni, 2005, and event recall, Donovan & Kelemen, 2004); and in research with younger children. For example, when asked to identify unanswerable questions, American 4- and 5-year-olds, unlike adults, judge the question "what's this for?" appropriate not only to artifacts and body parts but also to whole living things such as lions ("to go in the zoo") and nonliving natural things such as clouds ("for raining") (Kelemen, 1999a, Study 1). When asked whether they agree that, for example, raining is really just what a cloud "does" rather than what it is "made for," preschoolers demur, endorsing the view that natural entities such as clouds are "made for something" and "raining is why they are here" (Kelemen, 1999a, Study 2). Finally, when told about living and nonliving natural entities that can no longer perform certain functional activities (e.g. a mountain that can't be climbed), 5- and 6-year-olds intuit that they are broken and hence in need of repair or replacement (DiYanni & Kelemen, 2005).

Taken together, this body of findings converges to challenge the notion of a teleo-functional stance that is specific to biology and selective throughout development. But if the teleo-functional stance is not an adaptation for biological cognition, what is the source of children's teleo-functional intuitions? According to an alternative proposal (e.g., Kelemen, 1999c, 2004), children's broad tendency to ascribe objects with purpose is the evolutionary side effect of a socially intelligent mind that is naturally biased to intentional explanation (Rosset, 2005, in press; see also Donovan, 2007; Leslie, Knobe, & Cohen, 2006; Nadelhoffer, 2006) and is therefore oriented toward explanations characterizing nature as immanently goal-directed or an intentionally designed artifact. Although it is obviously the case that physical-causal alternatives become elaborated via both formal and informal learning over development, a core aspect of this proposal is that, among most people, the deeply rooted intention-based teleo-functional tendency never goes away. That is, a relatively elaborated physical-causal explanation of a particular phenomenon suppresses rather than replaces a more primary teleo-functional response—except when teleo-functional explanation is warranted from a scientific perspective (e.g., self-serving functional explanations of biological properties) (see Wright, 1973; Neander, 1991).

According to this view then, the central question is no longer whether children are promiscuously teleological—the weight of evidence seems to suggest that they are—but whether, in fact, adults might be, too. In contrast to views assuming inevitable conceptual change through developmental processes, most notably illustrated by Piaget, this dual processing "co-existence" model argues that substantial conceptual continuity should be observed between children's and adults' teleo-functional intuitions under certain circumstances. In the present study, we pursue one such predicted circumstance: a case involving adults *without* exposure to the kind of academic training that promotes the formal elaboration and positive valuing of scientifically warranted physical-causal explanations. If a Piagetian conceptual change view is right and an "artificialist" or overly broad teleo-functional explanation of objects and events is indeed a "childhood phenomenon" that mitigates as a function of age and experience in the world, then both formally schooled and unschooled adults should be equally selective in their endorsement of purpose-based explanations of natural phenomena. If, however, purposeful explanations represent an ongoing cognitive default, then only those participants with a relatively high level of scientific literacy should show a tendency to suppress purpose-based explanations.

Because compulsory school attendance laws mandate school attendance until 16–18 years of age in the United States and it is virtually impossible to find a typical American population preserved from exposure to a scientifically saturated media, the samples involved in this study were two groups of Romanian Romani adults (often referred to as gypsies or Gypsies, an inaccurate label considered pejorative by many),[2] from the same community who varied only with respect to their level of schooling.

Brief Ethnography: Romanian Roma

The group selected for this study lived in the Transylvania region of Romania, an area with strong Hungarian and German influences. Like most Roma, they have sustained much of their ethnic identity and traditions (Crowe, 1996; Reger & Berko Gleason, 1991). Four factors made this local group specifically, and the Roma in general, highly theoretically appropriate for the present investigation.

[2]An additional note about terminology: As noted previously the term "Gypsy" should be abandoned due to inaccuracy (based on a historical misconception of Egyptian orgins) and because of the label's pervasive associations with romantic, nomadic images (at best) or negative stereotypes (at worst). At present, however, there is little consensus on replacement nomenclature. In this paper, we follow one accepted convention of using "Roma" as a collective noun (i.e., the Roma), "Romani" as an adjective (e.g., Romani women), and "Rom" as a singular noun (i.e., a Rom).

Appropriate linguistic distinctions. The current study required use of a language that clearly distinguishes causal versus teleo-functional explanations. In English, the phrase "because" usually denotes a physical or causal explanation; the phrases "so that," "in order to," or "to" usually denote teleo-functional, purpose-based explanations. In Romanian, as in English, these distinctions are present.

Variable exposure to formal schooling. In contrast to most mainstream European and American groups, formal schooling is not a mandatory component of Romani life. Value is placed on practical skills learned via parents and community members (Shunear, 1992), thus many Roma retain responsibility for a wide range of services within the family. In recent years, only a third of primary school-aged Romani children have been enrolled in school (Shunear, 1992; Cahn et al., 1998). Nevertheless, many individuals do attend school and complete 12 or more years. This wide variability in exposure to schooling, especially to the sciences, made the Roma a natural test group for exploring the impact of formal education on teleo-functional reasoning.

Lifestyle. Members of Romani communities are participants in a post-industrial nation and work force. In recent decades, Romani trades have primarily consisted of modern/industrial services such as factory labor, car dealing, and making and selling products (Fraser, 1995; Stewart, 1997). A majority of participants in this study held jobs as construction workers, day laborers in nearby factories or farms, or workers in various other industries. The community was located on the outskirts of a mid-size city (population 35,000) known for its tourism industry, and in addition, the community was regularly visited by British and American staff from a nearby humanitarian organization. Accordingly, these participants were not markedly "close to nature" or "far from modernity" as are members of many low-literacy or nonliterate communities, nor were they unfamiliar or uncomfortable with the testing paradigm used here. They were highly comfortable interacting with foreigners, observing and interpreting conventional pictorial representations (e.g., books, photos, television), and answering questions.

Cosmology. In general, the Roma tend to accept mainstream religious practices from surrounding communities. In the country of Romania, there are Protestant Roma, Catholic Roma, Muslim Roma, and Orthodox Roma, but as with many Europeans and Americans, true piety within these religions is often nominal, with religious eclecticism widely noted (Fraser, 1995; Hancock, 2008). Although beliefs in ancestral spirits, superstition, and "luck" are common, the Roma restrict such beliefs to people and interpersonal relationships as part of a larger cultural practice of maintaining separation between pure versus polluted conditions in hygiene and deportment (Fraser, 1995; Hancock, 2008). Notably, modern-day Roma are not reported to animistically apply persona to the nonhuman entities explored in this study: animals and nonliving natural kinds such as rocks and ponds (see Hancock, 2008).

In sum, the Romanian Roma in this study offer a unique window on the nature and scope of teleo-functional reasoning. Do individuals restrict their purpose-based reasoning as a function of age? If so, adults from both high- and low-schooled groups should be selectively teleo-functional—much like Western-educated American adults. However, if individuals require a modestly well-established scientific understanding as a basis for suppressing purpose-based explanations in some domains, then the low-schooled Roma should apply teleo-functional explanations more broadly, whereas their schooled counterparts should be selectively teleo-functional. These competing possibilities are put to test using methodology based on Study 2 of Kelemen (1999b).

METHODS

Participants

Participants were residents of central Romania living just outside a mid-size city. The literacy rate in the village community was estimated by ex-patriate humanitarian workers at 15–20%. Most adults were day laborers in factories or farms or were in the construction industry; all were fluent speakers of Romanian. With respect to formal scientific knowledge, the sample consisted of two separate groups. The Low School Exposure (LSE) group ($n = 16$) had attended school, on average, less than 6 years. Twelve of these participants reported zero scientific instruction and all 16 reported less than 4 years of schooling that included science classes of any sort. Among the High School Exposure (HSE) group ($n = 19$), participants had attended school an average of nearly 12 years and had received a minimum of 4 years of schooling that specifically included science education (mean = 6.4 years of school that included scientific studies). The mean age for the LSE group was 36 years (range = 18 to 67) and for the HSE group was 29 years (range = 16 to 54); the difference in age was not significant, $t(33) = 1.74$, n.s.

Additional comparison data came from Study 2 of Kelemen (1999b), which included 16 adults attending an American university (mean age: 19 years, SD = 2.6 years), 16 first-graders (mean age: 7 years, 1 month, SD = 4 months), 16 second-graders (mean age: 8 years, 2 months, SD = 6 months), and 16 fourth-graders (mean age: 10 years, 2 months, SD = 7 months). The children came from a diverse, urban population in California. Please note that although American samples are included in the present analyses for purposes of comparison, this is in no way motivated by the Deficit Model that has often accompanied such direct cross-cultural contrasts. In this research, schooled Americans are in no way assumed as an "ideal" standard of attainment by which all other groups are judged (see Rogoff & Morelli, 1989, and Gutiérrez & Rogoff, 2003, for discussion of the Deficit Model, which historically has been associated with claims of ethnic differences in inherent cognitive maturity). The question at the heart of this research is whether an accumulation of scientific schooling inhibits a universal, life-long tendency to invoke teleo-functional explanation. In that context, comparisons are informative between any groups who differ from or resemble each other on the key dimension of exposure to schooling. Although each population could be described separately and the reader left to infer patterns across groups, it seems more straightforward and less practically cumbersome to make such theoretically relevant comparisons explicit.

Materials

The materials were identical to those used in Study 2 of Kelemen (1999b). Each participant saw four pairs of realistic, color, hand-drawn pictures. Each pair consisted of one unfamiliar animal (e.g., an aquatic reptile) and one nonliving natural object (e.g., a pointy rock). Questions were translated ahead of time by native Romanian speakers and, to ensure accuracy, back-translated to English by two additional translators. None of the translators was familiar with the experiment or its predictions. (See the Appendix for a copy of the test questions in English.)

Procedure

Participants were recruited by word of mouth via door-to-door visits in the community. They were asked if they were willing to listen to questions about natural objects such as rocks and lakes and also about animals from many years ago. If they agreed, the project was described in more detail and formal consent was obtained. Participants were tested in homes or other local settings by the first author and one of two native Romani translators who had grown up in the testing community and had excellent rapport with the participants.

To circumvent any comprehension issues arising from variability in reading and writing skills, LSE participants provided verbal answers after listening to the study questions and observing the pictures on laminated cards. The HSE participants were all fluent readers and therefore read and answered questions in an illustrated booklet after hearing an oral description of the task. These methods of presentation precisely duplicated those used by Kelemen (1999b), i.e., verbal presentation for those with less developed reading skills and paper-and-pencil presentation for fully literate participants.

All participants began by answering background questions on their schooling: 1) How many years did you go to school regularly as a child? 2) Did you learn about science topics when you were at school (such as biology, chemistry, ecology, geology, or physics)? If the second question was answered in the affirmative, a follow-up question was posed to elicit more information on how much science was included in their education.

After completing background questions, participants were told that they would look at pictures and consider questions about various animals and objects depicted. Further, they were told that they would be given two possible answers to each question, and they simply needed to pick the answer that made the most sense to them as being true and accurate. They were reassured not to be concerned if they did not know anything specifically about the particular animals or objects. The task took 10–15 minutes to complete.

The content of the trials was identical to that of Study 2 in Kelemen (1999b) with two minor exceptions. First, the Romani adults did not hear a pretrial tutorial providing a scientific explanation of the formation of clouds. This was included in the original Study 2 in an attempt to provide participants with a "science context" for the task and prime young children to physical-causal explanations. In the original study, the incitement to "think like a scientist" had no effect on participants' performance relative to an earlier study that did not include this tutorial (Study 1, Kelemen 1999b). The second change involved shortening some of the animal names so they could be more easily heard in the context of Romanian oral presentation.

Participants saw the four picture set pairs in random order. For each pair, the animal picture was presented and named first ("Here is a Morthium") followed by a separate picture of a natural object ("All around were these pointy kinds of rocks"). They received three questions about each picture set in random order: two questions about biological properties of the animal in each set (e.g., "Why do you think Morthium had such flat feet?" and "Why do you think they had such wide backs?") and one question about a property of the nonliving natural object (e.g., "Why do you think the rocks were so pointy?").[3] Each of the three questions was immediately followed by two possible answers. One option always provided a simple physical-causal explanation, that is, an explanation describing natural, physical-reductionist mechanisms ("Morthium had flat feet because their toe bones were shortened and all smoothed out"). The other answer was a purpose-based explanation; for half of the picture sets, this described a self-serving function ("They had flat feet so that they could stand on wet ground without slipping"), and for the other half of the picture sets it was a social or other-serving function ("They had flat feet so that they could have fun playing and kicking mud on each other"). After presentation of the question and two response options, participants indicated which explanation "made the most sense." The explanations were counterbalanced such that the two picture sets associated with self-serving teleo-functional explanations for half of the participants were instead associated with social, other-serving, teleo-functional explanations for the other half of participants. Furthermore, within each counterbalancing group, half of those participants saw set 1 or 2 first and the other half saw set 3 or 4 first. The order in which physical versus functional explanations were given was random. To make comparisons to American data as close as possible, however, the order presented to each Romani adult exactly matched the random order administered to one of the 16 American adults in Study 2 of Kelemen (1999b). At the end, participants were given time to ask questions or receive further information about the project. They were given a small gift in appreciation of their time.

One additional procedural note: In terms of overall execution of the study, it is reasonable to question whether the respondents—particularly those with little formal education—were engaged and comfortable with the experimenters and the task. It strongly appeared that they were. As noted previously, the interpreters were local individuals who came from these communities, yielding a high level of ease and normalcy. Those who heard the questions orally took time to think about responses, asked for a question to be repeated when necessary, and—most importantly—at times justified their selections and made relevant comments about the stimuli. Likewise, those who completed the questions in booklet form took their

[3]In Study 2 of Kelemen (1999b), each picture set involved two biological property questions rather than one in order to explore concerns about the content of social teleo-functional explanations originally presented in the biological property trials of Study 1 of that paper. The inclusion of the original Study 1 set plus a new Study 2 set allowed a comparison to be conducted that ultimately indicated that these concerns were unfounded (for discussion, see Kelemen, 1999b, pp. 1446, 1447). However, for consistency, as both sets of trials had been tested on American participants, they were also tested on Romani participants.

time to read thoroughly and contemplate their choices. At no time did participants seem confused by the task or dismayed by the questions. In short, participants appeared comfortable with the situation and took the task seriously.

RESULTS

Each participant was presented with four picture sets, and for each picture set, they were asked two questions about biological properties and one question about a nonliving natural kind of property. Because the social teleo-functional explanations in one set of biological property trials differed from the other set in having a more anthropomorphic tone,[4] following Kelemen (1999b) a preliminary analysis was conducted to see whether Romani participants' responses to the two sets of biological property trials differed. As in Kelemen (1999b), the particular concern was that anthropomorphic content to social teleo-functional explanations might artificially inflate endorsements of social teleo-functional explanations. A 2 (biological trial set) $\times$ 2 (function type) analysis of variance (ANOVA) on endorsements of teleo-functional explanations revealed that responses to the two sets of trials involving self-serving explanations of biological properties were no different for either LSE or HSE Romani. However, although there was also no difference in LSE Romani participants' endorsements of anthropomorphic (59%) and nonanthropomorphic (47%) social explanation trials, contrary to inflating responses, HSE Romani were actually significantly *less* likely to accept social teleo-functional explanations if they contained any anthropomorphic content (11% vs. 39%), $t(18) = 3.28$, $p < 0.004$. With this interesting difference noted, as in Kelemen (1999b, 2003), the biological property trials were collapsed together to simplify further analyses.

For each trial, participants had a choice of two options, a physical-causal explanation of why a property existed versus a purposeful explanation that was either social or self-serving in nature. A 6 (group: LSE Romani adults, HSE Romani adults, American adults and first, second, and fourth graders) $\times$ 2 (property type: biological vs. nonliving natural) $\times$ 2 (function

[4]The reason for comparing the two sets of biological trials was due to a methodological consideration associated with Study 2 of Kelemen (1999b). For each picture set, one biological trial came from Study 1 of Kelemen (1999b), offering social (other-serving) teleo-functional explanations that were also sometimes anthropomorphic, and the other biological trial for each set was designed for Study 2 and offered social explanations that were simply other-serving, never anthropomorphic. The paired-samples *t*-tests here explored whether anthropomorphism was a factor influencing participants' tendency to endorse teleo-functional explanations; it was not.

type: self-serving vs. social) ANOVA compared tendencies to endorse the teleo-functional explanations. Proportion scores were used here and in all subsequent analyses because of the different numbers of trials for nonliving natural object versus biological property trials. Main effects of group, property type, and function type were subsumed by a 3-way group $\times$ property $\times$ function type interaction, $F(5,93) = 3.63$, $p < 0.005$. Table 1 gives the percentage of trials in which participants chose purpose-based explanations as a function of property type.

To examine the interaction, two separate 6 (group) $\times$ 2 (function type) ANOVA explored participants' tendency to endorse different kinds of teleo-functional explanations for the biological properties and natural objects, respectively. Where appropriate, post hoc analyses were conducted using Fisher's LSD, paired, or t tests.

The ANOVA on responses to biological property questions revealed a group $\times$ function type interaction, $F(5, 93) = 6.23$, $p < 0.001$. Post hoc analyses revealed that all groups were equivalently likely to endorse self-serving teleo-functional rather than physical explanations of biological properties at the previous chance levels with the exception of the HSE Roma whose preference—consistent with the scientifically warranted nature of both physical and self-serving teleo-functional explanations of biological properties—did not reach above chance levels (American adults' preference was $t(15) = 2.03$, $p < 0.06$). In contrast, HSE Romani and American adults and fourth graders actively rejected social teleo-functional explanations of biological properties. However, LSE Romani adults and American first- and second-graders endorsed them as frequently as self-serving teleo-functional accounts and at levels greater than fourth graders and any other

TABLE 1
Percentage of Trials in Which Teleo-Functional Explanations Were Endorsed

	Biological Properties		*Nonliving Natural Kind Properties*	
Group	*Self-Serving*	*Social*	*Self-Serving*	*Social*
LSE Romani adults	64*	53	59	56
HSE Romani adults	61	25*	8*	24*
U.S. adults	67∞	19*	9*	13*
U.S. first graders	77*	75*	66∞	69∼
U.S. second graders	72*	61	75*	69*
U.S. fourth graders	75*	28*	41	47

[a]U.S. child and adult data are taken from Kelemen, 1999b

[b]Significance different from chance: *$p < 0.05$, two-tailed; ∼$p = 0.05$, two-tailed; ∞$p < 0.05$, one-tailed.

adult group. In short, individuals across all groups found it equally likely that an animal might, for example, have had a feature such as smooth skin for the self-beneficial reason of allowing it to glide through the water but only LSE Romani adults and younger American elementary school children found "other-serving" social functional teleo-functional explanations (e.g., that an animal species might have had wide backs to carry other animals) similarly compelling. The HSE Romani adults and American adults and fourth graders rejected such social explanations in favor of simple, physical-causal alternatives (e.g., the animal species' wide back occurred because it had large bones). Interestingly, however, although LSE Romani adults were more than twice as likely to endorse social teleo-functional explanations as HSE Romani adults, LSE Romani adults' social teleo-functional preference was statistically at chance.

The ANOVA on teleo-functional responses to natural object property questions revealed only a main effect of group $F(5,93) = 20.09$, $p < 0.001$. The LSE Roma (58%) and American first- (67%), second- (72%), and fourth-graders (44%) were significantly more likely to endorse teleo-functional explanations than HSE Romani (16%) or American adults (11%), who both actively rejected any kind of teleo-functional explanation (e.g., ponds were still so that they would not lose their water or so animals could safely bathe in them) in favor of physical explanations of natural object properties (e.g., ponds were still because no water ran into them). LSE Roma were also significantly more likely to endorse teleo-functional explanations than fourth-graders, although it should be noted that like fourth-graders—and unlike first- and second-graders—their teleo-functional preference was again not above chance. This was also true when responses to social and self-serving teleo-functional trials were explored separately.

To further clarify the responses of the LSE Roma, which were not always different from chance, a correlation explored the relationship between the scientifically unwarranted teleo-functional responding of Romani participants (both LSE and HSE) and their varied years of school exposure. The negative correlation was significant, $r(33) = -.588$, $p < .001$, revealing that as years of schooling increased, the number of teleo-functional explanations endorsed for nonliving natural phenomena and other-serving explanations of body parts linearly decreased. A regression analysis confirmed that years of schooling was a highly significant predictor of unwarranted teleo-functional explanation, $F(2, 32) = 9.424$, $p = .001$, accounting for over a third of the variance ($R^2 = .35$) in teleo-functional explanations endorsed for nonliving natural objects and other-serving explanations endorsed for body parts. When added to the regression analysis, age did not significantly predict teleo-functional explanation or account for more of the variance in responding, age: $b = .17$, $p = .268$, years of school: $b = -.527$, $p = .001$.

TABLE 2
Number of Times Romani and American Adults Endorsed Teleo-Functional Explanations of Nonliving Natural Kind Properties (four possibilities total)

	LSE Roma	*HSE Roma*	*US*
Never	0	9	11
One	3	8	4
Two	8	2	0
Three	2	0	1
Four	3	0	0

Finally, given that adults' responses to the nonliving natural objects were particularly pertinent to the issue of how formal scientific schooling might suppress a tendency toward promiscuous teleo-functional intuitions, an individual subject analysis was conducted on the Romani and American adults' responses to these items to explore their consistency. As Table 2 shows, 90% of HSE Romani adults and 94% of American adults never endorsed a teleo-functional explanation in relation to a nonliving natural entity (e.g., a rock) or did so on one occasion at most. In contrast, all of the LSE Romani adults endorsed a teleo-functional explanation at least once, with 81% endorsing such explanations on two or more occasions.

DISCUSSION

Previous research indicates that, when considering the natural world, young American (and British) children explain all sorts of entities in purpose-laden terms and by reference to various kinds of functions (Kelemen, 1999a, 1999b, 2003; DiYanni & Kelemen, 2005; but see Greif et al., 2006; Keil, 1992). From a Piagetian perspective, such results provide clear evidence of childhood conceptions that are fundamentally at odds with adult representations of the world. The question addressed in the current research is whether these differences are really as profound as they might first appear. Is an orientation to overly broad teleo-functional explanation truly only a childhood phenomenon—a tendency that through typical maturation and informal learning experiences inevitably gets revised and replaced by more scientifically warranted interpretations? Or alternatively, does a bias toward purposeful explanation represent a cognitive default that may exist throughout life? Specifically, in the absence of the kind of Western scientific schooling that both elaborates and weighs physical-causal explanations of natural phenomena, is there greater continuity between adults' and children's teleo-functional intuitions about nature than is predicted by theoretical positions assuming inevitable conceptual change over development?

As the results in Table 1 show, the notion of continuity has substantial support. The teleo-functional intuitions of LSE Romani adults with minimal exposure to a formal scientific schooling more closely resemble those of American elementary school children with minimal exposure to scientific schooling than the more highly schooled members of their Romani community. More specifically, whereas HSE Romani adults demonstrate the kind of selective intuitions expected by core knowledge continuity accounts characterizing the teleo-functional stance as an adaptation for biological cognition (e.g., Atran, 1996; Keil, 1992), LSE Romani adults and American children are significantly more likely to explain biological properties (e.g., soft feathers) in terms of both self-serving (e.g., camouflage) and other serving (e.g., shelter other organisms) functions, and—even more strikingly—to extend teleo-functional explanations to nonbiological natural object properties.

Having noted the evidence of developmental continuity, however, it is also important to point out two concerns. First, Romani children were not tested in this study. Thus, although we consider it highly unlikely that they would be selectively teleological—as this would not comport with what we know of American children, British children, and Romani adults—developmental claims of continuity and discontinuity among the Roma cannot be made with absolute certainty. Additionally, although there were no statistical differences, the teleo-functional intuitions of the LSE adults were not as marked as those of American first- and second-grade children. Several reasons for this seem possible. One possibility is that the current results inaccurately reflect the explanatory intuitions of LSE Romani adults because, despite having inevitably matured into a predominantly physical-causal construal of the natural world, the LSE Romani adults simply did not understand the task at hand. In consequence, they resorted to guessing. Of course, an initial response to this possibility is that maturation into a primarily physical-causal construal of nature would seem to obviate any need for guessing. Even if gaps in the LSE Romani adults' knowledge base impaired their ability to judge the details of any particular physical-causal explanation, the general reductionist structure and content of those explanations—particularly when contrasted with their teleo-functional alternatives—should have been sufficient to trigger recognition as the "the right sort of explanation" among adults who automatically assume a primarily physical-causal account of nonliving natural phenomena. Putting this response aside, however, several other factors also render a "confusion" account highly unlikely. Most notably, as regression analyses clearly demonstrated, teleo-functional responding was actively predicted by years of schooling. That is, as years of schooling increased, the tendency to choose scientifically unwarranted explanations for natural objects and body parts decreased. This pattern of responses was not random, as would be expected if participants were guessing. The LSE adults also showed a particularly marked tendency to endorse self-serving teleo-functional explanations of biological properties, which suggests that procedurally they did understand the task. If they had not, their responses should have been at chance across the board. Finally, it is highly unlikely that, from a procedural standpoint, LSE adults would not have understood the task structure. Unlike the more isolated cultural groups that are a focus of some cross-cultural research, Romani communities are part of a modern society and work force; answering a short series of questions was not novel or complicated for them. And as noted earlier, the affective response of our participants strongly indicated that they were fully engaged in the task.

This brings us to two other possible explanations: one that argues for developmental discontinuity and conceptual change and the other that argues for developmental continuity and explanatory coexistence. The conceptual change option is as follows: Perhaps the LSE adults' lack of marked preference for teleo-functional explanation is evidence that a physical-causal view does inevitably overwrite a teleo-functional construal but that this conceptual change is rapidly expedited by exposure to scientific schooling. In other words, perhaps maturation, life experience and informal learning about physical-causal mechanisms gradually and inevitably lead an initial teleo-functional orientation to be outgrown and replaced by a more scientifically veridical physical-causal construal of nature. What we have displayed here, then, is just the unexpedited but inevitable conceptual change of LSE adults' intuitions about nature—one that is still in process. By contrast, the co-existence option argues that there is no inevitable revise-and-replace conceptual change. Rather than conceptually overwriting a natural teleo-functional orientation over time, what an accumulation of acquired physical mechanical knowledge serves to do in any individual (especially one from a culture that emphatically values scientific explanation) is *suppress* a default teleo-functional explanatory tendency that is common to all. In consequence, the degree of teleo-functional bias displayed by the LSE Romani adults is evidence of what happens when the quantity, coherence, and/or perceived social desirability of scientifically warranted physical explanation is not sufficient to exert full inhibitory influence over the default response tendency.

These interpretations cannot be adjudicated based on the current study's results alone. However, we believe that when particular aspects of the present findings are considered together with other recent research, the balance of evidence favors the coexistence position. First, in the current study, the change position presumably would have predicted that older individuals should be somewhat more selectively teleo-functional by virtue of their greater accumulation of life experience and informal learning. However, this was not the case. Second, consistent with the idea that coherent physical-causal explanation suppresses a default teleo-functional response, research with American adults suffering Alzheimer's disease—a dementia-causing disease that fragments the semantic physical-causal knowledge base (Zaitchik, Koff, Brownell, Winner, & Albert, 2004, 2006)—finds that on child-appropriate assessments, schooled elderly Alzheimer's patients differ from elderly and young adult controls by systematically and promiscuously accepting and preferring teleo-functional explanations of natural phenomena (Lombrozo, Kelemen, & Zaitchik, 2007). Finally, in the same vein, recent studies also find that when young American undergraduate adults are asked to judge explanations under speeded processing conditions, they are significantly more likely than unspeeded undergraduates to broadly accept scientifically unwarranted teleo-functional explanations (e.g., the sun makes light because plants need photosynthesis) even though they answer control explanations with equivalently high accuracy (Kelemen & Rosset, 2008).

These findings—taken together with education research indicating the difficulties of effecting theory change through instruction (Brumby, 1984; McCloskey, Caramazza, & Green, 1980) and neuropsychological work revealing the inhibitory activation even as schooled individuals offer scientifically "correct" answers on science tasks (Dunbar, Fugelsand, & Stein, 2007)—suggest that when probed a little more deeply, differences between children's and adults' reasoning may not be as profound or widespread as they might first appear. Indeed, far from an underestimation, Piaget's discussions of broad purpose-based reasoning appear to apply not just to young children but, in many conditions, to adults as well. It remains the work of future investigations to explore whether there are any circumstances under which scientific and physical knowledge ever lead to complete conceptual change.

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APPENDIX

Crypto (Aquatic Reptile)

BIOLOGICAL PROPERTY 1: "Crypto had these long necks. Why do you think they had such long necks?"

Physical: "They had long necks because the stuff inside got all stretched out and curved."

Self-serving: "They had long necks so they could grab at fish and feed on them."

Social: "They had long necks so that they could hold up their friends when they got tired swimming."

BIOLOGICAL PROPERTY 2: "Crypto had smooth skin. Why do you think they had such smooth skin?"

Physical: "They had smooth skin because it got stretched out tight across their bones."

Self-serving: "They had smooth skin so that they could move easily through the water."

Social: "They had smooth skin so that other animals could swim alongside them without getting cut."

NATURAL KIND PROPERTY: "All around there were these pointy kinds of rocks. Why do you think the rocks were so pointy?"

Physical: "They were pointy because little bits of stuff got piled up on tope of one another over a long time."

Self-serving: "They were pointy so that animals wouldn't sit on them and smash them."

Social: "They were pointy so that animals like Crypto could scratch on them when they got itchy."

Macruchia (Large Terrestrial Mammal)

BIOLOGICAL PROPERTY 1: "Macruchia had these big snouts. Why do you think they had such big snouts?"

Physical: "They had big snouts because their face muscles and bones pulled down and got longer."

Self-serving: "They had big snouts so they could pull down leaves from trees and eat them."

Social: "They had big snouts so that they could stroke their babies and make them feel loved."

BIOLOGICAL PROPERTY 2: "Macruchia had a big body. Why do you think they had such big bodies."

Physical: "They had big bodies because of the way all their fat deposits collected around their bodies."

Self-serving: "They had big bodies so that they could push a path through all the trees in the forest."

Social: "They had big bodies so that smaller animals could shelter underneath them from the rain."

NATURAL KIND PROPERTY: "All around there were these very still kinds of ponds – ponds that never had waves. Why do you think the ponds were so still?"

Physical: "They were still because no moving water ran into them."

Self-serving: "They were still so that they would never spill and lose all their water."

Social: "They were still so that animals like Macruchia could cool off in them without being washed away."

Monikus (Terrestrial Bird)

BIOLOGICAL PROPERTY 1: "Monikus had these long tails. Why do you think they had such long tails?"

Physical: "They had long tails because their feathers were big and stuck out from behind their body."

Self-serving: "They had long tails so that they could keep their balance while they ran."

Social: "They had long tails so that their behinds were covered and other animals could look without getting embarrassed."

BIOLOGICAL PROPERTY 2: "Monikus had soft feathers on their bodies. Why do you think they had such soft feathers?"

Physical: "They had soft feathers because furry stuff got built up all over them and pressed together in a certain way."

Self-serving: "They had soft feathers so that they could look like leaves on trees and stay hidden."

Social: "They had soft feathers so other tiny animals could crawl under them and stay warm and protected."

NATURAL KIND PROPERTY: "All around there was this grainy (rough) kind of sand. Why do you think the sand was so grainy?"

Physical: "It was grainy because bits of shells got broken up and mixed in making it that way."

Self-serving: "It was grainy so that it wouldn't get blown away and scattered by the wind."

Social: "It was grainy so that animals like Monikus could easily bury their eggs in it."

Morthium (Squat Mammal)

BIOLOGICAL PROPERTY 1: "Morthium had these flat feet. Why do you think they had such flat feet?

Physical: "They had flat feet because their toe bones got shortened and all smoothed out."

Self-serving: "They had flat feet so that they could stand on wet ground without slipping."

Social: "They had flat feet so that they could have fun playing and kicking much on each other."

BIOLOGICAL PROPERTY 2: "Morthium had a wide back. Why do you think they had such wide backs?"

Physical: "They had wide backs because they had large bones that got joined together in a certain way."

Self-serving: "They had wide backs so that their bodies would be strong and firm."

Social: "They had wide backs so that birds and other animals could ride around on top of them."

NATURAL KIND PROPERTY: "All around there were these green kinds of stones. Why do you think the stones were so green?"

Physical: "They were green because lots of colored stuff got mixed together to make them that way."

Self-serving: "They were green so that they couldn't be seen in the grass and no one would pick them up and take them."

Social: "They were green so that animals like Morthium could live in a nice place with pretty things around them."