

Inferring design: Evidence of a preference for teleological explanations from patients with Alzheimer's Disease

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Abstract

Unlike educated adults, young children demonstrate a ‘promiscuous’ tendency to explain objects and phenomena by reference to functions, endorsing what are called teleological explanations. This tendency becomes more selective as children acquire increasingly coherent beliefs about causal mechanisms, but a question remains as to whether a widespread preference for teleology is ever truly outgrown. The study reported here tests this question by examining explanatory judgments in patients with Alzheimer’s disease (AD), a population whose dementia impacts the rich causal beliefs adults typically consult in evaluating explanations. Results indicate that unlike healthy adults, AD patients systematically and promiscuously prefer teleological explanations, suggesting that an underlying tendency to construe the world in terms of functions persists throughout life. This finding has broad relevance to our understanding of conceptual impairments in AD, but also to theories of development, learning and conceptual change. Moreover, this finding sheds light on the intuitive appeal of creationism.

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In 1802, William Paley invited us to imagine coming across a stone or a watch. In either case one could ask why the object exists, but different explanations would seem appropriate. For a stone, one might be content to conclude that “it had lain there for ever” (Paley, 1802, p. 1). But for the watch, argued Paley, this explanation wouldn’t do. The complex coordination of the watch’s components, each essential to the watch’s proper functioning, suggested the existence of an underlying design and an accompanying designer. Applying the same reasoning to humans and other aspects of nature, Paley argued for the existence of an ultimate designer: God.

While contemporary scholars debate the merits of Paley’s argument, his reasoning is intuitively compelling. We typically explain the existence and properties of objects such as stones by appeal to proximate causal mechanisms (e.g. geological processes), and the existence and properties of artifacts such as watches by appeal to their functions (e.g. telling time). When confronted with objects that appear to have functions, such as hearts, it seems only natural to adopt a functional or ‘teleological’ mode of explanation: hearts exist and have the properties they do because they are for pumping blood.

The inference from an apparent function to the appropriateness of a teleological explanation, which we call the ‘inference to design’, is often quite reasonable. The intricate correspondence between a watch and time-telling provides evidence that watches were designed for telling time, just as the correspondence between hearts and pumping blood provides evidence that hearts resulted from divine creation (for Paley) or natural selection (for contemporary scientists). But the inference to design is not always valid. Mountains support the function of climbing, yet most adults reject the explanation that mountains exist *because* they are for climbing (Kelemen, 1999b). This is because adults generally restrict teleological explanations to cases for which the function invoked in the explanation played a causal role in bringing about

what is being explained (Lombrozo & Carey, 2006): the fact that watches tell time led to the existence of watches, but the fact that mountains support climbing did not lead to the existence of mountains. The ‘fit’ between the structure being explained and a plausible function provides evidence that this causal condition holds, but background beliefs (e.g. about the origins of mountains) can override the inference to design and lead to the rejection of a given teleological explanation.

This paper examines the hypothesis that teleological explanations are compelling and pervasive because they reflect an explanatory default: unless we have evidence to the contrary, we assume that a good fit between an object’s structure and a plausible function licenses a teleological explanation. This explanatory default can be overridden by background beliefs inconsistent with a teleological explanation, as typically occurs for adults when explaining the existence and properties of non-living natural objects such as stones or mountains. Our hypothesis predicts that a population with sparse or compromised background beliefs should err on the side of accepting too many rather than too few teleological explanations. Evidence from children, a population that lacks many of the background beliefs that prevent adults from accepting teleological explanations, confirms this prediction. In fact, young children have been characterized as ‘promiscuously teleological’: they overwhelmingly accept and prefer teleological explanations for objects like watches, but also for objects like stones and mountains (DiYanni & Kelemen, 2005; Kelemen, 1999a, 1999b, 2003; Kelemen & DiYanni, 2005; but see Grief et al., 2006; Keil, 1992). For example, a majority of 7- and 8-year-olds endorse explanations such as “mountains exist to give animals a place to climb” over the alternative that “mountains exist because volcanoes cooled into lumps” (Kelemen, 1999b).

The phenomenon of ‘promiscuous teleology’ in childhood provides support for the hypothesis that the inference to design is an explanatory default. However, developmental evidence is inconclusive about whether this default persists into adulthood. Moreover, the hypothesis is difficult to test in adults, who have deeply held beliefs about the origins of familiar objects, and more general beliefs that constrain explanations of novel objects (Keil, 2003; Lombrozo, 2006; Sloman, Lombrozo, & Malt, 2007). Such beliefs restrict the acceptance and preference for teleology (Lombrozo & Carey, 2006; Kelemen & Rosset, 2006), and could thus mask an underlying preference for teleological explanations. A stringent test for the hypothesis that the inference to design is a life-long default would come from the emergence of ‘promiscuous teleology’ in an adult population with impaired or inferentially weakened causal beliefs. One such population is patients with Alzheimer’s disease (AD), a form of dementia that causes serious semantic and conceptual deficits (Silveri et al., 1991; Zannino et al., 2002). Recently, Zaitchik and Solomon (submitted, a) reported that AD patients mirror young children’s ‘Piagetian animism’ in attributing life to inanimate entities such as airplanes and the sun, suggesting that relevant biological beliefs have been compromised. If AD patients’ causal beliefs about the origins of objects have also been compromised, they should—like children—exhibit a promiscuous tendency to accept and prefer teleological explanations.

In the experiment that follows we test the prediction that AD patients will exhibit ‘promiscuous teleology.’ In addition, we examine beliefs about the origins of the objects being explained. Kelemen and DiYanni (2005) found that children often invoked a designer, usually God, to account for the existence of entities like mountains, and that the extent to which individual children accepted teleological explanations correlated with how often they invoked a

designer. We were interested in whether Alzheimer's patients might similarly exhibit a promiscuous tendency to invoke a designer.

Methods

Participants. Forty-one adults participated. Twelve *Healthy Young* (6 men, 6 women; mean age 21 years, range 18-28) and twelve *Healthy Elderly* adults (5 men, 7 women; mean age 73 years, range 66-81; mean education 15.3, range 12-20) were recruited from the general public in the Boston area. The cognitive status of each participant was reviewed to confirm there was no history of progressive cognitive decline. None of the controls had conditions known to cause cognitive deficits (e.g., vitamin deficiency, electrolyte imbalance) or a history of severe head trauma, alcoholism, or psychiatric illness. To corroborate the cognitive status of the elderly participants, an experienced tester administered the Mini-Mental State Examination [MMSE] (Folstein, Folstein, & McHugh, 1975). The mean MMSE score of the *Healthy Elderly* group was 29 (range 26-30).

Seventeen *Alzheimer's patients* (6 men, 11 women; mean age 84 years, range 73-93; mean education 14.7 years, range 10-18) were recruited from the Gerontology Research Unit of the Massachusetts General Hospital in Boston and the Hebrew Rehabilitation Center for the Aged. Neurologic, psychiatric, and neuropsychologic evaluations indicated participants met standard criteria for probable AD (McKhann et al., 1984). Individuals with other complicating medical conditions were excluded. All participants had adequate hearing and visual abilities for the task demands. The mean MMSE score of the AD patients was 23.1 (range 17-30).

Procedure. Participants completed an interview that consisted of two parts, an *Explanation Choice* task and a *Causal Beliefs* task. The script for the Explanation Choice task began as follows:

“I’m going to read you some questions and possible answers. Some of the answers will seem appropriate, but others may seem silly or untrue. For each answer I just want you to tell me whether or not you think it’s an appropriate answer to the question. If you’re unsure, just tell me that. Ready? Here’s the first question:”

Participants were then presented with ten why-questions with two possible answers for each: one teleological and one mechanistic (see Sample Stimuli below). Responses to the two possible answers were coded as *Acceptance* judgments. Following these two *Acceptance* judgments, participants were asked to make a single *Preference* judgment, specifying which of the two answers – the teleological or the mechanistic – they preferred. The stimuli, adapted from items used with children in Kelemen & DiYanni (2005), included two items from each of five domains: artifacts (cars, tables), biological traits (eyes, stomach), biological organisms (trees, dogs), non-living natural objects (mountains, sun), and natural phenomena (rain, wind).

Sample Stimuli:

Artifact: **Why do tables have flat tops?**

Mechanistic: Because flat pieces of wood were placed on wooden legs.

Teleological: So that people can eat on them.

Biological trait: **Why are there eyes?**

Mechanistic: Because bodies have special cells that combine to produce eyes.

Teleological: So people and animals can see.

Biological organism: **Why does Earth have trees?**

Mechanistic: Because they grow from tree seeds.

Teleological: So that animals can have shade and protection.

Non-living natural kind: **Why is the sun so bright?**

Mechanistic: Because the chemical reactions on the sun produce light.

Teleological: So that animals and plants have enough light to survive.

Natural phenomena: **Why is there rain?**

Mechanistic: Because water condenses in clouds and forms droplets.

Teleological: So that plants and animals have water for drinking and growing.

For artifacts, non-living natural objects, and natural phenomena, one question was about an object's properties and the other about an object's existence (this distinction did not yield reliable differences and is not discussed further). Questions involving biological traits were necessarily about properties of entire organisms, and those involving entire organisms were necessarily about existence. The questions were presented in one of four orders. For each participant, mechanistic explanations were presented first for half of the items.

At the conclusion of the *Explanation Choice* task, participants completed the *Causal Beliefs* task, in which they were asked about the causal origin of each of the items in the *Explanation Choice* task. For example, for the *sun* item they were asked: "Did someone or

something make the sun so bright or did it just happen?” For the *eyes* item they were asked: “Did someone or something make eyes or did they just appear?” The ten causal origins questions were asked in the same order as the corresponding explanation choice questions for that participant.

Results

Explanation Choice task. As few items were tested in each domain, the five domains were divided into two categories for further analysis: those that typically warrant teleological explanations (artifacts, biological traits) and those that typically do not (biological organisms, non-biological natural kinds, natural phenomena); henceforward the *warranted* and *unwarranted* items. Using this classification, acceptance and preference for explanations can be examined as a function of population (young, elderly, AD) and teleological explanation status (warranted, unwarranted).

”Don’t know” responses were generated in only six cases, by one elderly and five AD patients. Appropriate responses were provided for the remaining 1,224 questions. There were no significant order effects nor significant differences between the young and elderly participants except where noted; insignificant order and post-hoc tests comparing the healthy young and elderly will not be reported in the analyses that follow.

A 2 x 3 ANOVA with explanation status (warranted, unwarranted) as a within-subjects variable, population (young, elderly, AD) as a between-subjects variable, and proportion of accepted teleological explanations as a dependent variable revealed significant main effects of both explanation status ($F(1, 38) = 67.20, p < .01, p_{\text{rep}} > .99, \text{partial } \eta^2 = .639$) and population ($F(2, 38) = 4.53, p < .05, \text{partial } \eta^2 = .193$), as well as a two-way interaction ($F(2, 38) = 6.40, p < .01, \text{partial } \eta^2 = .252$) (see Figure 1a). Teleological explanations were more often accepted for

warranted than for unwarranted items (98% versus 62%, paired-samples t-test, $t(40) = 6.89, p < .01, p_{\text{rep}} > .99$), and AD patients accepted teleological explanations 87% of the time, significantly more often than the young (66%; $t(27) = -3.59, p < .01, p_{\text{rep}} = .990$) and marginally more often than the elderly (73%; $t(27) = -1.92, p = .065, p_{\text{rep}} = .904$). There were no significant population differences in acceptance of teleological explanations for warranted items, but AD patients accepted teleological explanations more often in the unwarranted cases than did young ($t(27) = -4.02, p < .01, p_{\text{rep}} > .99$) or elderly ($t(27) = -2.05, p < .05, p_{\text{rep}} = .917$) participants, generating the observed interaction. Critically, the elevated teleological acceptance in AD patients cannot be accounted for by an indiscriminate tendency to accept proffered explanations: even the Alzheimer's patients discriminated item types, more often accepting teleological explanations for warranted than for unwarranted items (97% versus 79%, paired-samples t-test, $t(16) = 3.25, p < .01, p_{\text{rep}} = .976$).

The same analysis was carried out with acceptance of mechanistic explanations as the dependent variable, revealing a significant main effect of teleological explanation status ($F(1, 38) = 5.31, p < .05, p_{\text{rep}} = .941, \text{partial } \eta^2 = .123$), but no effect of population ($F(2, 38) = 1.53, p = .230, \text{partial } \eta^2 = .074$) nor an interaction ($F(2, 38) = 1.37, p = .265, \text{partial } \eta^2 = .067$).

Participants were less likely to accept mechanistic explanations when teleological explanations were warranted: 64% versus 79% (paired samples t-test, $t(40) = -2.54, p < .05, p_{\text{rep}} = .957$).

These analyses of explanation acceptance reveal that AD patients differ from healthy participants in accepting teleological explanations 'promiscuously': they are more likely to accept teleological explanations overall and in particular for unwarranted items, but do not differ from healthy participants in accepting mechanistic explanations. A stronger test of teleological tendencies in AD patients is explanatory *preference*: will they prefer teleological explanations

over mechanistic alternatives, even for unwarranted items? A 2 x 3 ANOVA with explanation status (warranted, unwarranted) as a within-subjects variable, population (young, elderly, AD) as a between-subjects variable, and explanation preference as a dependent variable revealed main effects of explanation status ($F(1, 38) = 145.05, p < .01, p_{\text{rep}} > .99, \text{partial } \eta^2 = .792$) and population ($F(2, 38) = 6.36, p < .01, \text{partial } \eta^2 = .251$), as well as a significant interaction ($F(2, 38) = 4.48, p < .05, \text{partial } \eta^2 = .191$) (see Figure 1b). Overall, participants were more likely to prefer teleological explanations for warranted than for unwarranted items (81% versus 32%; paired samples t-test, $t(40) = 10.92, p < .01, p_{\text{rep}} > .99$). However, AD patients preferred teleological explanations in 65% of cases, significantly more often than either the young (38%; $t(27) = -4.58, p < .01, p_{\text{rep}} > .99$) or the elderly (45%; $t(27) = -2.42, p < .05, p_{\text{rep}} = .947$). As with acceptance judgments, the difference between populations was greatest for unwarranted items. AD patients were significantly more likely to prefer teleological explanation for unwarranted items than were the young ($t(27) = -4.81, p < .01, p_{\text{rep}} > .99$) or elderly ($t(27) = -2.32, p < .05, p_{\text{rep}} = .940$), but no more likely to prefer teleological explanations for warranted items than were the young ($t(27) = -1.34, p = .191, p_{\text{rep}} = .822$) or elderly ($t(27) = -1.76, p = .091, p_{\text{rep}} = .884$).

Importantly, preference for teleological explanations in the AD population cannot be accounted for by chance responding: AD participants preferred teleological explanations more often than predicted by chance (6.5/10 versus 5/10; one-sample t-test, $t(16) = 3.71, p < .01, p_{\text{rep}} = .986$), and were more likely to prefer teleological explanation for warranted than for unwarranted items (88% versus 50%; paired-samples t-test, $t(16) = 6.74, p < .01, p_{\text{rep}} > .99$). To address the concern that AD patients may have preferred teleological explanations because they failed to understand the mechanistic alternatives, the 2 x 3 ANOVA on explanation preferences was

repeated with only those items for which individuals accepted both the mechanistic and the teleological explanations. The analysis yielded identical patterns of significance. AD patients preferred the teleological option for unwarranted items 57% of the time despite having accepted the mechanistic alternative, while the young and elderly only accepted 6% or 25% of teleological explanations, respectively, when they accepted the mechanistic alternative (young: $t(25) = -4.41$, $p < .01$, $p_{\text{rep}} > .99$; elderly: $t(25) = -2.14$, $p < .05$, $p_{\text{rep}} = .925$).

Finally, Table 1 reports the proportion of judgment types for each domain as a function of group. Because the healthy young and elderly did not differ statistically in the analyses reported above, they were combined into a single “control” group. AD patients were more likely than controls to accept and prefer teleological explanations for each of the unwarranted domains: biological organisms, non-biological natural kinds, and natural phenomena.

Causal beliefs task. Participants’ responses to questions about causal origins were classified into four categories: those that invoked a supernatural agent (*God* responses), those that invoked a human agent (*person* responses), those that discussed the evolution of a biological trait (*evolution* responses), and those that discussed a natural process other than the evolution of a biological trait (*process* responses), such as plate tectonics, growth, or a chemical reaction. Only in five cases did a participant fail to provide a response; these five cases were generated by three AD patients. The 405 generated responses were classified by two independent coders, one not affiliated with the study, with a total agreement of over 98%. Fewer than 3% of responses failed to conform to one of the four response categories.

Responses were analyzed as a function of population (young, elderly, AD), with teleological explanation status (warranted, unwarranted) and response type (*God*, *person*, *evolution*, *process*) as within-subjects variables (see Figure 2). There were significant main

effects of population ($F(2, 38) = 5.00, p < .05, \text{partial } \eta^2 = .208$) and response type ($F(3, 36) = 142.13, p < .01, \text{partial } \eta^2 = .922$), as well as a significant interaction between response type and teleological explanation status ($F(3, 36) = 445.45, p < .01, \text{partial } \eta^2 = .974$). Most notably, the young generated *process* responses significantly more often than the elderly ($t(22) = 2.29, p < .05, p_{\text{rep}} = .932$) and AD ($t(27) = 2.17, p < .05, p_{\text{rep}} = .928$), but tended to invoke *God* less often than the elderly ($t(22) = -1.93, p = .071, p_{\text{rep}} = .899$) and AD ($t(27) = -1.76, p = .068, p_{\text{rep}} = .902$). The elderly and AD populations did not differ from each other in frequency of either *process* responses ($t(27) = -.26, p = .800, p_{\text{rep}} = .571$) or *God* responses ($t(27) = .36, p = .719, p_{\text{rep}} = .600$).

Relationship between tasks. Although AD patients were significantly more likely to accept and prefer teleological explanations than healthy participants, they were no more likely to invoke creation (by divine or human agents). The comparison between AD patients and the healthy elderly is especially telling: while they invoked God equally often, AD patients accepted and preferred teleological explanations more often than the elderly.

To further investigate the relationship between performance on both tasks, two composite scores were created for each participant: an *explanation index* corresponding to the total number of teleological explanations accepted (of 10) in the Explanation Choice task, and an *origins index* corresponding to the total number of items (of 10) for which the participant invoked a process that typically supports teleological explanations (*God, person, or evolution* responses) in the Causal Beliefs task. Consistent with reported analyses, the *explanation index* varied significantly as a function of population ($F(2, 38) = 5.05, p < .05, \text{partial } \eta^2 = .210$) but the *origins index* did not ($F(2, 38) = 1.97, p = .153, \text{partial } \eta^2 = .094$). These indices were correlated within each population, yielding values of .33 in the young ($p = .30$), .36 in the elderly ($p = .25$), and .06 in the AD patients ($p = .83$). Although non-significant, the correlation sizes observed for healthy

participants are comparable to those documented in Kelemen and DiYanni (2005) for children. The absence of a correlation within the AD population suggests that patients accepted teleological explanations independently of their beliefs about items' origins. In particular, they were significantly more likely than controls to accept teleological explanations for items they did not attribute to God, a person, or evolution (4.5 versus 3.0 of 10, $t(39) = -2.04$, $p < .05$, $p_{rep} = .919$).

Discussion

In contrast to healthy adults, patients with Alzheimer's Disease broadly accept and prefer teleological explanations. They explain the existence of rain by noting it provides water for plants and animals, and the existence of trees by noting they provide shade. This tendency mirrors the phenomenon of 'promiscuous teleology' in children, but goes beyond developmental data to suggest the preference for teleology is never outgrown. Rather, the preference persists throughout life to re-emerge when causal beliefs that might otherwise constrain it are limited or compromised. In short, these findings provide converging evidence for a basic human preference to understand the world in terms of purpose. When faced with an object that supports a plausible function, humans immediately (but defeasibly) make the inference to design, and assume a teleological explanation is warranted.

Additional evidence supports our conclusion that a preference for teleology persists throughout life. First, the data reported here suggest that healthy adults are surprisingly willing to entertain scientifically questionable teleological explanations (see Figure 1a), even if they ultimately prefer a mechanistic alternative (see Figure 1b). A second source of evidence comes from ongoing research with scientifically naïve adults, as well as adults responding under

speeded conditions. Casler & Kelemen (in preparation) report elevated teleological endorsements among Roma “Gypsy” adults with little schooling, suggesting that a teleological preference is primarily reduced as a result of causal beliefs typically acquired through formal education. Kelemen & Rosset (in preparation) find that educated adults making speeded judgments show heightened acceptance of teleological explanations, presumably because processing limitations restrict access to background beliefs that defeat the inference to design. Finally, the appeal of Intelligent Design Creationism (Evans, 2000; Kelemen, 1999c; Lombrozo, Shtulman, & Weisberg, 2006), ultra-adaptationism in evolutionary biology (Gould & Lewontin, 1979; Pinker & Bloom, 1990), and widespread misunderstanding of evolution as a goal-directed process (Brumby, 1985; Shtulman, 2006) provide further evidence of our tendency to view the world in terms of design.

But does the tendency to infer design also require an inference to a designer? The current results suggest not. AD patients were no more likely to spontaneously invoke a designer (human or divine) than were healthy elderly participants, and healthy participants accepted teleological explanations for properties they attributed to natural selection. AD patients also differed from healthy adults and children in that their judgments about the acceptability of teleological explanations were not correlated with a tendency to invoke processes like intentional design or natural selection (cp. Kelemen & DiYanni, 2005). In particular, Alzheimer’s patients generally accepted teleological explanations whether or not they explained the corresponding items by appeal to design or selection. This pattern confirms our initial hypothesis that the mere presence of a plausible function is sufficient for a teleological explanation to be accepted; mechanistic beliefs are required to reject teleology, but are unnecessary for acceptance. Moreover, the finding that AD patients have a robust preference for teleological explanations without the ‘promiscuous

theism' observed in children suggests that promiscuous teleology is not a *consequence* of promiscuous theism.

While our central conclusion concerns the existence and persistence of teleological tendencies, the current findings are also significant for what they tell us about the conceptual life of Alzheimer's patients. Alzheimer's disease is best known for its devastating effects on memory, but a growing literature suggests that AD patients may be better characterized as suffering inferential problems at the level of intuitive theories rather than indiscriminate, low-level semantic deficits (Zaitchik et al., 2004; Zaitchik et al., 2006; Zaitchik & Solomon, submitted, ab). For example, many AD patients (like preschoolers) attribute life to inanimate but active objects like the sun (Zaitchik & Solomon, submitted, a), and claim that a salient but superficial change in an animal's properties (e.g. removing a lion's mane) can change its species (Zaitchik & Solomon, submitted, b). In young children such errors in folk-biological reasoning are attributed to ignorance (e.g. Carey, 1985), but AD patients seem to have a basic understanding of the biological mechanisms, such as growth and reproduction, that should constrain attributions of life and species membership. In most AD patients such knowledge may be present, but no longer used to properly constrain inferences. Similarly, we find that AD patients accept mechanistic explanations as often as their healthy counterparts, but fail to spontaneously consult such beliefs in determining whether to restrict the scope of teleology. This interpretation is partially supported by the responses on causal origins questions, for which AD patients spontaneously invoked natural processes less often than young adults.

Finally, the current findings have important implications for our understanding of learning and education. Recent work in folk physics (Dunbar, Fugelsand, & Stein, in press) and theory of mind (Apperly et al., 2006) suggests that the persistence of reasoning strategies

observed in childhood is not uncommon. Such strategies may be masked by additional or alternative mechanisms that dominate in adulthood, only to re-emerge when these secondary mechanisms are inhibited or impaired. Recognizing the developmental continuity of a preference for teleological explanation can help us understand public issues like the appeal of creationism, and inform educational efforts about topics like evolution.

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References

- Apperly, I.A., Riggs, K.J., Simpson, A., Chiavarino, C., & Samson, D. (2006). Is belief reasoning automatic? *Psychological Science*, 17(10), 841-844.
- Brumby, M. (1985). Misconceptions about the concept of natural selection by medical biology students. *Science Education*, 68, 493 - 503.
- Casler, K. & Kelemen, D. (in preparation). Teleological explanation and conceptual change: Reasoning about nature among Romanian Roma adults (“Gypsies”).
- Carey, S. (1985). *Conceptual Change in Childhood*. Cambridge, MA: MIT Press.
- DiYanni, C. & Kelemen, D. (2005). Time to get a new mountain? The role of function in children’s conceptions of natural kinds. *Cognition*, 97, 325-335.
- Dunbar, K.N., Fugelsand, J.N., & Stein, C. (in press). Do naïve theories ever go away? Using brain and behavior to understand changes in concepts. I P. Shah and M. Lovett (Eds.), *Thinking about Data*, Hillsdale, NJ: Erlbaum
- Evans, E. M. (2000). Beyond scopes: Why Creationism is here to stay. In K. Rosengren, C. Johnson, & P. Harris (Eds.), *Imagining the impossible: The development of magical, scientific and religious thinking in contemporary society*, (pp. 305-333). Cambridge: Cambridge University Press.
- Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*, 12, 189-198.
- Gould, S.J. & Lewontin, R. (1979). The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. *Proc R Soc Lond B*, 205(1161), 581-598.

- Greif, M., Kemler-Nelson, G., Keil, F.C., & Guterrez, F. (2006). What do children want to know about animals and artifacts?: Domain-specific requests for information, *Psychological Science*, 17(6), 455-459.
- Keil, F.C. (1992) The origins of an autonomous biology. In M.R Gunnar & M. Maratsos (Eds.), *Modularity and Constraints in Language and Cognition, Vol. 25 Minnesota Symposium on Child Psychology* (pp. 103-138). Hillsdale, NJ: Earlbaum.
- Keil, F. C. (2003). Folkscience: coarse interpretations of a complex reality. *Trends in Cognitive Sciences*, 7, 368-373.
- Kelemen, D. (1999a). Function, goals, and intention: children's teleological reasoning about objects. *Trends in Cognitive Sciences*, 3, 461-468.
- Kelemen, D. (1999b). Why are rocks pointy? Children's preference for teleological explanations of the natural world. *Developmental Psychology*, 35(6), 1440-1452.
- Kelemen, D. (1999c). Beliefs about purpose: On the origins of teleological thought. In M. Corballis and S. Lea (Eds.). *The descent of mind: Psychological perspectives on hominid evolution* (pp. 278-294). Oxford: Oxford University Press.
- Kelemen, D. & DiYanni, C. (2005). Intuitions about origins: Purpose and intelligent design in children's reasoning about nature. *Journal of Cognition and Development*, 6(1), 3-31.
- Kelemen, D. & Rosset, E. (in preparation). Adults' teleo-functional ascriptions of purpose to nature.
- Lombrozo, T. (2006). The structure and function of explanations. *Trends in Cognitive Sciences*, 10(10), 464-470.
- Lombrozo, T. & Carey, S. (2006). Functional explanation and the function of explanation. *Cognition*, 99, 167-204.

- Lombrozo, T., Shtulman, A., & Weisberg, M. (2006). The Intelligent Design controversy: lessons from psychology and education. *Trends in Cognitive Sciences*, 10(2), 56-57.
- McKhann, G., Drachman, D., Folstein, M.F., Katzman, R., Price, D., & Stadlan, E. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Workgroup under the auspices of Department of Health and Human Services Task Force. *Neurol*, 34, 939-944.
- Paley, W. (1802/1998). *Natural Theology; or, Evidence of the Existence and Attributes of the Deity*. Ann Arbor, MI: University of Michigan Humanities Text Initiative.
- Pinker, S. and Bloom, P.(1990). Natural language and natural selection. *The Behavioral and Brain Sciences*, 13, 707 - 84.
- Shtulman, A. (2006). Qualitative differences between naïve and scientific theories of evolution. *Cognitive Psychology*, 52(2), 170-194.
- Silveri , M.C., Daniele, A., Giustolisi, L., Gainotti, G. (1991). Dissociation between knowledge of living and non-living things in Dementia of the Alzheimer Type. *Neurology*, 41(4), 545-546.
- Sloman, S., Lombrozo, T. & Malt, B. (2007). Ontological commitments and domain-specific categorisation. In M. J. Roberts (Ed.). *Integrating the Mind*. Hove, UK: Psychology Press.
- Zannino, G. D., Perri, R., Carlesimo, G. A., Pasqualetti, P., Caltagirone, C. (2002) Category-specific impairment in patients with Alzheimer's disease as a function of disease severity : a cross-sectional investigation.*Neuropsychologia*, 40(13), 268-279.

Zaitchik, D., Koff, E., Brownell, H., Winner, E., & Albert, M. (2004). Inference of mental states in patients with Alzheimer's Disease. *Cognitive Neuropsychiatry*, 9(4), 301 – 313.

Zaitchik, D., Koff, E., Brownell, H., Winner, E., & Albert, M. (2006). Inference of beliefs and emotions in patients with Alzheimer's Disease. *Neuropsychology*, 20(1), 11-20.

Zaitchik, D. & Solomon, G. (Submitted, a). Animist thinking in the elderly and in patients with Alzheimer's disease.

Zaitchik, D. & Solomon, G. (Submitted, b). Conservation of species, liquid, and belief: Evidence for category-specific conceptual impairment in patients with Alzheimer's disease.

Table and Figure Captions

Table 1. The average number of explanations accepted and preferred are indicated as a function of domain. Healthy young and elderly participants are combined in a single control group.

Figure 1. Average percent of teleological explanations *accepted* (panel a) and *preferred* (panel b) as a function of domain and population. Domains are grouped according to whether or not they typically warrant teleological explanations.

Figure 2. Distribution of responses to questions about the causal origins of items as a function of domain and population. Domains are grouped according to whether or not they typically warrant teleological explanations.

Tables and Figures

Table 1

Status	Domain	Population	Accept Mechanistic	Accept Teleological	Prefer Teleological
<i>Warranted</i>	Artifacts	<i>Control</i>	75	98	* 77
		<i>AD patients</i>	59	97	91
	Biological Traits	<i>Control</i>	61	100	75
		<i>AD patients</i>	59	97	86
<i>Unwarranted</i>	Biological Organisms	<i>Control</i>	71	** 44	** 25
		<i>AD patients</i>	71	80	56
	Non-Biolog. Kinds	<i>Control</i>	82	* 46	** 17
		<i>AD patients</i>	91	68	41
Natural Phenomena	<i>Control</i>	75	** 61	** 15	
	<i>AD patients</i>	88	91	53	

Single asterisks (*) indicate significant population differences at the $p < .05$ level, one-tailed ($p_{rep} > .87$). Double asterisks (**) indicate significant population differences at the $p < .05$ level, two-tailed ($p_{rep} > .91$).