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Animist thinking in the elderly and in patients with Alzheimer's disease

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Some patients with Alzheimer's disease (AD) reveal low-level impairment in their concepts of living things (i.e., forgetting that zebras are striped). To test for more profound impairment, we investigated the concept *alive*—a "higher order" concept spanning every member of the domain. Many elderly controls were animists, attributing life to inanimates capable of self-generated activity (the sun, fire). Most AD patients were animists, with half even attributing life to inanimates whose activity is not self-generated (cars, lamps). Adult animists, like young children who have not yet acquired biological concepts, overattributed life to active inanimates. We believe this reflects an innate disposition to view active entities as agents, and that *agency* interferes with the biological concept *alive*. This interference, we suggest, reflects degradation of biological concepts in the face of spared perception of agents. It sheds light on the nature of fundamental questions concerning conceptual organization, innate endowment, and conceptual change.

Keywords: Folkbiology; Conceptual change; Domain-specificity; Aging; Alzheimer's disease.

Numerous studies of brain-damaged patients support a claim of category-specific impairment in the domain of living things (Capitani, Laiacona, Mahon, & Caramazza, 2003; Caramazza & Shelton, 1998; Forde & Humphreys, 1999; Humphreys & Forde, 2001; Tyler & Moss, 2001). This category appears to fractionate into two distinct subcategories: animals and fruits/vegetables (Capitani et al., 2003). The suggestion has been made that, for evolutionary reasons, knowledge about animals (as *predators* and *prey*), as well as fruits and vegetables (as *food* and *toxins*), have special status in the conceptual system, special locations in the brain, and consequently special vulnerabilities to certain kinds of brain damage (Caramazza & Shelton, 1998).

Several studies of patients with Alzheimer's disease (AD) have reported the presence of a category-specific impairment for living things (Whatmough & Chertkow, 2002). Tasks on which patients have shown category effects include identification questions, picture naming,

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word-to-picture matching, semantic probe questions, drawing, and similarity ratings (Chan, Salmon, & De La Pena, 2001; Chertkow & Bub, 1990; Daum, Riesch, Sartori, & Birbaumer, 1996; Garrard, Patterson, Watson, & Hodges, 1998; Laiacona, Barbarotto, & Capitani, 1998; Mauri, Daum, Sartori, Riesch, & Birbaumer, 1994; Silveri, Daniele, Giustolisi, & Gainotti, 1991; Zannino, Perri, Carlesimo, Pasqualetti, & Caltagirone, 2002). While several studies failed to find category effects (Cronin-Golomb, Keane, Kokodis, Corkin, & Growdon, 1992; Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Hodges, Salmon, & Butters, 1992; Montanes, Goldblum, & Boller, 1996; Tippett, Grossman, & Farah, 1996), and some found it only in restricted groups (Laiacona et al., 1998; Montanes et al., 1996), AD patients do, on average, perform worse on living things than on nonliving things (Whatmough & Chertkow, 2002). A category-specific impairment for living things appears to characterize at least some AD patients.

Low-level versus high-level degradation

The conceptual category of living things has been described in the neuropsychological literature as a hierarchically organized taxonomy, with more general knowledge at the top and more specific knowledge at the bottom (Martin, 1992; Martin & Fedio, 1983). On this view, the concept *living thing* might appear at the top level, *animal, vegetable*, and *fruit* at the next level, and *dog, cat*, and *gorilla* lower still. Results of tasks tapping category fluency, generation of definitions, picture naming, picture sorting, and category membership (Hodges et al., 1992; Martin & Fedio, 1983; Moss, Tyler, & Jennings, 1997; Troster, Salmon, McCollough, & Butters, 1989; Zannino et al., 2002) all reveal worse performance on subordinates than on superordinates in patients with AD. For example, while patients might have trouble identifying a zebra as a zebra rather than a horse, they will not have trouble identifying it as an animal rather than a vegetable. For this reason, it has been broadly claimed in the neuropsychological literature that patients with AD have a progressive bottom-up impairment in the hierarchical organization of semantic knowledge (Martin, 1992). We argue that such a claim is premature.

The claim that the conceptual system is organized in a category-specific manner has already been made quite forcefully by cognitive scientists and philosophers tracking the growth and elaboration of knowledge across childhood. There is much to gain by bringing the theories and methodological advances in this literature to bear on the neurosciences. For example, there is growing understanding that a conceptual domain, such as the domain of living things, not only specifies a taxonomy, but also has, at its core, a rich and powerful set of causal concepts that do much of the work in explaining the phenomena captured in the domain. As laid out in seminal work by Carey (1985), the domain of living things includes not only a taxonomy of animals, but also such concepts as *life cycle, bodily machine, respiration, birth, disease*, and *death*. These concepts include functions, mechanisms, and processes—all of which play a causal role in animal (and plant) behaviour. Many of these processes are defined in terms of one another (e.g., *conception* and *birth* are early stages in the *life cycle*; *disease* is a malfunction in the *bodily machine; death* is the cessation of *respiration* and other bodily processes). This relationship between concepts speaks to the *coherence* of the domain. Coherence reflects the notion that knowledge of a domain entails more than a list of isolated facts or even a taxonomy; it also entails richly specified mechanisms and powerful general principles that support inference and explanation. This domain is often referred to as an intuitive *theory*, a *folkbiology*.

The tasks most commonly used by neuropsychologists—category fluency, picture naming, word-to-picture matching, sorting, and the like—were not designed to test the integrity of the domain at its highest level (Zaitchik & Solomon, 2001). Though these tests may tell us that it is easier to identify *animals*, a superordinate concept, than to identify *dogs*, a subordinate, they tell us little about the integrity of the core concepts that support causal-explanatory reasoning.

Fortunately, we can look to the developmental literature for a set of tasks specifically designed to probe high-level understanding of the domain.

In the present study, we use the Animism Interview of Laurendeau and Pinard (1962) to investigate whether the low-level conceptual impairment reported in the neuropsychology literature is accompanied by a higher level impairment in the understanding of the concept *alive*, arguably the central concept in the domain of living things. In his classic studies of childhood thought, Piaget (1929) provided evidence that young children commonly engage in animism—the attribution of life to inanimate objects. Since Piaget's initial discovery of childhood animism, there have been many replications of the finding (Carey, 1985). In these studies, activity and motion have been found to play a central role in driving young children's judgements of what is or is not alive. Thus, cars and the sun are frequently judged to be alive "because they move". Slightly older children attribute life only to objects that move autonomously (the sun, but not cars). Surprisingly, animism can persist. Even at ages when children have already acquired a large number of low-level concepts, when they can name many animals and plants and know some relevant properties of living things, many still do not make adult-like judgements about what is alive.

There is consensus that, at least by adolescence, the child largely shares the central lay adult understanding of what it means for something to be a living thing (Carey, 1985; Hatano & Ingaki, 1994; Medin & Atran, 2004). Because developmental psychologists have generally considered the end target of development to be the conceptual structure evident in adolescence, there are few studies of conceptual change in later life. Indeed, we know of only a single recent study (McDonald & Stuart-Hamilton, 2000) that probed the concept "alive" among groups of different ages. It was only the oldest age group, people in their seventies, who were significantly different from all other age groups. Given the paucity of data, we simply do not know for sure whether this higher level semantic understanding is vulnerable to cognitive effects of ageing (Albert, 2001; Backman, Small, & Wahlin, 2001), let alone to Alzheimer's disease. In the present study, we ask whether healthy elderly, about whom little is known in this regard, or patients with AD, many of whom show low-level impairment, also suffer higher level impairment in the domain of living things. Might age or Alzheimer's disease impair the ability to recruit relevant folkbiological concepts and relate them in a coherent manner in reasoning about what is a living thing? In other words, might healthy elderly or AD patients, like young children, be animists?

Method

Participants

A total of 20 *healthy young* (7 men, 13 women; mean age 20 years, range 18–23; mean education 13.8 years, range 11–15) and 20 *healthy elderly* adults (10 men, 10 women; mean age 74 years, range 65–81; mean education 15.6 years, range 12–22) were recruited from the general public in the Greater Boston area. The cognitive status of each participant was carefully reviewed to determine that 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 participants' cognitive status, an experienced tester administered the Mini-Mental State Examination (MMSE) to all participants (Folstein, Folstein, & McHugh, 1975). All healthy controls had a score of 29–30 on the MMSE. A total of 24 *patients with Alzheimer's disease* (7 men, 17 women; mean age 81 years, range 73–93; mean education 14.4 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. The diagnosis of AD was based on a neurologic, psychiatric, and neuropsychologic evaluation. Participants met the National Institute of Neurological Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA)

criteria for probable AD (McKhann et al., 1984). Medical conditions known to produce dementia were excluded. Laboratory tests were given to rule out various neoplastic, infectious, or metabolic causes for dementia. Individuals with a record of severe head trauma, alcoholism, or serious psychiatric illness were excluded. The mean MMSE score of the AD patients was 22.1, with a range of 10–30. All participants had adequate hearing and visual abilities for the task demands. All but one of the participants were native English speakers.

Procedure

Participants were presented with two tasks. In the *Living Thing Judgement Task*, they were individually read a list of object names, including four animals (cat, bird, snake, and fly), two plants (flower and tree), six natural phenomena (rain, cloud, sun, fire, wind, and mountain), and eight artefacts (bicycle, car, bell, table, watch, airplane, lamp, and pencil). After each object was named, participants were asked, "Is a(n) *x* alive, is it a living thing?" In the *Animism Interview*, participants were asked three questions: (a) "What does it mean for something to be alive, to be a living thing?"; (b) "Can you name some things that are alive, that are living things?"; and (c) "Can you name some things that are not alive, that are not living things?" The Animism Interview was conducted immediately before the Living Thing Judgement Task so as not to contaminate their free recall. The tasks are presented here in reversed order for reasons of exposition.

Results

Living Thing Judgement Task

Each participant's judgements were categorized so as to allow inferences about the underlying reasoning. Participants were said to show a *canonical adult* pattern if they judged all four of the animals to be living things and none of the six natural phenomena or eight artefacts. Participants showed a *nature animist* pattern if they judged all of the animals, at least one of the natural phenomena, and none of the artefacts to be living things. Participants showed an *artefact animist* judgement pattern if they judged all of the animals, at least one natural phenomenon, and at least one artefact to be living things, but did not judge all objects to be living things. Finally, participants showed a *mixed* pattern if their judgements did not fall into any of the above categories. This category would include participants who judged all or none of the objects to be living things, participants who failed to attribute life to all four animals, or participants who responded according to some other basis. In short, if patients with AD were unable to give meaningful responses for any reason—if the questions were too difficult or too taxing on cognitive processes known to be impaired in AD (memory, language, attention, or executive function)—their responses should have fallen into this mixed pattern. Table 1 shows the percentage of participants in each group whose judgements fell into each pattern category.

The first thing to notice is that not a single participant, not even the most impaired AD patients, fell into the mixed category; AD patients were not responding in a biased or random fashion.

As expected, nearly all (95%) of the healthy young controls showed a canonical adult pattern, attributing life to animals and plants only. A total of 70% of the healthy elderly also showed the canonical adult pattern. Surprisingly, 30% of the healthy elderly showed a nature animist pattern, attributing life not only to animals and plants but also to inanimate natural phenomena such as fire or clouds.

In contrast to the healthy young and healthy elderly, the great majority of AD patients made animist judgements; only 29% showed a canonical

Table 1. *Percentage of participants showing each pattern of judgement about what kinds of objects are living things*

		Pattern of judgement			
Participant group	*n*	*Canonical adult*	*Nature animist*	*Artefact animist*	*Mixed*
Healthy young	20	95	5	0	0
Healthy elderly	20	70	30	0	0
AD patients	24	29	21	50	0

Note: AD = Alzheimer's disease.

adult pattern. The proportion of AD patients making animist judgements (71%) is significantly greater than that of healthy elderly (30%), $\chi^2(1) = 7.291$, $p < .01$. Moreover, the AD patients were also significantly more likely than the healthy elderly to attribute life to artefacts as well as to natural phenomena, $\chi^2(1) = 23.704$, $p < .001$. Fully 50% of AD patients crossed this ontological divide, whereas the healthy young and the healthy elderly never did so.

The results further indicate an association between tendency to make animist judgements and severity of disease. Across participants, there is a significant correlation between MMSE score and number of animist judgements made ($r = .511$, $p < .001$). The association still holds when we look at patients' likelihood of making any animist judgements at all. The 15 more impaired patients (MMSE < 25, mean = 18.5) were significantly more likely than the 9 very mildly impaired patients (i.e., MMSE > 25, mean = 28.2) to be animists, $\chi^2(1) = 4.407$, $p < .05$. Nonetheless, as can be seen in Table 2, the effect was not carried solely by the most severely impaired. Almost half of those in the very mildly impaired group were animists, and almost a quarter were artefact animists.

There is a striking correspondence between the judgement patterns shown by our healthy elderly and AD patients and the developmental stages identified by Laurendeau and Pinard (1962) in their study of children's reasoning about the concept *alive* (see Table 3). Stage 1 children, like our adult artefact animists, often attribute life to active or moving things, even those that cannot move on their own (e.g., balls, airplanes). Stage 2 children, like our nature animists, often attribute life to inanimate objects that appear to be capable of autonomous movement (e.g., the sun, rain). Stage 3 children, like our adult folkbiologists, make no animist judgements at all.

Table 2. *Percentage of AD patients showing each pattern of judgement about what kinds of objects are living things, according to severity of disease*

				Pattern of judgement			
Disease severity	*n*	*MMSE*	*M*	*Canonical adult*	*Nature animist*	*Artefact animist*	*Mixed*
Less impaired	9	>25	28.5	56	22	22	0
More impaired	15	<25	18.2	13	40	47	0

Note: AD = Alzheimer's disease. MMSE = Mini-Mental State Examination.

Table 3. *Laurendeau and Pinard's stages in the meaning of* alive

Stage	
0	No concept
	Random judgements
	Inconsistent or irrelevant justifications
1	Activity or movement
	Things that are active, that move, or both, are alive
2	Autonomous movement
	Things that move by themselves are alive
3	Adult concept
	Only animals (or animals and plants) are alive

Note: Adapted from Carey (1985) with permission.

The similarity between our results and those of Laurendeau and Pinard (1962) requires two important qualifications: First, we are not claiming that healthy elderly and AD patients are just like children. They are not. They know, for example, many more facts about animals and living things. Second, whereas Laurendeau and Pinard characterized younger children's attributions of *alive* as being based upon a single criterion (i.e., activity), we make no such claim about adults. In our data, not a single animist attributed life to *every* active or moving inanimate object. That said, our data do suggest that motion and activity are salient factors driving animist judgements. Of the natural entities and artefacts, those capable of activity and motion (the sun, fire, and rain; cars, planes, and lamps) had the greatest number of animist attributions, whereas the most solid and inert of entities (mountain and table) had few (see Tables 4 and 5).

When examining judgements of fire, the most active and moving of the natural entities, to be alive, we find that the 63% of AD patients overall who judged it to be alive is significantly greater than the 5% of healthy young controls who did so, $\chi^2(1) = 15.587$, $p < .001$. Similarly,

Table 4. *Percentage of animist responses for each natural entity*

Participant group	*Fire*	*Sun*	*Wind*	*Rain*	*Cloud*	*Mountain*
Healthy young	5	5	5	0	5	5
Health elderly	25	30	20	10	10	0
AD patients	63	46	42	42	33	21

Note: AD = Alzheimer's disease.

when we look to judgements of the airplane, a prototypically moving and active artefact, we find that 33% of AD patients judged it to be alive, whereas none of the healthy young did so, also a significant difference, $\chi^2(1) = 8.149$, $p < .01$. By contrast, when we examine judgements of mountain, the most solid and immoveable of the natural entities, we find no significant difference between the 21% of AD patients and 5% of healthy young who judged it to be alive. When we examine table, the most solid of the artefacts, we find that only 4% of AD patients judged it to be alive, and that none of the healthy young did so.

A further examination of the results shows that severity of disease is associated with animist attributions of the kind noted above (see Tables 6 and 7). First, we note that differences between the proportions of mild AD patients and healthy young were not significant on any of the individual entities. Second, the patients with moderate AD showed higher rates of animist judgements than did the patients with mild AD, for the natural entities as well as the artefacts. Most importantly, note that the difference between the moderate AD patients and the healthy young controls underscores the salience of motion and activity in animist judgements. The 80% of moderate AD patients who judged fire to be alive is significantly

Table 5. *Percentage of animist responses on each artefact*

Participant group	*Bell*	*Airplane*	*Lamp*	*Car*	*Watch*	*Bicycle*	*Pencil*	*Table*
Healthy young	0	0	0	0	0	0	0	0
Healthy elderly	0	0	0	0	0	0	0	0
AD patients	29	33	29	25	21	12	4	4

Note: AD = Alzheimer's disease.

Table 6. *Percentage of animist responses for each natural entity, by AD subgroups*

AD subgroup	*Fire*	*Sun*	*Wind*	*Rain*	*Cloud*	*Mountain*
Mild	33	22	11	11	11	11
Moderate	80	60	60	60	47	27

Note: AD = Alzheimer's disease.

Table 7. *Percentage of animist errors to artefacts, by AD subgroups*

AD subgroup	*Airplane*	*Bell*	*Lamp*	*Car*	*Watch*	*Bicycle*	*Pencil*	*Table*
Mild	11	0	11	11	0	0	0	0
Moderate	47	47	40	33	33	20	7	7

Note: AD = Alzheimer's disease.

greater than the 5% of healthy elderly, $\chi^2(1) = 20.651$, $p < .001$. Similarly, 47% of moderate AD patients judged airplanes to be alive, whereas none of the healthy young did so, also a significant difference, $\chi^2(1) = 11.667$, $p < .001$. By contrast, the AD patients were not significantly more likely than the healthy elderly to judge the most inactive entities, mountains or table, to be alive.

It would appear that the more impaired a patient was, the more important motion and activity were in driving judgements of what was alive. Nevertheless, this is not to say that the less impaired AD patients were just like the healthy young. Indeed, it is still striking that of our group of extremely mild AD patients, a group with a mean MMSE over 28, almost half were animists, while almost a quarter were artefact animists.

Animism Interview

Motion and activity are certainly important and salient factors in reasoning about living things, but so are biological properties. Thus, we examined our participants' responses on the Animism Interview for whether they invoked motion and activity and for whether they provided at least rudimentary folkbiological explanations.

Question 1: "What does it mean to be alive, to be a living thing?"

Most participants responded to the question by listing properties associated with living things.

Responses were coded as to whether they invoked *motion or activity* (described in a manner that could be applied to inanimates as easily as to animates), *biological properties* (e.g., "eats" or "grows," which are true only of living things), or *other* bases of reasoning. Two researchers coded the explanations with a reliability of .98. Disagreements were resolved by fisticuffs.

Motion and activity were mentioned by only 30% of healthy young, 50% of healthy elderly, and 54% of AD patients (see Table 8). The difference between the healthy elderly and AD patients was not significant. It would appear that motion remains a salient property of living things, for the healthy elderly as well as for the AD patients, but is less often appealed to by healthy young.

In contrast, almost all of healthy young and healthy elderly (95% and 90%, respectively), mentioned some biological properties of living things, as did most (78%) of the extremely mild AD patients. Strikingly, only 20% of the moderate AD patients did so, significantly less than the proportion of mild AD patients, $\chi^2(1) = 7.726$, $p < .01$. That some AD patients mentioned some biological properties is not surprising, given that these properties (e.g., *breathes*) have been strongly associated with people and animals for the many decades of the patients' lives. Nevertheless, we again see that moderate AD patients were significantly different from the very mild AD patients (and healthy elderly) not on their attention to motion and activity, but their inattention to biological properties.

Question 2: "Can you name some things that are alive, that are living things?"

As can be seen in Table 9, the majority of AD patients, like the majority of healthy young and healthy elderly controls, spontaneously cited animals and people as examples of living things. Also like healthy controls, the AD patients rarely showed evidence of animist intrusions. Only 2 participants, both moderately impaired AD patients, named nonliving items (snow and clock). At first pass, this strong performance by the AD patients is surprising, certainly in the context of their performances on the Living Thing Judgement Task and on the other questions in the Animism Interview. But, as we know from the cognitive literature, the most prototypical exemplars of a category are most likely to be named in naming tasks. This result tells us that for AD patients, as for the healthy controls and for young children, animals are still the prototypical living things. What this result does not tell us, however, is why. It seems likely that the reason animals and people are such excellent prototypes of living things (and the reason they are judged to be alive in the Living Thing Judgement Task) is that they are so clearly active and so often in motion. AD patients, healthy elderly, and healthy young all list people and animals as prototypical living things, but they could be doing so for very different reasons.

For evidence of a difference, let us look to the range of exemplars named by participants (see Table 9). Whereas a majority of healthy young and healthy elderly spontaneously named plants as examples of living things (albeit fewer than had done so for animals and people), only a minority of AD patients named plants. The 25% of AD (22% of mild, 27% of moderate) patients who named plants is

Table 8. *Percentage of participants invoking motion/activity or biological properties in response to Question 1 of the Animism Interview*

Participant group	*Motion/activity*	*Biological property*
Healthy young	30	95
Healthy elderly	50	90
Mild AD	56	78
Moderate AD	53	20

Note: AD = Alzheimer's disease. Question 1 was: "What does it mean to be alive?"

Table 9. *Percentage of participants who spontaneously listed objects of a given category as examples of living things in response to Question 2 of the Animism Interview*

Participant group	*Animals*	*People*	*Plants*	*Inanimates*
Healthy young	95	85	75	0
Healthy elderly	100	95	75	0
Mild AD	100	67	22	0
Moderate AD	94	60	27	13

Note: AD = Alzheimer's disease. Question 2 was: "Name some things that are alive."

significantly fewer than the 75% of healthy elderly, $\chi^2(1) = 10.32$, $p < .001$. Again, we see evidence that for AD patients the attribution of life depends on an object's capacity for activity and movement. Plants, of course, do not appear to be terribly active.

Question 3: "Can you name some things that are NOT alive, that are NOT living things?"

Not surprisingly, when asked to name things that are not living things, all healthy young and elderly participants offered appropriate responses, listing inanimate natural kinds (e.g., rocks, water), artefacts (furniture), and man-made substances (plastic). Even 83% of AD patients appropriately named inanimate objects. There was, however, an important aspect to the errors that some participants made: A total of 5% of healthy young, 15% of healthy elderly, and 33% of AD patients included dead people, dead animals, and dead plants in their lists of nonliving things. The difference between the proportion of healthy elderly and mild or moderate AD patients who did so was not significant.

This result suggests that for a substantial number of healthy elderly and AD patients, the *alive–dead* distinction has intruded into the *living thing–nonliving thing* distinction. Carey (1985) had observed the same intrusion with children and interpreted it as indicative of a fundamental lack of understanding of the concept *living thing*. Note that in the present data, as in Carey's, the intrusion cannot be explained away as a simple misunderstanding of the question. That is, if it were the case that participants did have an intact understanding of the concept *living thing*, but had simply interpreted the question as asking them to "name some things that are dead" rather than to "name some things that are not living things," then they would not have included inanimate objects on their lists as well as dead animates. Among the AD patients who listed dead animals, dead people, or dead plants as instances of nonliving things, 82% also listed inanimate objects as part of the same category.

Finally, consistent with the suggestion that the *dead–alive* intrusion is indicative of confusion in the concept *living thing*, 83% of the participants who showed the intrusion also made animist judgements on the Living Thing Judgement task, whereas only 27% of the remaining participants made animist judgements, $\chi^2(1) = 13.238$, $p < .001$. This intrusion is further support for the notion that, for those participants for whom the concept of living thing is impaired (whether by age or by AD), activity plays a greater role in reasoning about what is a living thing. And dead things, like plants, do not do much of anything.

An anonymous reviewer of an earlier version of this paper suggested an alternative interpretation of our results: Some participants' judgements might reflect impairment on dimensions related to "temporary properties" or "changes of state". That is, such participants would have considered those entities that are temporary or that change states to be living things, and they would have considered those entities that are permanent or do not change states (at least in the short term) to be nonliving things. The dimension of change of state is posited as an explanation for why more AD patients judged a lamp to be alive (29%) than judged a bicycle (12%), car (25%), or watch (21%) to be alive, despite the fact that bicycles, cars, and watches are arguably more strongly associated with movement.

This is an intriguing possibility, but there are two reasons why we do not find it completely satisfying as an explanation of our results. The first reason is empirical: None of the participants ever appealed to changes of state or temporary properties when justifying their judgements or when defining what is alive and what is not alive. Moreover, the AD patients did not judge lamps to be alive significantly more often than they did cars, watches, or bicycles. The second reason is semantic: The temporary changes of state appealed to in these judgements are precisely those of activity and movement. For example, the lamp changes from being inactive in its "off" mode to lighting up a room in its "on" mode. Emitting light is the lamp's activity. It is not clear what is gained by referring to the more general notion of change of state.

Discussion

In demonstrating that the majority of AD patients—and many healthy elderly—are animists,

the present study reveals the presence of high-level conceptual impairment in the domain of living things. As noted above, understanding the concept *alive* entails more than knowing a list of exemplars subsumed within a hierarchical structure that goes, for example, from *living thing* to *animal* to *mammal* to *dog* to *poodle*. It entails the coordination of a system of concepts in a coherent manner to support inferences and to provide explanations about a range of phenomena, including why something is or is not a living thing.

The present study yielded the following important results: First, no one, not even the most impaired AD patient, ever denied that any of the probed animals was alive. This finding does not support the general claim that AD patients have a progressive bottom-up impairment in the domain of living things, for there is little evidence in these data suggesting that degradation of the higher level concept *living thing* was based on degradation of the taxonomically lower level concept *animal*.

Second, there were participants in all groups who found activity and motion to be indicators of living things. Animist attributions were almost always limited to active objects and were explicitly justified by appeal to the object's activity. This explains as well why, for animists, spontaneous lists of living things so rarely included plants and why spontaneous lists of nonliving things so often included dead people and dead animals. By contrast, for healthy young (and most healthy elderly), though activity may be a property of living things, biological properties—mechanisms, processes, and functions—are the critical attributes of living things. Animism, then, may be a consequence of the well-maintained salience of activity and motion in the face of a degraded folkbiology.

Third, given the common assumption that conceptual development in the domain of living things is fixed by adolescence and does not change thereafter, it is striking to find that 30% of the healthy elderly were animists. Even more striking is the finding that healthy elderly's animist judgements look like those of Laurendeau and Pinard's (1962) Stage 2 children: Among those entities judged to be alive were some natural phenomena that move on their own.

Fourth, there was widespread animism among AD patients. Not only did the majority of AD patients attribute life to some autonomously moving natural phenomena, but half of them attributed life to artefacts as well. Again, like young children, they sometimes attributed life to things that move or are active, even if that activity is not self-generated.

Fifth, animism in AD patients increased with severity of disease. This makes sense if, as suggested above, animism reflects the continued salience of activity and motion in the face of a degraded folkbiology. Presumably, with increasing disease burden comes increasing degradation of folkbiological concepts and hence increased animism.

For an explanation of why movement and activity should play such a prominent role in reasoning about living things, we again turn to the literature in cognitive development. There is increasing evidence supporting the existence of domain-specific innate first principles (or core knowledge) that predisposes us to attend to particular aspects of the perceptual world and that supports or constrains further learning in that domain (Carey & Spelke, 1996; Gelman, 1990). Evidence suggests that one first principle is that things that move on their own are agents. That is, we are predisposed to interpret autonomously moving objects as being capable of intentional or goal-directed behaviour (Bertenthal, Proffitt, Spetner, & Thomas, 1985; Caramazza & Shelton, 1998; Gergely, Nadasdy, Csibra, & Biro, 1995; Massey & Gelman, 1988; Opfer, 2002; Rakison & Poulin-Dubois, 2001; Spelke, Phillips, & Woodward, 1995; Subrahmanyam, Gelman, & Lafosse, 2002). The prime examples of such agents are people and animals. People and animals are also the prototypical living things, and since their most salient feature is their agency, we speculate that the meaning of the word "alive" initially gets mapped onto the concept *agency*. Animist judgements likely reflect this early mapping. When young children say that the sun or a car is alive, they do not mean that it eats or breathes; they have not yet constructed a folkbiology that would support such inferences. Over the course of development, the

child does come to build a folkbiology, and the meaning of *alive* changes accordingly. We speculate that though a richly elaborated folkbiology is constructed, the underlying association of *agency* with the concept *alive* remains intact. When one is unable to draw on high-level folkbiological knowledge (as sometimes happens in AD patients and the elderly), one defaults to this underlying association. The result is animist thinking.

These results raise interesting questions. Is this conceptual domain, or aspects of it, especially vulnerable? And if so, why? We note that those cues that infants are disposed to attend to (cues to agency) are precisely the same cues that, to a fault, AD patients considered salient in their attributions of life. In contrast, biological concepts that are acquired later in childhood appear more vulnerable to age and AD. We speculate that future studies, comparing preserved and impaired conceptual knowledge in a range of domains, may demonstrate that first principles degrade last.

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