

# Inference of Beliefs and Emotions in Patients With Alzheimer's Disease

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The present study compared 20 patients with mild to moderate Alzheimer's disease with 20 older controls (ages 69–94 years) on their ability to make inferences about emotions and beliefs in others. Six tasks tested their ability to make 1st-order and 2nd-order inferences as well as to offer explanations and moral evaluations of human action by appeal to emotions and beliefs. Results showed that the ability to infer emotions and beliefs in 1st-order tasks remains largely intact in patients with mild to moderate Alzheimer's. Patients were able to use mental states in the prediction, explanation, and moral evaluation of behavior. Impairment on 2nd-order tasks involving inference of mental states was equivalent to impairment on control tasks, suggesting that patients' difficulty is secondary to their cognitive impairments.

*Keywords:* Alzheimer's disease, emotion, theory of mind, mental state attribution

Successful social interaction depends at least in part on the ability to make inferences about the beliefs and emotions of others (Fodor, 1987). Studies have examined how the ability to make such inferences develops in young children and how they are affected by varying developmental disorders. More recently, the impact of neurodegenerative disorders, such as Alzheimer's disease (AD), on these functions has been examined.

Studies investigating emotion processing in patients with AD have focused primarily on the ability to identify emotions (either perceptually or by inference). Results of these studies suggest that AD patients are not impaired in processing emotional information conveyed in facial expression, vocal intonation, or gesture, but that they are impaired on tasks that require interpretation of situational information portrayed in scenes and stories (Albert, Cohen, & Koff, 1991; Allender & Kaszniak, 1989; Cadieux & Greve, 1997; Koff, Zaitchik, Montepare, & Albert, 1999).

The ability to infer the beliefs of others has also been examined in several studies involving AD patients. One of these studies included both first-order tasks (in which participants are asked to infer the beliefs of others) and second-order tasks (in which participants are asked to infer someone's belief about someone else's belief). In this study, performance of AD patients on the

first-order tasks was no different from that of healthy controls, but AD patients were impaired relative to controls on the second-order tasks (Gregory et al., 2002). One study examining only first-order tasks (Zaitchik, Koff, Brownell, Winner, & Albert, 2004) and another examining only second-order tasks (Garcia Cuerva et al., 2001) reported similar findings.

To our knowledge, there are no studies directly comparing the ability to infer emotions with the ability to infer beliefs in patients with AD. This is important to examine, because other types of neurological patients who show selective deficits in the ability to make inferences about either beliefs or emotions have marked impairments in social functioning (Baron-Cohen, Leslie, & Frith, 1985, 1986; Brownell, Pincus, Blum, Rehak, & Winner, 1997; Gregory et al., 2002; Tager-Flusberg & Sullivan, 1994; Winner, Brownell, Happe, Blum, & Pincus, 1998). As AD evolves, many patients also have such difficulties, and it would be important to determine whether impairments in the ability to infer emotion or beliefs are contributing factors.

Moreover, the conceptual underpinnings of these abilities are important to understand in their own right, because of the critical role they play in healthy function. Cognitive psychologists have addressed these issues from a theoretical perspective primarily through the concept of theory of mind (e.g., Leslie, 1987; Wellman, 1985). This conceptualization posits that healthy individuals make inferences about the mental states of other individuals (such as beliefs) because healthy individuals have a conceptual structure founded on the notion that such mental states exist, that they can be discerned by observation, that they can be used to predict human action, and that they can thus help guide behavior in daily life. According to this perspective, the actions of healthy individuals suggest that they hold such an underlying theory of mind, even though they might not state it consciously. It has been argued that both the ability to infer emotion and the ability to infer mental states in others are species universal, are innately specified, and have a dedicated cognitive mechanism that is brain based. Support for this conclusion comes in part from cross-cultural studies of emotion (Ekman, 1992, 1993) and inference of mental states (Avis

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& Harris, 1991), including the finding that there is a consistent developmental pattern in young children.

The present study extends the investigation of the ability to infer emotions and the ability to infer beliefs in patients with AD in several ways. First, parallel procedures were used to assess inference of beliefs and inference of emotion in both first-order and second-order tasks. Second, each task contained a control condition to determine whether any impairments of the participants were due to the mental state inference in particular (i.e., inference about an emotion or a belief), as compared with inferences about information unrelated to a mental state (e.g., inference about an object, such as a picture). It was hypothesized that if participants had impairments that were not selective to mental states in particular, they would be impaired on both the mental state condition and the control condition. Third, we included tasks involving moral evaluations that rely, in part, on inferences of beliefs and emotions, as these have relevance to social interaction as well. Mildly to moderately impaired AD patients with an average age of 79 years were compared with controls, so that the results might apply to a broad range of patients.

## Method and Initial Discussion

### Participants

This study was conducted in the Greater Boston area. Forty older people (ages 69–94 years) gave informed consent to participate in the study; 20 (4 men and 16 women) were cognitively normal controls (NC) and 20 (7 men and 13 women) were patients with AD. AD patients were recruited through the Hebrew Rehabilitation Center for the Aged, a 720-bed facility in Boston, and the Gerontology Research Unit of the Massachusetts General Hospital. As success on basic theory of mind tasks appears to be virtually universal among 4-year-olds of both sexes (Wimmer & Perner, 1983; Zaitchik, 1990), the small number of male participants was not considered problematic. *T* tests revealed no significant differences between groups on age, NC = 78.1 ( $SD = 6.83$ , range = 69–94), AD = 79.55 ( $SD = 6.64$ , range = 67–91); or education, NC = 13.90 ( $SD = 2.67$ , range = 12–20), AD = 13.95 ( $SD = 3.07$ , range = 9–20).

For the normally functioning control group, we carefully reviewed the cognitive status of each participant to determine that there was no history of progressive cognitive decline. Laboratory tests to determine general medical health were also given (e.g., SMA-20, vitamin B12 and folate levels, serologic tests, and thyroid function tests). 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. Hearing and vision were also evaluated, and all participants had adequate hearing and visual abilities for the task demands. To corroborate the adequacy of the participants' cognitive status, an experienced tester administered the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) to all participants. The mean MMSE of the controls was 29.5 ( $SD = 0.69$ , range 28–30).

The diagnosis of AD was based on a neurological, psychiatric, and neuropsychological evaluation. Participants met the National Institute of Neurological and Communications 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. All AD participants received an ischemic score of 4 or less on the Ischemic Scale for assessing the likelihood of multi-infarct dementia (Hachinski, 1978), and all showed adequate hearing and visual abilities for the task demands. The mean MMSE of the AD patients

was 24.1 ( $SD = 3.12$ , range 17–30). Some AD patients were mildly impaired and some were moderately impaired.

### Neuropsychological Assessment

Four standardized neuropsychological tests were administered to all participants. The neuropsychological tests were (a) the MMSE, a standard measure for assessing overall level of global cognitive function; (b) the Delayed Recall test from the Consortium to Establish a Registry for Alzheimer's Disease battery (Morris et al., 1989), which assesses immediate and delayed recall of verbal material; (c) the Similarities subtest of the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981), which assesses concept formation; and (d) 15 items from the Boston Naming Test, as used in the Consortium to Establish a Registry for Alzheimer's Disease battery (Morris et al., 1989). The performance of the participants on these tasks is provided in Table 1.

### Assessment of Inference of Beliefs and Emotions

Six tasks were used to assess the participants' ability to infer beliefs and emotions in others. Four tasks (Tasks 2, 3, 5, and 6) used parallel procedures to assess inference of beliefs and inference of emotion in both first-order and second-order tasks. Two of these four tasks (Tasks 5 and 6) assessed the participants' ability to explain the actions of the characters in a story. These tasks, which included moral evaluations, were designed so that even if participants failed to predict a character's belief or emotion in Tasks 2 and 3, it would be possible to determine whether they could explain the behavior of others by virtue of information provided to them about belief or emotion. Two tasks (Tasks 1 and 4) assessed the ability of the participants to make inferences about beliefs, but did not include a condition related to emotion. Because of the large number and variety of tasks included in the battery, the results of each task and an initial discussion of the findings follow the description of the methods for each task.

#### Task 1: The False Belief–Real Object Task

##### Description

The false belief–real object task (which is based on work by Astington & Gopnik, 1988) assesses the ability to report on your own former false belief as well as the ability to infer someone else's belief. It was the least demanding of the tasks that we administered, because it used concrete objects, was non-narrative,

Table 1  
Scores (Means, Ranges, and Standard Deviations) on  
Neuropsychological Tests by Controls and AD Patients

Group	Mini-Mental State Exam	Delayed recall	Similarities	Naming
AD				
<i>M</i>	24.0	0.5	15.9	12.3
Range	17–30	0–4	6–24	7–15
<i>SD</i>	3.1	1.1	5.9	2.1
NC				
<i>M</i>	29.5	7.4	19.1	14.0
Range	28–30	2–10	11–27	10–15
<i>SD</i>	0.7	2.2	4.3	1.4

Note. AD = Alzheimer's disease; NC = normally functioning controls.

and minimized memory demands. In the first part of the task, the participant was misled by the exterior of a box into holding a false belief about its contents. The participant was then shown the real contents of the box. Participants were then asked an initial set of questions about their own previous false beliefs, which technically only required recall of the immediate past events. These questions were used to set up a frame of reference for the final question, which demanded an inference about the belief of another individual.

The task included two trials. In each trial, the participant was shown a container, for example, a Band-Aid box. The participant was then asked the first question, the initial belief question: "What do you think is inside the box?" The experimenter then opened the box and showed the participant its contents, which were not what is usually found in the box (i.e., paper clips rather than Band-Aids). After the participant saw the contents of the box, he or she was asked the second question, the reality question: "What is really in the box?" These first two questions documented that the participant underwent a change in belief. The next question, called a former false belief question, tested the participant's ability to recall the former belief: "What did you think was in the box before we opened it?" Finally, the last question, the other's false belief question, tested the participant's ability to infer the false belief of another person: "If I bring another person into the room and show him the box all closed up like I first showed it to you, what will he think is in the box?" To be credited with the ability to report on one's own former false belief, the participant must have correctly responded to both the second and third questions, that is, the reality question and the former false belief question. To be credited with the ability to infer another person's false belief, the participant must have correctly responded to the second and fourth questions, that is, the reality question and the other's false belief question. Task 1 assessed the participant's understanding that beliefs are mental representations, and as such they may be false, and that perceptual experience (e.g., seeing the Band-Aid box) can lead to a false mental representation (i.e., a false belief).

### *Results and Initial Discussion*

Both the older controls and the AD patients were correct on all test questions (data not shown). The AD patients, like the controls, had no difficulty inferring that other individuals would have had a false belief about the contents of the container, if they had only seen the outside of the container. The performance of AD patients suggests that they understood that perceptual experience leads to belief (e.g., seeing a Band-Aid box leads to the belief that Band-Aids are inside) and that beliefs may be false (i.e., may conflict with reality).

#### *Task 2: The False Belief–False Picture–Emotion Story Task*

##### *Description*

This task assesses the ability to make inferences about both beliefs and emotions. It was more demanding than Task 1 because the participant had to infer the beliefs or emotions of story characters. To reduce the memory demands of the task, we illustrated each story by a set of four simple line drawings depicting the main

events in the story. The experimenter read each story aloud, pointing to the relevant characters in the illustrations. The task comprised four sets of illustrated stories, each of which had three conditions: One condition assessed the ability to make inferences about beliefs; the second condition assessed the ability to make inferences about emotions; and the third condition was a control condition that was included to determine whether any difficulty in the belief condition was due to the fact that it pertained to mental states (i.e., beliefs or emotions). The control condition was structurally identical to the belief condition, but assessed the ability of the participant to make inferences about whether a picture accurately portrayed reality rather than whether a belief did.

To respond correctly in the first two conditions, the participant had to understand that another person's belief or emotion would depend on that person's perspective. In the belief condition, this perspective could have led to a belief that might have been false. In the emotion condition, this perspective led to a particular emotion. In the control condition, adequate performance of the task required the participant to understand that a picture can represent events that are no longer true (and, in that sense, that a picture can be false).

*Belief condition.* In the belief condition, each story involved a character who had a false belief about the location or identity of an object (Wimmer & Perner, 1983; Zaitchik, 1990, 1991). For example, in one story, a woman puts a set of keys in her pocketbook; in the woman's absence, a man takes the keys out of the pocketbook and places them in his briefcase. The participant was then asked two questions: first, a fact question: "Where are the keys really, in the pocketbook or the briefcase?" and, second, a belief inference question: "Where does the woman think the keys are, in the pocketbook or the briefcase?" To be scored as correct in the belief condition, the participant must have correctly answered both the reality and the false belief questions of that story, demonstrating the understanding that beliefs can conflict with reality.

*Emotion condition.* In the emotion condition, each story involved a character in a situation that would lead to a particular emotional response. For example, in one story a woman hands a postman a large box that she is mailing to a friend; the box, which contains a glass vase, is marked *fragile*. When the postman lifts it, it slips through his hands. As it hits the floor, the glass shatters. The participant was asked first the fact question: "Did the vase shatter, yes or no?" and, second, the emotion inference question: "How does the postman feel, happy or sad?"

*Control condition.* The control condition was structurally identical to the belief condition, as mentioned above, but it involved pictorial representations rather than representations of mental states such as beliefs. In the control condition, as in the belief condition, a representation was formed of an object in a specific location; the object was then moved to a different location. To answer the critical questions correctly, the participant must have understood that the picture misrepresented the object's current location. For example, in one story a woman puts a vase of flowers on the dining room table. She next takes a photograph of the vase and then leaves the house. While she is gone, a man takes the vase off the table and places it on the windowsill. The participant was then asked two questions: first, the fact question: "Where is the vase now, on the table or the windowsill?" and, second, the pictorial inference question: "Where is the vase in the photo, on the table or the windowsill?" To be scored as correct in the control

condition, the participant must have correctly answered both the reality and the false picture question of the story, demonstrating an understanding that pictorial representations can conflict with reality (e.g., that the vase is on the table in the photo but the vase is now on the windowsill).

### Results and Initial Discussion

The performance on each question type (fact or inference) for each group in each condition (belief, emotion, control) is shown in Table 2. The performance of the control group showed a ceiling effect. As their data lacked the variance necessary for parametric analysis, we used a series of six  $2 \times 2$  Fisher's exact tests to compare the two groups. Each test included participant group as one dimension (AD, NC) and accuracy as the other dimension (perfect vs. less than perfect). In the belief condition, the fact question showed a significant group difference ( $p = .004$ ,  $\eta = .60$ ), but the inference question did not ( $p = .09$ ,  $\eta = .30$ ). In the emotion condition, the fact question showed no group difference ( $p = .09$ ,  $\eta = .30$ ) whereas the inference question approached significance ( $p = .06$ ,  $\eta = .34$ ). In the control condition, both the fact question ( $p < .001$ ,  $\eta = .76$ ) and the inference question ( $p = .009$ ,  $\eta = .69$ ) showed a significant group effect.

To further explore the performance of the AD group alone, we analyzed the percentage of correct responses in a  $3$  (condition)  $\times$   $2$  (question) analysis of variance (ANOVA). This analysis yielded a significant effect of condition,  $F(2, 38) = 9.93$ ,  $p < .001$ ,  $\eta = .59$ , that was due to poorer performance in the control condition (mean Control Condition  $\times$  Question Type = 73%) and better performance on the two mental state conditions (mean Belief Condition  $\times$  Question Type = 92%, mean Emotion Condition  $\times$  Question Type = 92%). The ANOVA also showed an effect of question type that approached significance,  $F(1, 19) = 3.52$ ,  $p = .08$ ,  $\eta = .39$ . This was due to a slight trend in the data for the fact question to be harder than the inference question, suggesting that difficulty remembering the story facts might be responsible for diminished performance on this task. In addition, the Question Type  $\times$  Condition interaction approached significance,  $F(2, 38) = 2.53$ ,  $p = .09$ ,  $\eta = .34$ , suggesting that the inference question was harder in the emotion condition.

These findings indicated that AD patients performed well on both of the conditions related to inference of mental states in others (beliefs or emotions). Their performance was impaired, however, in the control condition. This suggests that their difficulty was not specific to reasoning about mental states.

Table 2  
Task 2 Scores (% Correct) by Group, Condition, and Question Type

Group	Belief		Control		Emotion	
	Fact	Inf	Fact	Inf	Fact	Inf
NC	100	99	99	95	99	98
AD	90*	94	68*	78*	93	91

Note. Inf = inference. NC = normally functioning controls; AD = Alzheimer's disease.

\*  $p \leq .05$ .

### Task 3: Second-Order Inference Story Task

#### Description

This task, like Task 2, evaluated the ability to make inferences about the beliefs and emotions of others. As in Task 2, the task comprised four sets of illustrated stories, each of which had three conditions: the belief condition, the emotion condition, and the control condition. In Task 3, however, the participant had to make second-order inferences. In the belief condition, the participant had to infer one character's belief about another character's belief. In the emotion condition, the participant had to infer one character's feeling about another character's feeling. In the control condition, the participant had to make an inference about one picture's depiction of another picture. As in Task 2, each story was illustrated by a set of four simple line drawings depicting the main events in the story. The experimenter read each story aloud. To simplify both the memory and linguistic demands of the task, we asked the participant questions as the story was presented, rather than at the end.

**Belief condition.** In the belief condition (Sullivan, Zaitchik, & Tager-Flusberg, 1994), each story included a character that held a false belief about another character's belief. For example, in one story, a mother and her son are putting groceries away in the kitchen. They put the box of cookies in a big jar on the counter. The son leaves the room, and the mother removes the cookies from the jar and puts them in the cabinet. At this point, the participant was asked two questions: first, a fact question: "Where are the cookies now, the jar or the cabinet?" and, second, a first-order belief question: "Where does the son think the cookies are, the jar or the cabinet?" The story proceeds as follows: The mother then leaves the kitchen and the son comes in with a friend and discovers the cookies. Following this, another first-order belief question was asked: "Does the son know that the cookies are in the cabinet now, yes or no?" Subsequently, in the story, the mother is in another room with the father and tells him she bought some cookies and put them in the cabinet. The father then poses two questions that the participants were asked to answer from the mother's perspective; the inference required was such that the questions served as second-order belief questions: "'Does our son know where the cookies are now?' What does Mother say, 'yes' or 'no?'" and "'Where does our son think the cookies are?' What does Mother say, 'in the jar' or 'in the cabinet?'"

**Emotion condition.** In the emotion condition, each story involved a character that experienced an emotion about another character's emotion. For example, in one story the participants were told that Peggy has just won an important race. The participant was asked two questions: first, a fact question: "Did Peggy win the race or did Peggy lose the race?" and, second, a first-order emotion question: "How does Peggy feel—happy or sad?" The participant was then introduced to Sandra, who hates Peggy because Peggy stole her boyfriend. Sandra has been watching the race. To verify that the participant had the necessary information to answer the second-order emotion questions, we asked the participant the following two questions: "Does Sandra know that Peggy has won the race, yes or no?" and "Does Sandra know that Peggy is happy now that she won the race, yes or no?" This was followed by the second-order emotion question: "How does San-

dra feel about Peggy feeling happy? Does Sandra feel happy that Peggy is happy or sad that Peggy is happy?"

**Control condition.** In the control condition (which is based on work by Zaitchik, 1990), each story pertained to a photograph of a drawing depicting an object in a particular location. For example, in one story, a boy makes a chalk drawing of his sister lying on the couch. The sister takes a photo of the boy holding up his drawing. The sister then leaves the room. The father enters and lies down on the couch. The participant was then asked two questions: first, a fact question: "Who is lying on the couch now, the sister or the father?" and, second, a first-order picture question: "In the chalk drawing, who is lying on the couch, the sister or the father?" The brother then erases his drawing and makes a new drawing of his father lying on the couch. Following this, another first-order picture question was asked: "If you look at the chalkboard now, does it show the father lying on the couch, yes or no?" The story proceeds as follows: The sister returns with a photograph of the boy holding up the original drawing. Two second-order picture questions were then asked: "The photograph shows the boy holding up a drawing of someone lying on the couch. Is the person lying on the couch in the photograph the same person who is lying on the couch now, yes or no?" and "What does the photo show, a drawing of the sister lying on the couch or a drawing of the father lying on the couch?" Parallel to the belief condition, the picture condition involved the photo (second-order depiction) of the drawing (first-order depiction) showing the sister on the couch. In both cases, the second-order representation was not in accord with reality or with a revised first-order representation (the revised drawing's depiction of the father on the couch.)

### Results and Initial Discussion

The percentage correct, by group and condition, for first-order inferences is shown in Table 3. The belief and control conditions included two questions requiring the same type of first-order inference (Questions 2 and 3), therefore these data were pooled. The emotion condition included only one question requiring a first-order emotion inference (Question 2). Because of the lack of variance in the NC group's first-order scores, Fisher's exact tests were used to evaluate group differences. One dimension was group (AD, NC), and the other dimension was degree of accuracy (perfect vs. less than perfect). There were no significant differences in either the belief condition ( $p = .20$ ,  $\eta = .20$ ) or the emotion condition ( $p = .12$ ,  $\eta = .29$ ). In the control condition, however, there was a significant group difference ( $p = .002$ ,  $\eta = .50$ ).

Table 4 shows the percentage correct, by group and condition, for second-order questions. The belief condition and the control condition included two questions requiring the same type of second-order inference (Questions 4 and 5); therefore, these data were

Table 3  
*Task 3 First-Order Scores (% Correct) by Group and Condition*

Group	Belief	Control	Emotion
NC	99	100	100
AD	96	91**	99

Note. NC = normally functioning controls; AD = Alzheimer's disease. \*\*  $p \leq .004$ .

Table 4  
*Task 3 Second-Order Scores (% Correct) by Group and Condition*

Group	Belief	Control	Emotion
NC	95	97	89
AD	72***	71***	81

Note. NC = normally functioning controls; AD = Alzheimer's disease. \*\*\*  $p \leq .001$ .

pooled. In contrast, the emotion condition included only one question requiring a second-order inference (Question 5). First, two sign tests (one for each group) compared how many participants in the group performed better on the first-order questions (collapsed across conditions) than on the second-order questions (collapsed across conditions). These tests revealed that both groups showed better performance on first-order than second-order questions ( $p < .001$ , for both groups). Then a 2 (group)  $\times$  3 (condition) ANOVA was performed on the second-order inference data. There was a significant group difference (NC  $M = 94\%$ , AD  $M = 75\%$ ),  $F(1, 38) = 31.55$ ,  $p < .001$ ,  $\eta = .67$ . The condition effect was not significant,  $F(2, 76) = .07$ ,  $\eta = .04$ , whereas the Group  $\times$  Condition interaction approached significance,  $F(2, 76) = 2.76$ ,  $p = .07$ ,  $\eta = .26$ . Fisher's exact tests with group (AD, NC) as one dimension and performance scores (perfect vs. less than perfect) as the other dimension revealed that the groups differed significantly in both the second-order belief ( $p = .002$ ,  $\eta = .50$ ) and control conditions ( $p < .001$ ,  $\eta = .70$ ), but not in the second-order emotion condition ( $p = .26$ ,  $\eta = .16$ ).

These findings suggest that the belief and control conditions might make greater demands than does the emotion condition on cognitive processes that are particularly vulnerable in AD patients. A close comparison of the tasks offers some initial support for this view. Consider that the correct response in the belief condition required that the participant represent—and then correctly choose between—two possible responses: "Mother thinks that the son thinks that the cookies are in the jar" or "Mother thinks that the son thinks that the cookies are in the cabinet." Similarly, in the control condition, the participant had to choose between "The photo shows the drawing that shows that the sister is lying on the couch" or "The photo shows the drawing that shows that the father is lying on the couch." To respond correctly, the participant had to remember all the information, including the information represented in that final doubly embedded proposition. This demand was not present in the emotion condition. Although the story specified that "Sandra feels sad that Peggy is happy that she won the race," the final proposition ("that she won the race") can be forgotten and the question as to how Sandra feels about Peggy feeling happy can still be answered correctly. If you remember that Peggy is happy and that Sandra hates Peggy (the gist of the story), you can infer that Sandra will be sad that Peggy is happy. It simply does not matter why Peggy is happy. So, although the answer required a correct second-order attribution of emotion (Sandra feels sad that Peggy feels happy), it did not appear to make the same demands on either memory or language processes as the other two conditions did. If this is right, it might explain why this condition was less vulnerable to the effects of AD.

These findings also indicate that AD patients have difficulty with second-order belief attributions only and that the level of difficulty appears similar in both the belief and the control conditions. Findings also suggest that the primary difference between first-order and second-order belief attributions lies much less in demands on the processing of mental states per se, than in demands on general cognitive processes.

To assess the hypothesis that the greater difficulty of the second-order belief and control conditions lies in their demands on cognitive processes that are vulnerable in patients with AD, we examined the correlations between scores on the second-order mental state questions (pooled) and scores on each of the neuropsychological tests administered to the participants. For healthy controls ( $df = 18$ ), there were no significant correlations (MMSE,  $r = -.22, p = .34$ ; Similarities,  $r = .23, p = .32$ ; Delayed Recall,  $r = -.08, p = .73$ ; and Boston Naming Test,  $r = -.14, p = .57$ ). For AD patients ( $df = 18$ ), there was a significant correlation between the Boston Naming Test and the second-order mental state questions ( $r = .56, p = .009$ ). The other correlations were as follows: MMSE,  $r = +.25, p = .29$ ; similarities,  $r = +.19, p = .44$ ; delayed recall,  $r = +.18, p = .44$ . The correlation with the Boston Naming Test, a test that makes no demands on the ability to attribute beliefs (but that might be particularly sensitive to disease severity), was consistent with the hypothesis that patients' difficulty in the attribution of second-order beliefs was not due to any specific impairment in the ability to attribute mental states per se. As mentioned above, this hypothesis was also supported by the fact that the patients' performance on the second-order belief condition was very similar to performance on the second-order control condition, another task that did not involve the attribution of mental states.

*Task 4: Social Responsibility Story Task*

*Description*

This task (which was based on work by Mant & Perner, 1988) assesses the ability to make first-order and second-order inferences about beliefs and to apply them to situations that involved social and/or moral responsibility. In addition, it assesses the participants' understanding that the same behavior can be morally right or wrong, depending on the actor's mental state. The task contains three conditions: (a) the commitment condition, (b) the no commitment condition, and (c) the control condition. In each condition, participants were presented with four illustrated stories.

*Commitment condition.* In the commitment condition, each story involved two characters who are discussing plans for the evening. The first character invites the second character to join him

or her later at a specified location, and the second character accepts. However, the first character later changes his or her mind and does not show up, but the second character arrives as planned.

*No commitment condition.* In the no commitment condition, the first character invites the second character to join him later in a specified location. This time, however, the second character does not accept (because he or she already has plans for the evening). As things turn out, the plans fall through, so the second character shows up at the place suggested by the first character, hoping to find him or her there. However the first character does not come.

*Control condition.* In the control condition, (originally known as the Act of God condition) the first character invites the second character, who accepts the invitation (just as in the commitment condition). However, the first character is unable to come to the meeting because of an event outside of his control (e.g., a flat tire). The second character shows up as planned.

For each story, the participant was asked four types of questions: first, a fact question: "Does the first character come to the potential meeting place?"; second, a first-order mental state question: "Does the second character know that the first character is not coming?"; third, a second-order mental state question: "Does the first character know that the second character expects to meet him or her?"; and fourth, a social-moral responsibility question: "When the meeting did not occur, did the first character do something wrong?"

*Results and Initial Discussion*

The percentage correct for each question in each condition by group is shown in Table 5. A three-way ANOVA on Group  $\times$  Condition  $\times$  Question Type showed no significant group effect,  $F(1, 38) = 2.8, p = .10, \eta = .26$ , and no significant interaction of group with either condition,  $F(2, 76) = .97, p = .38, \eta = .16$ , or question,  $F(2, 76) = 1.8, p = .15, \eta = .21$ . There was, however, a significant main effect of condition, reflecting the greater difficulty of the no commitment condition across both groups of participants,  $F(2, 76) = 16.10, p < .001, \eta = .55$ . There was also a significant main effect of question type, showing that, for both groups, the fact question and first-order question were easier than the second-order question and social-moral responsibility question,  $F(3, 114) = 32.41, p < .0001, \eta = .68$ . Last, there was a significant interaction of Condition  $\times$  Question Type, showing that, for both groups, the difference between question types was greater in the no commitment condition than in the other conditions,  $F(6, 228) = 9.32, p < .0001, \eta = .44$ . Most important, however, there were no effects involving group.

The absence of a significant difference between the AD and NC groups supports the conclusion from the previous tasks, that the

Table 5  
Task 4 Scores (% Correct) by Group, Condition, and Question Type

Group	Commitment				No Commitment				Control			
	Fact	1st order	2nd order	Social-moral	Fact	1st order	2nd order	Social-moral	Fact	1st order	2nd order	Social-moral
NC	99	100	95	94	99	100	81	64	100	100	91	91
AD	99	100	79	96	95	99	66	53	100	100	91	90

Note. NC = normally functioning controls; AD = Alzheimer's disease.

basic ability to infer beliefs is not impaired in AD. Moreover, the patients with AD are similar to the controls in two additional ways: They correctly perceived the difference between predictions and promises, and they understood that distinct social and/or moral obligations follow from them. The difference between promising and predicting is relatively subtle and, based on work that has been done with children, is more difficult than inference of beliefs. Whereas most children can infer beliefs correctly by age 4 (Astington & Gopnik, 1988; Wellman, 1985; Wimmer & Perner, 1983; Zaitchik, 1990, 1991), they typically do not master the distinction between prediction and promise until age 9 or older (Mant & Perner, 1988),

*Task 5: First-Order Explanation Story Task*

*Description*

Both Task 5 and Task 6 evaluated the participants' understanding of the relationship between belief and behavior, as well as the relationship between emotion and behavior. In these tasks, participants did not need to infer the story character's belief or emotion; they needed only to choose the appropriate belief or emotion as the correct explanation for the character's behavior. There were three conditions in the task: (a) the belief condition, (b) the emotion condition, and (c) the control condition. The task consisted of four stories portrayed in drawings. Each story contained a structure that remained constant across conditions. However, each condition filled in relevant details that led to different explanations for a character's behavior. For example, one story involved a man driving his car, with his wife as a passenger, on his way to a specific location. He pulls over to the side of the road and gets out of the car. The details of the story vary by condition.

*Belief condition.* In this condition, the participant was told that the driver and his wife are going to visit a friend. They believe the friend lives in a big house, though he actually lives in a small house. The participant was then asked the fact question: "Where does the friend really live, the small house or the big house?" The driver gets to the big house, pulls over, and gets out of the car. The participant was then asked the explanation question: "Why does the driver stop there, near the big house? Is it because his friend lives in the big house or because he thinks his friend lives in the big house?"

*Emotion condition.* In this condition, the participant was told that the driver and his wife are on their way to the library. The driver's wife starts to complain about his driving and to tell him to slow down. He responds that if she does not like the way he drives, she can drive herself. The participant was asked the fact question: "Does the driver's wife complain to him about his driving?" The

story continues with the driver pulling over to the side of the road, stopping, and getting out. The participant was then asked the explanation question: "Why does the driver stop the car there by the side of the road? Is it because he's at the library or because he's angry at his wife for criticizing him?"

*Control condition.* In this condition, the participant was told that the driver and his wife are going to the store. Their car starts to smoke and make a terrible clanging noise. The participant is then asked the fact question: "Is something wrong with their car?" The driver pulls over to the side of the road, stops the car, and gets out. The participant was then asked the explanation question: "Why does the driver stop there by the side of the road? Is it because he reached the store or because he's having car trouble?"

*Results and Initial Discussion*

Mean scores on each question type (fact or explanation) for each condition (belief, emotion, control) by group are shown in Table 6. The performance of the controls and AD patients was at ceiling. Thus, Fisher's exact test was used to evaluate group differences for each question. One dimension was participant group (AD, NC), and the other was degree of accuracy (perfect vs. less than perfect). In the belief condition there were no significant differences between the groups on either the fact question ( $p = .20, \eta = .19$ ) or the explanation question ( $p = .204, \eta = .19$ ). In both the emotion condition and the control condition, there were also no significant group differences on either the fact question ( $p = .50, \eta = .00$  in both conditions) or the explanation question ( $p = .50, \eta = .00$  in both conditions).

These findings demonstrate that performance in the belief and emotion conditions is equivalent. The results offer converging evidence that AD patients maintain their understanding of the relation between mental states (beliefs and emotions) and behavior derived from them.

*Task 6: Second-Order Explanation Story Task*

*Description*

Task 6, as noted above, evaluated the participants' understanding of the relationship between belief and behavior, as well as of the relationship between emotion and behavior. In these tasks, as in Task 5, participants did not need to infer the character's belief or emotion; they needed only to choose the appropriate belief or emotion as the correct explanation for the character's behavior. However, in Task 6 the explanations were of both first-order and second-order inferences. There were three conditions in the task:

Table 6  
*Task 5 Scores (% Correct) by Group, Condition, and Question Type*

Group	Belief		Control		Emotion	
	Fact	Explanation	Fact	Explanation	Fact	Explanation
NC	98	98	99	100	98	99
AD	94	96	98	100	99	98

Note. NC = normally functioning controls; AD = Alzheimer's disease.

(a) the belief condition, (b) the emotion condition, and (c) the control condition. Each condition included four stories portrayed in drawings.

**Belief condition.** In the belief condition, one character in the story is misled by a second character. The character who has been misled learns the truth. Then a third character learns about the character who has been misled and asks what that character thinks is the truth (not knowing he has learned he has been misled). For example, one story involves a young student who asks an older student which room is the library. The older student tells him it is the large room at the end of the hall. This is, however, untrue; the older student purposely misled the young student, and the library is actually in the smaller room. The participant was then asked the first-order question: "Which room does the young student think is the library, the larger room or the smaller room?" The story continues with the older student going upstairs to his next class. The new student starts walking down the hall. He passes a small room marked *Library* and realizes the older student has misled him. By this time, the older student is upstairs in class, telling a friend that he misled the young student who asked him where the library was. The friend then asks where the young student thinks the library is, and the older student says "the large room at the end of the hall." The participant was asked the second-order question: "Does the older student say that the young student doesn't know the location of the library because he doesn't know that the new student found out the truth? Or does he say it because he thinks the big room is the library?"

**Emotion condition.** In the emotion condition, the first character has an emotional reaction to a situation. A second character feels differently about the same situation. For example, one story tells of a basketball player who is happy that he has just been awarded a trophy. The participant is asked the first-order question: "How does the boy feel, happy or sad?" A second character, who is not a good basketball player and is often criticized by the basketball player, is sad that the athlete is happy. The participant is then asked why one character is happy and one is sad, with the following second-order question: "Is it because the star athlete criticized him or is it because he's jealous of the star athlete's girlfriend?"

**Control condition.** In the control condition, as in Task 2 and Task 3, each story pertained to a photograph of a drawing depicting an object in a particular location. The location of the object then changed. For example, one story involved a girl who has just received a skirt and a pair of pants as a gift. She puts on the skirt and her friend makes a drawing of her in the new skirt. The participant was then asked the first-order question: "What is the

girl wearing in the drawing, the skirt or the pants?" The girl then takes a photo of her friend holding the drawing she made of her in a skirt. The girl then puts on the new pants, so the friend erases her old drawing and draws a new sketch of the girl wearing the pants. The participant was then asked the second-order question: "Does the photo show the girl wearing a skirt because it was taken when the friend was holding up her first drawing—a drawing of the girl in the skirt—not her second drawing? Or does the photo show the girl wearing a skirt because the friend never made a drawing of the girl wearing pants?" As in Task 3, this condition evaluated whether any difficulty participants have in the belief condition was due to impairment in their ability to explain the actions of others based on their understanding of their mental state in particular or whether it was due to cognitive demands of the task that had nothing to do with understanding mental states.

### Results and Initial Discussion

The performance of the participants on each question type for each condition by group is presented in Table 7. A 2 (group)  $\times$  3 (condition)  $\times$  2 (question type) ANOVA revealed the significant main effects for group,  $F(1, 38) = 13.22, p < .001, \eta = .51$ ; condition,  $F(2, 76) = 6.89, p < .002, \eta = .39$ ; and question type,  $F(1, 38) = 25.98, p < .001, \eta = .64$ . There was also a significant interaction between Group  $\times$  Question Type,  $F(1, 38) = 8.93, p < .005, \eta = .44$ . Moreover, there was a significant three-factor interaction involving Group  $\times$  Condition  $\times$  Question Type,  $F(2, 76) = 4.75, p = .01, \eta = .33$ . A series of *t* tests we used to explore the source of this interaction showed that the group difference for the second-order question in the control condition was significant ( $p = .001$ ), whereas none of the other group differences for the other questions and conditions approached statistical significance. That is, the only compelling group difference was in the control condition, a condition that does not require an understanding of mental states. Apparently, AD patients' difficulty lay in the cognitive demands of the task rather than in impairment in their theory of mind.

### General Discussion

The primary result of the study is that across the full range of first-order tasks, AD patients were not significantly different from controls on any of the tasks assessing inference of beliefs or inference of emotions. In addition, AD patients were not significantly different from older controls in moral evaluations or explanations of the actions of others that depended on beliefs or emotions.

Table 7  
Task 6 Scores (% Correct) by Group, Condition, and Question Type

Group	Belief		Control		Emotion	
	1st order	2nd order	1st order	2nd order	1st order	2nd order
NC	94	86	94	93	100	94
AD	90	80	96	61***	99	86

Note. NC = normally functioning controls; AD = Alzheimer's disease.  
\*\*\*  $p < .001$ .

The performance of the AD patients was mixed on the second-order inference tasks. On two tasks (Task 4 and 6), they performed as well as controls did on the questions pertaining to inference of beliefs and emotions, but on one task (Task 3) they did not. It is important to note, however, that in Task 3, the performance of the patients on the inference of belief tasks was comparable with their performance on the control condition (inference involving photographs or drawings) and was highly correlated with a test of cognitive ability, the Boston Naming Test, that does not involve mental state reasoning at all.

The results pertaining to inference of emotion confirm previous studies that suggested that AD patients do not have a primary difficulty inferring emotions in others (Albert et al., 1991; Allender & Kaszniak, 1989; Cadieux & Greve, 1997; Koff et al., 1999). The results pertaining to inference of beliefs are also in agreement with previous findings showing that AD patients do not have a difficulty with first-order inference of beliefs (Gregory et al., 2002; Zaitchik et al., 2004) but that they do have difficulty with second-order beliefs (Garcia Cuerva et al., 2001). Like the last authors, we hypothesized that the problems with second-order belief inference are related to the cognitive-processing demands of the task, rather than to reasoning about the mental states of others.

The present study extends these previous findings in several ways. First, parallel tasks were designed to directly compare the inference of beliefs versus emotions versus control conditions. The comparison of AD patients' performance on these three conditions suggests that first-order inference of beliefs is similar in difficulty to first-order inference of emotions and that performance on both of these first-order mental state conditions is easier than performance on the control condition. This is particularly striking when one considers the representational requirements of the three tasks. In the belief condition, the participant must represent and manipulate two conflicting representations—the story character's belief about the object's location as well as the object's actual location; in this condition, the belief is false, in that it misrepresents reality. Similarly, in the control condition, the participant must manipulate the pictorial representation of the object's location as well as the object's actual location; from this perspective, the picture also misrepresents reality. This conflict is not present in the emotion condition; as assessed in these tasks, the emotions are not true or false. One might therefore expect that AD patients would perform better on the inference of emotion tasks than on the other two conditions. However, the level of performance was similar in both the first-order belief and emotion conditions, whereas the control condition was selectively impaired. This is consistent with one of the central hypotheses of the theory of mind literature: The ability to make first-order inferences of another person's mental state uses a dedicated brain system that enables such processes to proceed automatically (Avis & Harris, 1991; Fodor, 1987; Leslie, 1987). These theorists have argued that a hardwired system has evolved because the ability to make inferences about the mental states of others is critical to the survival of the species. There is no reason to think that the ability to make an inference about a picture or drawing is essential for evolution. Thus, one would predict that performance on the first-order belief or emotion task would be better than performance on the first-order control task, a finding consistent with our data.

The results of the second-order inference tasks are quite different. Second-order inference of belief appears to be just as hard for

the AD patients as for the second-order control condition, and both are markedly harder than second-order emotion inference. As mentioned in the initial discussion of Task 3, the cognitive demands of these second-order inference tasks are considerable, as they require the representation in working memory of doubly embedded clauses. Because the second-order emotion condition does not involve inferring emotions that conflict with reality, the task makes fewer cognitive demands. The differential cognitive demands of the second-order tasks therefore appear to directly explain the patients' performance.

An additional contribution of the present study is that it investigated the participants' understanding of moral responsibility and its relation to beliefs and knowledge. The impressive performance of AD patients on this task—showing a normal understanding of the moral obligations that distinguish predicting from promising—goes well beyond simple inference of belief. Finally, all of these findings were observed not only in AD patients with early onset disease (as was the case in the study of Gregory et al., 2002), but also in older mild- to moderate-AD patients.

A limitation of the study is the forced-choice format of most of the tasks and the finding that, on some tasks, the participants performed at ceiling. It is therefore possible that participants with only partially preserved mental state inference could perform well. The fact that AD patients' performance on second-order inference tasks was generally equivalent to that on the control tasks suggests that ceiling effects on the easier tasks were not obscuring subtle deficits.

Taken together, these findings support the hypothesis that the basic ability to infer mental states (beliefs and emotions) in others is intact in mild- to moderate-AD patients. Across a variety of tasks, the patients' behavior is consistent with a normal understanding of mental states, as delineated in the theory of mind literature: that beliefs are representational, that they may be true or false, that beliefs can be caused by perceptual experience, that beliefs play a causal role in behavior, that emotions are feeling states, that people can have different emotional responses to the same event, that emotions can be caused by experiences, and that they can affect behavior and cause other experiences. Furthermore, AD patients' behavior suggests that they understand that social and moral evaluation must take account of beliefs and knowledge. Across the battery, then, AD patients were able to use mental states in the prediction and explanation of behavior, as well as in their role in moral evaluation. It is still not known at what point in the disease patients might lose the ability to make inferences about mental states. Future research will shed light on this question and on the way that such impairment might affect the personal lives of patients with AD.

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