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# Conscious Knowledge and Decision Making Under Ambiguity in Mild Cognitive Impairment and Alzheimer Disease

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**Key Words:** decision making, Iowa Gambling Task, mild cognitive impairment, Alzheimer disease

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Older adults face many situations that require them to make important decisions. Decision making is a broad and complex construct. One conceptualization of decision making is the somatic marker hypothesis developed by Bechara et al.<sup>1</sup> These authors state that the experience of emotion that operates unconsciously is tied to the decision-making processes. Empirical support for the somatic marker hypothesis is largely based on performance on the Iowa Gambling Task (IGT), a paradigm designed to stimulate decisions in terms of uncertainty (ie, implicit rules), reward, and punishment.

According to Bechara et al.,<sup>2</sup> normal participants started to make the right selections in that card game before they had conscious knowledge that those were the best selections. In this task, healthy controls demonstrate an anticipatory electrodermal response (ie, unconscious and automatic bodily signals) to card selection; before selecting a risky choice, they show a physiological reaction indicating that they are bodily experiencing the anticipated risk even before conscious knowledge is available. Since the seminal work of Bechara et al.,<sup>2</sup> some authors have suggested that an explicit/analytical understanding can be sufficient to guide advantageous decision making measured by the IGT.<sup>3</sup>

In fact, healthy individuals with higher levels of conscious explicit knowledge of the advantageous strategy during the IGT also have better decision performance on the task<sup>2,3</sup> and there was no significant association between level of explicit knowledge and development of anticipatory skin conductance responses for these individuals.<sup>2</sup> Advantageous decision making therefore seems to be associated with 2 distinct, namely implicit and explicit, systems.

Patients with mild cognitive impairments (MCI) and Alzheimer disease (AD) typically perform less well on decision-making tasks than do healthy controls.<sup>4,5</sup> To the best of our knowledge, however, no study has directly compared decision-making performances of older adults with MCI and AD in ambiguous context. Furthermore, there are no data available on the relationship between conscious knowledge of contingencies and decision-making performances under conditions of uncertainty in AD and MCI. In the present study, we investigated these 2 questions and hypothesized that decision-making performances would be impaired in both MCI and AD patients. Explicit knowledge would be associated with advantageous decision-making performance under conditions of uncertainty in both AD and MCI.

## PARTICIPANTS AND METHODS

### Participants

Sixty participants took part in the study: 20 healthy controls, 20 patients suffering from AD, and 20 participants with MCI. AD and MCI patients were recruited from a memory clinic (Centre Hospitalier du val d'Ariège, France). MCI was diagnosed according to specific operational criteria.<sup>6</sup> AD patients were diagnosed according to the NINCDS-ADRDA criteria.<sup>7</sup> The severity of their disease ranged from mild to moderate (range = 22 to 29). All patients underwent extensive medical, neurological, and neuroimaging examinations to ensure the absence of any other major neurological conditions. The control group included 20 healthy community-dwelling adults recruited from a volunteer registry or senior-citizen group advertisements. They had no history of neurological disease or psychiatric disorder. All controls had a Mini Mental State Examination (MMSE) score above the 10th percentile. None of the participants were prescribed medications known to affect memory or other cognitive functions.

### Decision Making and Explicit Knowledge

Decision making was investigated using the computerized version of the IGT.<sup>1</sup> The procedure has been described elsewhere.<sup>1</sup> Briefly, participants have to resolve an uncertain situation by learning to sacrifice immediate rewards in favor of long-term rewards. The main dependent measure was the IGT net score. This score is the difference between the numbers of choices from advantageous decks for which little money is won but even less is lost (resulting in a net gain) and disadvantageous decks for which a lot of money is won but even more is lost (resulting in a net loss). The cutoff of 22/100 was applied to distinguish advantageous decision

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making from random and disadvantageous decision-making profiles.<sup>8</sup>

After the task, we assessed the explicit understanding of the participants of the contingencies in the IGT, by asking them which options yielded higher gain or loss. Answers were classified as “Full explicit knowledge” or “No explicit knowledge.” Full explicit knowledge meant that the participant reported and correctly identified the 2 best decks (ie, producing small, immediate gains of money, but the unpredictable losses are small, with accumulated penalties being smaller than the accumulated gains).

**RESULTS**

Table 1 presents demographic data and differences between groups on IGT and explicit knowledge. Given the sample size, nonparametric methods were used (ie, Mann-Whitney and  $\chi^2$  tests).

AD and aMCI participants were older, less educated, and had a lower premorbid intellectual level than controls (all  $P$ 's < 0.05), without any difference between AD and aMCI participants (respectively,  $P = 0.10$ ,  $P = 0.82$ , and  $P = 0.79$ ). Groups were matched for sex. As expected, MMSE scores were significantly lower for AD participants as compared with aMCI participants ( $P = 0.006$ ) or controls ( $P < 0.001$ ). Significant differences in MMSE was also observed between aMCI participants and controls ( $P = 0.018$ ). Despite significant group differences, age, premorbid intellectual level, and education were not associated with decision-making performances when comparing participants with advantageous decision-making profile (IGT net score  $\geq 22/100$ ) to those with a disadvantageous profile (respectively,  $Z = -0.67$ ,  $P = 0.49$ ;  $Z = -1.76$ ,  $P = 0.08$ ;  $Z = -1.67$ ,  $P = 0.09$ ). The same pattern of results was observed for the explicit knowledge variable (respectively,  $Z = -0.02$ ,  $P = 0.98$ ;  $Z = -1.79$ ,  $P = 0.07$ ;  $Z = -0.72$ ,  $P = 0.47$ ).

The percentage of participants with advantageous decision-making profile (IGT net score  $\geq 22/100$ ) was higher in controls (55%) than in AD and MCI (respectively, 15% and 10%,  $P = 0.006$ ) (Table 1). No significant difference was observed between AD and MCI groups ( $\chi^2 = 0.23$ ,  $P = 0.5$ ). Within the entire sample, full explicit knowledge was significantly associated with an advantageous decision-making profile on the IGT ( $P < 0.001$ ). Correct explicit understanding task was reported less often in both MCI and AD participants than in controls (10% and 10% vs. 55%,  $P = 0.002$ ) without any difference

between the 2 cognitively impaired groups ( $P = 1$ ). As illustrated in Figure 1, the same pattern of association was observed in both MCI and AD (respectively,  $P = 0.046$  and  $P = 0.005$ ). In these groups, advantageous decision-making profile (IGT net score  $\geq 22/100$ ) was associated with full explicit knowledge. This relationship was not observed in controls ( $P = 0.37$ ). Neither age nor sex was associated with decision-making profile or explicit knowledge in the whole sample (all  $P$ 's > 0.05).

**DISCUSSION**

Our study is the first to explore decision making under ambiguity in MCI and AD. Reduced decision-making performance was observed in both the groups. The profile of decision making for MCI patients also mimicked that of AD patients. In fact, both groups opted more frequently than controls for decks with high immediate reward regardless of higher future punishment. This study adds to previous investigations on decision making assessed by the IGT in MCI<sup>4</sup> and AD.<sup>5</sup> However, no study so far has jointly investigated decision making under ambiguity in patients with MCI and AD.

After the task, we assessed the explicit understanding of the participants of the contingencies in the IGT, by asking them which options yielded higher gain or loss. Correct explicit understanding was reported less often in MCI and AD participants than in controls with no difference between these 2 groups. Full explicit understanding was associated with better decision-making performance within the entire sample and in both MCI and AD, but not in healthy controls. This suggests that MCI and AD patients have impaired decision making because they are unable to acquire a sufficient explicit knowledge. These findings provided support for several reports that explicit knowledge may be of greater importance for successful performance in the IGT than previously suggested.<sup>2,3</sup> Our results are also in line with several investigations of IGT performance in amnesic patients that emphasize the critical role of declarative memory on decision making under ambiguous conditions.<sup>9,10</sup> In fact, patients with amnesia due to bilateral hippocampal damage do not develop a preference for advantageous choices in the IGT.<sup>9</sup> These results were corroborated by Gupta and colleagues who demonstrated impaired IGT performance in amnesic patients. This impairment occurred both when there was a 6-second delay between card selections and when no delay was interposed between card selections. These results

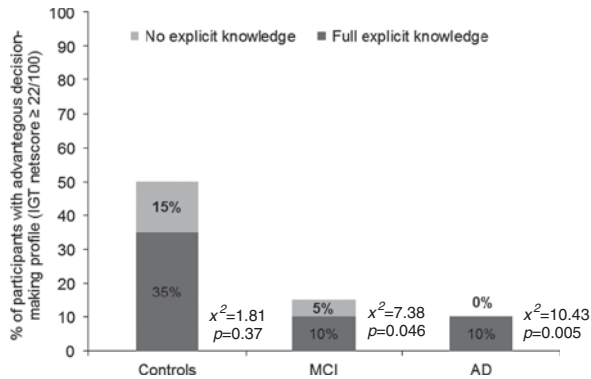
**TABLE 1.** Demographic Data, Differences Between Groups on IOWA Gambling Task and on Explicit Knowledge

	Controls	MCI	AD	Statistics	P
Demographical and clinical data [median (range)]					
Age	71 (64-86)	79.5 (67-85)	82 (71-90)	$Z = 12.71$	0.002*
Education	11.5 (6-17)	7.5 (6-17)	7 (6-12)	$Z = 13.23$	0.001†
f-NART	118 (100-125)	106 (96-121)	109 (93-120)	$Z = 9.41$	0.002†
Mini Mental State Examination	28.5 (27-30)	27.5 (24-30)	25 (22-29)	$Z = 21.33$	< 0.001†
Iowa Gambling Task					
Net score $\geq 22/100$ [n (%)]	10 (50)	3 (15)	2 (10)	$\chi^2 = 10.13$	0.006†
Explicit knowledge					
Full explicit knowledge [n (%)]	11 (55)	3 (15)	2 (10)	$\chi^2 = 12.44$	0.002†

\*Controls < (MCI = AD).

†Controls > (MCI = AD).

AD indicates Alzheimer disease; f-NART, French version of the National Adult Reading Test; MCI, mild cognitive impairment.



**FIGURE 1.** Percentage of participants with advantageous decision-making profile [Iowa Gambling Task (IGT) net score  $\geq$  22/100] depending on explicit understanding of the contingencies in the task.

suggest that the hippocampus (and perhaps other medial temporal lobe structures) is necessary for complex decision making of the type tapped by the IGT. Declarative memory seems to be necessary for forming and updating the relational representation between the decks and their associated rewards and punishments, resulting in the amnesic participants' impaired ability to make sustained advantageous decisions over time. We observed that nearly one half of the healthy controls showed impaired decision-making profile on the IGT. This heterogeneous result is consistent with a previous study carried out by Denburg et al<sup>8</sup> who have reported a decision-making impairment in 48% of older healthy adults, despite otherwise intact cognitive functioning. It is possible that different nonexclusive processes (ie, emotional processes or implicit knowledge) are preferentially involved in this population. In fact, these authors documented that older healthy adults with disadvantageous decision making on the IGT did not demonstrate reliable anticipatory psychophysiological discrimination of good and bad choices, supporting the somatic marker hypothesis.<sup>8</sup>

Several limitations to our study need to be addressed. One is the difference in education, premorbid intellectual level, and age between groups. However, we found no association between age, premorbid intellectual level, education, and IGT performance. We are aware that our sample size is small. This statistical limitation might explain the similar IGT decision-making profiles of AD and aMCI.

In conclusion, our results provide evidence that explicit understanding is an essential condition to make advantageous decisions in uncertain situations (ie, where options are initially unknown and have to be learned through experience) in MCI and AD. In this clinical context, improving explicit/analytical understanding of real-life situations that require decision making in ambiguous context could be a critical point for such patients to make favorable choices. Future research might investigate whether our findings can be generalized to real-life decision situations.

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