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A Dual Process in Memory: How to Make an Evaluation from Complex and Complete Information? — An Experimental Study

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Abstract

In this paper, we will put forward an original experiment to reveal empirical “anomalies” in the process of acquisition, elaboration and retrieval of information in the context of reading economic related content. Our results support the existence of the memory dual process suggested in the Fuzzy Trace Theory: acquisition of information leads to the formation of a gist representation which may be incompatible with the exact verbatim information stored in memory. We give to subjects complex and complete information and evaluate their cognitive ability. To answer some specific questions, individuals used this gist representation rather than processing verbatim information appropriately.

Keywords: Fuzzy Trace Theory; Memory; Dual Process; Cognitive reflection test; Bounded rationality

JEL Classification: C91; D83 ; D89

1 Introduction

Because of the multiple sources of information that may provide different perspectives on a problem, learning how to make a correct decision in a rich and complex environment is not an easy task. “It is a commonplace that human beings are not capable of holding very complex picture in mind. We consider reality by focusing on one perspective at a time

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and show difficulties in combining perspectives as amply documented.” write Lambert-Mogiliansky and Dubois (2016, p367). This is particularly true in the context of economic decisions, where economic actors, such as policy makers, financial analysts, or consumers need to make informed decisions. Nowadays, these economic agents are overwhelmed by information, either as textual or visual content, which is easily and cheaply available via the Internet or social media. Criteria and descriptions by which individuals use to make decisions are often complex in real life. Indeed, they need to cope with uncertain, dispersed, incomplete, and incompatible sources of information. People memorize each source of information and combine them by creating a mental picture of the particular problem they are faced with.

In this paper, we investigate how people combine heterogeneous and complex information to make a decision. This research departs from the approach in experimental economics and psychology, which studies how people learn to make correct decisions — namely, the clicking paradigm (Erev and Haruvy, 2013; Erev and Roth, 2014). By exploiting the feedback value signal, this paradigm requires experimental subjects to explore alternatives repeatedly, by choosing them, in order to discover the best one. People in our study were instead requested to make a single evaluation based on complex and abundant information from different perspectives. They could not try repeatedly and receive a feedback value signal from their choices.

In this context, the memory–reasoning relation plays a crucial role. How do people combine the different pieces of information in their memory? Does each source of information simply add a piece to the mental picture (as in a puzzle, the more data, the more precise the picture) or can the pieces of information interact and interfere, thus disrupting the mental picture?

Fuzzy Trace Theory (hereinafter FTT) provides a reference psychological theory of cognition to deal with the proposed experimental setting (Reyna and Brainerd, 1995; Brainerd and Reyna, 2001; Liberali et al., 2012; Reyna et al., 2016). FTT is based on a dual-process of memory (gist and verbatim), which rests on the assumption that people form representations of an event both by identifying semantic features (gist traces) and by storing surface details (verbatim traces). The theory has successfully accounted for various phenomena such as the generation of false memory, risk perception and estimation, as well as general biases and fallacies in decision making. The psychological literature reports that people tend to reason with gist rather than verbatim traces, that is, by attempting to create meaningful mental pictures which are not the sum of an event’s surface details (Reyna, 2012).

In this paper, we report and discuss the results of an experiment where we test the role of verbatim and gist memory traces in making a correct evaluation. It is worth noting that in our experiment, the description of the event is complete, in that we provide sufficient information, distributed in various pieces, to make a rational and objective evaluation. First, we test whether the subjects have stored the information required to provide the

rational answer and then see if they use this information — as they should — to answer correctly. We find that only a small proportion of the subjects answer correctly, which requires a proper combination of the relevant memorized pieces of information. Instead, most of them seem to rely more on gist representation rather than combining their verbatim traces. Finally, we also provide original statistical evidence showing that cognitive ability explains, to some extent, the misalignment between correct memory storage and the ability to answer correctly.

This paper is organized as follows. The experimental design is described in Section 2. The results are discussed in Section 3, and Section 4 concludes.

2 Experimental Design

The experiment was conducted from 14 to 18 December 2015 at the Experimental Economics Laboratory of Nice (LEEN, France). 321 students from a broad range of disciplines at the University of Côte d’Azur were recruited with a web-based online recruitment system (ORSEE, Greiner (2015)), and nineteen one-hour sessions were run. Tasks were implemented on computers using the z-Tree software (Fischbacher, 2007). Subjects were remunerated for participating in the experiment. The payment included a fixed amount of EUR10, plus a performance-related amount of up to EUR 6.¹

The task consisted in reading a description of a country (Australia) without giving its name to participants. The information was presented in three or four consecutive screens, each providing a different perspective of the country:

- an *introductory perspective* (*IP*) screen, made up of 131 words, giving a kind of “touristic description” of the country;
- a *demographic perspective* (*DP*) screen, consisting of 92 words and 1 graph, providing demographic data of the country, including the number of inhabitants;
- an *economic perspective* (*EP*) screen with 81 words and 2 graphs focusing on the definition and value of the gross national income (*GNI*) of the country;
- and, depending on the treatment: either a *climate perspective* (*CP*) screen, containing climate (e.g. temperature) and geographical (desert, etc.) information of 131 words or an *empty information* screen (*NP*) with a written message asking subjects to wait.

Each screen lasted 70 seconds. We introduced an empty (*NP*) screen to compare the effect of additional climate information (*CP*) while keeping the total time constant. Apart from the *IP* screen, which was always displayed in the first position, each of the twelve possible screen orders was presented to subjects as shown in Table 1.

¹Correct answers were paid EUR2 for *Q1*; EUR1 for *Q2*, and EUR3, for the control questions.

Treatment	Slide 1	Slide 2	Slide 3	Slide 4	#Subj
T1	IP	EP	DP	CP	41
T2	IP	EP	CP	DP	40
T3	IP	DP	EP	CP	40
T4	IP	DP	CP	EP	40
T5	IP	CP	EP	DP	40
T6	IP	CP	DP	EP	40
T7	IP	NP	EP	DP	13
T8	IP	EP	NP	DP	13
T9	IP	EP	DP	NP	14
T10	IP	NP	DP	EP	13
T11	IP	DP	NP	EP	13
T12	IP	DP	EP	NP	14

Table 1: Treatments

After reading all the information, subjects were asked to answer several questions successively. First, we asked subjects to evaluate the welfare of the country described compared to their own country (France):

Q1) “According to you, on average, does an inhabitant of this country earn more or less money than an inhabitant of France?”

Then, we asked them to reveal the country which fits the best the description, according to them:

Q2) “According to you, which country was described in the text?”

Secondly, we tested their ability to recall verbatim information by administrating a set of memory *control questions*, in particular, about the total *gross national income* (GNI_1) and the *number of inhabitants* (POP_1) of the country. We also elicited the subject’s belief about the “*French average income*” (F), which was not included in the description. Nevertheless, we argue that students should know it approximately, and rational individuals should thus use this verbatim information to answer Q1 correctly.

Finally, at the end of the experiment, we tested the subjects’ cognitive abilities by means of the “*Cognitive Reflection Test*” (CRT hereafter), proposed by Frederick (2005). We adopted the modified version of the CRT offered by Finucane and Gullion (2010) to ensure that students had never been exposed to the questions before.² Subjects were not

² Indeed, the CRT is a well-known test. The modified CRT consists of three consecutive questions,

allowed to take any notes during the whole experiment, but they had access to a basic calculator if they wished to process verbatim information.

3 Results

The correct answer to $Q1$ is “*More*” because the average income in Australia (\$64,540) is greater than in France (\$42,960). We score this answer as $Q1 = 1$ (respectively $Q1 = 0$, if the subject answered “*Less*”). In our sample, only 28% correctly answered $Q1$ and 9% found the right country.³

This low rate of accuracy doesn’t provide much information alone. However, we have to consider that complete information was given to subjects to answer $Q1$ in a rational way: 1) The GNI was introduced in EP ; 2) The country’s number of inhabitants was presented in DP . Using the calculator, they should divide the GNI by the population to calculate GNI per capita, which indicates how much an inhabitant of the country earns in average. Thus, the low rate of correct answers to $Q1$ might be explained by the fact that subjects either did not memorize or did not combine the information given previously. Indeed, much information was provided to subjects during the experiment. Since we elicited verbatim memories of the gross national income (GNI_1) and population (POP_1), we could assess the impact of verbatim memory on the evaluation of the welfare of the country’s inhabitants (through the probability of answering $Q1$ correctly). As a first control of verbatim memory, we introduced the variable MEM , equal to 1 if the subject recalled both the population and GNI , and 0 otherwise.⁴ We now consider the following hypothesis.

H1: Subjects recalling the verbatim information had a higher probability of answering $Q1$ correctly.

$$(H1) \quad MEM \Rightarrow Q1$$

We ran a t-test on the two populations $P(Q1 = 1 | MEM = 1) = 0.317$ and $P(Q1 = 1 | MEM = 0) = 0.267$, reported in Table 2, and this test failed to reject the null hypothesis of equality between the two populations (p -value = 0.363).

each of which has an intuitive but false answer and a reflexive true answer. Scores were given on the basis of a number between 0 and 3 according to the number of correct answers.

³Top answered countries were Brazil (30), Australia (29), “Africa” (18), China (14), Morocco (13), Egypt (12), South Africa (12), USA (12), and India (11).

⁴Subjects were informed that they were entitled to a maximum 10% margin of error for these two control questions.

	MEM=0	MEM=1
Q1 = 0	159	71
Q1 = 1	58	33
mean	26.73%	31.73%

Table 2: Q1 and MEM contingency

We conjecture that the difference between the two proportions is not statistically significant because of the large proportion of subjects with low cognitive ability. Indeed, Toplak et al. (2011) have shown that the CRT score is correlated with the probability of recalling verbatim information.⁵ Thus, we argue that people with lower CRT scores may also be less able to use this information to make an evaluation. To study this, we propose to test the following hypothesis.

H1b: Subjects recalling the verbatim information had a higher probability of answering Q1 correctly (conditional on cognitive ability).

$$(H1b) \quad MEM \Rightarrow_{|CRTscore} Q1$$

According to the CRT score, we divided the subject pool among two groups: subjects with a CRT score of 0 or 1 are hereafter called the “*LOW*” group ($n = 266$) and those with a CRT score of 2 or 3 the “*HIGH*” group ($n = 55$). We then analyzed the answer to Q1, depending on the subjects’ ability to recall verbatim information or not. For each group, Table 3 displays the cross tabulation between verbatim memorization and the answer to Q1.

	<i>LOW</i>		<i>HIGH</i>	
	MEM=0	MEM=1	MEM=0	MEM=1
Q1 = 0	135	59	24	12
Q1 = 1	52	20	6	13
mean	27.81%	25.32%	20.00%	52.00%

Table 3: Q1 and MEM contingency, conditional to CRT

We also conducted a logistic regression (Table 4) on the probability of answering Q1 correctly, as a function of *MEM* and CRT. As we hypothesized, we did not find any effect of recalling verbatim information for *LOW* subjects (cf. Model 3, coeff = -0.01 , p -value

⁵Our study also confirms their results since 29.70% of *LOW* subjects remembered both pieces of verbatim information compared to 45.45% of *HIGH* subjects (t-test, p -value = 0.035).

= 0.975) but found a statistically significant one for *HIGH* subjects (cf. Model 2, coeff = 2.01, p -value = 0.0027).⁶

	Model 1	Model 2	Model 3
(Intercept)	−0.93** (0.35)	−1.29* (0.62)	−0.60 (0.39)
Mem	0.45 (0.28)	2.01** (0.67)	−0.01 (0.33)
low		0.69 (0.54)	
Memo:low		−2.02** (0.74)	
high			−0.69 (0.54)
Memo:high			2.02** (0.74)
Logistic regressions. Treatment controls are masked.			
AIC	379.18	373.73	373.73
BIC	428.21	434.07	434.07
Log Likelihood	−176.59	−170.86	−170.86
Deviance	353.18	341.73	341.73
Num. obs.	321	321	321

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 4: Impact of memory on Q1

However, we have to control for subjects’ heterogeneity in their beliefs concerning French average income. For example, someone with exact verbatim memory of both GNI and population of the described country, may rationally answer “Less” to $Q1$ if he overestimates French average income. Thus, for each subject, the ratio between recalled GNI_1 and POP_1 should be compared with his belief about French average income (F). The variable $R1$ indicates the sense of the inequality:

$$R1 = 1 \Leftrightarrow \frac{GNI_1}{POP_1} > F \quad \text{and} \quad R1 = 0 \Leftrightarrow \frac{GNI_1}{POP_1} < F.$$

Thanks to this method, we were able to distinguish if subjects answered “rationally”, by processing verbatim memory or not (Table 5).

⁶ We ran a likelihood ratio test. Model 3 is statistically better than Model 1 (p -value = 0.012).

	R1=0	R1=1
Q1 = 0	110	120
Q1 = 1	39	52
mean	26.17%	30.23%

Table 5: Q1 and R1 contingency

We noted that only half (50.47%) of the population answered $Q1$ consistently based on $R1$, i.e. $Q1 = R1$. Thus, based on these first observations, we statistically tested the following hypothesis:

H2: Subjects rationally combined their verbatim memory and their beliefs to answer $Q1$.

$$(H2) \quad R1 = 1 \Rightarrow Q1 = 1$$

If individuals rationally processed their verbatim memory to answer $Q1$, we should expect that the probability of answering $Q1$ correctly, given that $R1 = 1$, should be greater than the probability of answering $Q1$ correctly, given that $R1 = 0$. Thus, we conducted a t-test between the two proportions ($P(Q1 = 1|R1 = 1) = 0.302$ and $P(Q1 = 1|R1 = 0) = 0.262$) and failed to reject the null hypothesis of equality (p -value = 0.421).

Again, we controlled for cognitive ability, suspecting that only *HIGH* subjects rationally processed their verbatim information to answer $Q1$. Results in Table 6 suggest that there is a difference according to cognitive ability.

	<i>LOW</i>		<i>HIGH</i>	
	R1=0	R1=1	R1=0	R1=1
Q1 = 0	92	102	18	18
Q1 = 1	34	38	5	14
mean	26.98%	27.14%	21.73%	43.75%

Table 6: Q1 and R1 contingency, conditional to CRT

Thus, we propose testing the following hypothesis:

H2b: Subjects with high cognitive ability rationally combined their verbatim memory and beliefs more easily to answer $Q1$.

$$(H2b) \quad R1 \Rightarrow_{|CRTscore} Q1$$

We conducted a logistic regression (Table 7) of the probability of answering $Q1$, as a function of $R1$ and CRT score.

	Model 4	Model 5	Model 6	Model 7
(Intercept)	−0.94*	−1.26	−0.59	−0.67
	(0.37)	(0.67)	(0.41)	(0.37)
$R1$	0.30	1.68*	0.01	
	(0.27)	(0.69)	(0.30)	
low		0.67		
		(0.61)		
$R1:low$		−1.67*		
		(0.75)		
high			−0.67	
			(0.61)	
$R1:high$			1.67*	
			(0.75)	
$R1:CRTscore$				0.39*
				(0.17)
Logistic regressions. Treatment controls are masked.				
AIC	380.44	377.19	377.19	376.19
BIC	429.47	437.54	437.54	428.99
Log Likelihood	−177.22	−172.60	−172.60	−174.09
Deviance	354.44	345.19	345.19	348.19
Num. obs.	321	321	321	321

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 7: Impact of verbatim memory to $Q1$ answer

We found that the results of $H1$ and $H1b$ are robust to heterogeneity of beliefs about French average income. *LOW* subjects did not seem to process verbatim information to answer $Q1$ (coeff = 0.01, p -value = 0.972). Conversely, *HIGH* individuals did so (coeff = 1.68, p -value = 0.0157).⁷ As most of subjects did not process verbatim information to answer $Q1$, we conjecture that they based their evaluation on their gist representation.

H3: Subjects with a “rich-country” gist representation had a higher probability of answering $Q1$ correctly.

$$(H3) \quad R2 \Rightarrow_{|CRTscore} Q1 \quad (R2 \text{ defined below.})$$

Verbatim reasoning about GNI and POP should not be affected by any other information.

⁷We ran a likelihood ratio test, and Model 6 is statistically better than Model 4 (p -value = 0.038).

In contrast, the gist representation of inhabitants' welfare is built from all the received information (demographic, economic, climatic, and touristic descriptions). To estimate the information contained in subjects' gist representation, we used the answers to $Q2$ concerning which country was described in the experiment. We are aware that even if the answer to this question did not exactly reveal subjects' gist representations, in many cases it should indicate the most likely representation. In particular, we used World Bank data to extract GNI_2 and POP_2 from the country revealed by subjects. Then we compared the $\frac{GNI_2}{POP_2}$ ratio with subjects' beliefs about the average income in France (F). The variable $R2$ shows the sense of this inequality:

$$R2 = 1 \Leftrightarrow \frac{GNI_2}{POP_2} > F \quad \text{and} \quad R2 = 0 \Leftrightarrow \frac{GNI_2}{POP_2} < F^8$$

Naturally, it is impossible to be sure that the gist representation of the inhabitants' welfare of the described country corresponds to the per capita GNI (using World Bank data) of the country revealed in $Q2$. For example, 1) one can think that South Africa is most likely the described country in many aspects but not concerning inhabitants' welfare; 2) gist representation of South Africa welfare may be lower or greater than it is in reality. This leads to very conservative results due to a noisy proxy of gist representation. Despite this, if the probability of answering $Q1$ correctly, given that $R2 = 1$, is greater than the probability of answering it correctly, given that $R2 = 0$, then it suggests that subjects were using their gist representation in the evaluation of inhabitant's welfare of the described country: $P(Q1 = 1|R2 = 1) > P(Q1 = 1|R2 = 0)$. Results are displayed in Table 8.

We conducted a t-test on the two proportions ($P(Q1 = 1|R2 = 1) = 0.485$) and ($P(Q1 = 1|R2 = 0) = 0.204$) and found a statistically significant difference (p -value = $2.6 * 10^{-6}$).

	R2=0	R2=1
Q1 = 0	141	53
Q1 = 1	36	50
mean	20.39%	48.54%

Table 8: Q1 and R2 contingency

To control for cognitive ability and verbatim processes, we ran a logistic regression (Table 9) on the probability of answering $Q1$ correctly.

⁸For example, if someone answered "South Africa" to $Q2$, and thought that the average income in France was \$25,400 per year, $R2$ was computed as: $\frac{GNI_2}{POP_2} = \frac{3.233 * 10^{11}}{50,520,000} = 6399 < 25,400 = F \Leftarrow R2 = 0$. With the same answer to $Q2$ but with a lower belief about French welfare, one would obtain $R2 = 1$. Since the answer to $Q2$ could be freely input, we excluded from our analysis the 41 subjects who did not report a real country (e.g. "a country in Africa", or "Brazil or China", etc.).

	Model 8	Model 9	Model 10	Model 11
(Intercept)	−0.56 (0.56)	−0.86* (0.44)	−1.76* (0.82)	−0.86 (0.48)
R2	1.70* (0.73)	1.30*** (0.33)	1.76* (0.76)	1.30*** (0.34)
low	−0.30 (0.49)		0.90 (0.78)	
R2:low	−0.39 (0.81)		−0.46 (0.84)	
high		0.30 (0.49)		−0.90 (0.78)
R2:high		0.39 (0.81)		0.46 (0.84)
R1			1.87* (0.79)	−0.08 (0.33)
R1:low			−1.95* (0.85)	
R1:high				1.95* (0.85)
Logistic regressions. Treatment controls are masked.				
AIC	322.75	322.75	320.41	320.41
BIC	380.90	380.90	385.83	385.83
Log Likelihood	−145.37	−145.37	−142.20	−142.20
Deviance	290.75	290.75	284.41	284.41
Num. obs.	280	280	280	280

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 9: Impact of Verbatim and Gist on Q1 answer

We found that gist representation impacted the evaluation for both *LOW* (coeff = 1.30, p -value = 0.00011) and *HIGH* subjects (coeff = 1.76, p -value = 0.021). However, we found no statistical difference of this effect between the two groups (p -value = 0.58).⁹ These results are robust for the use of *MEM* (Table 10) instead of *R1* as a control of verbatim memory, which provides support to results presented in H1.

⁹The latter regression also supports *H2*.

	Model 12	Model 13
(Intercept)	-1.98*	-0.90
	(0.83)	(0.46)
R2	2.03*	1.31***
	(0.82)	(0.34)
low	1.08	
	(0.78)	
MEM	2.36**	0.00
	(0.82)	(0.36)
R2:low	-0.71	
	(0.89)	
MEM:low	-2.35**	
	(0.89)	
high		-1.08
		(0.78)
R2:high		0.71
		(0.89)
MEM:high		2.35**
		(0.89)
Logistic regressions. Treatment controls are masked.		
AIC	316.92	316.92
BIC	382.35	382.35
Log Likelihood	-140.46	-140.46
Deviance	280.92	280.92
Num. obs.	280	280

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 10: Impact of gist and verbatim memory on the evaluation

To summarize the main points, results of this experiment can be accounted for by the dual memory process described in the FTT. Moreover, subjects rely mainly on their gist information to evaluate the described country’s welfare. This is principally true for *LOW* subjects, while *HIGH* subjects also seem to consider verbatim information.

To understand the formation of this dual process, we investigated the impact of additional information on both verbatim and gist representations. According to the treatments, subjects received either a blank screen (*NP*) or one with climate information (*CP*). Since subjects with the *CP* screen received more information, it might have been more difficult for them to remember economic and demographic verbatim information, compared to subjects with the *NP*.

H4: Climatic Information damages economic and demographic verbatim memory.

$$(H4) \quad CP \Rightarrow \neg MEM$$

Table 11 displays the frequencies of recalling both *GNI* and *POP* verbatim information, i.e. $MEM = 1$, according to CP .

	CP=0	CP=1
MEM = 0	59	158
MEM = 1	21	83
mean	26.25%	34.44%

Table 11: MEM and CP contingency

We ran a t-test between the two proportions and did not find sufficient evidence that receiving more information decreases the probability of recalling economic and demographic data (p -value = 0.1618).

As for the previous hypotheses, we also controlled here for subjects' cognitive ability (Table 12).

H4b: Climatic information damages economic and demographic verbatim memory (conditional on cognitive ability).

$$(H4b) \quad CP \Rightarrow_{|CRT_{score}} \neg MEM$$

	<i>LOW</i>		<i>HIGH</i>	
	CP=0	CP=1	CP=0	CP=1
MEM = 0	48	139	11	19
MEM = 1	18	61	3	22
mean	27.27%	30.5%	21.42%	53.66%

Table 12: MEM and CP contingency, conditional to CRT

We ran a logistic regression (Table 13) on the probability of recalling both *GNI* and *POP* verbatim information (MEM).

	Model 14	Model 15	Model 16
(Intercept)	-1.03*** (0.25)	-0.98*** (0.28)	-1.30* (0.65)
CP	0.39 (0.29)	0.16 (0.32)	1.45* (0.72)
HIGH		-0.32 (0.71)	
CP:HIGH		1.29 (0.79)	
LOW			0.32 (0.71)
CP:LOW			-1.29 (0.79)
AIC	406.47	402.53	402.53
BIC	414.01	417.61	417.61
Log Likelihood	-201.23	-197.26	-197.26
Deviance	402.47	394.53	394.53
Num. obs.	321	321	321

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 13: Impacts on Climate Information on Verbatim Memory

We did not find that providing climate information to *LOW* subjects impacted their probability of recalling verbatim economic and demographic information (coeff = 0.16, p -value = 0.62), as opposed to the *HIGH* group for which it increases their recall rate (coeff = 1.45, p -value = 0.045). We anticipated that giving more information would reduce the ability to remember demographic and economic data. Nevertheless, climate information (compared to a blank screen) may help *HIGH* subjects to remain focused on the country data.

We now study whether the climate information, that describes the country as hot (“up to 50 degrees Celsius”) and “mostly desert”, can interfere with the gist memory of the country, leading to a representation of a poorer country.¹⁰

H5: Climate information impacts economic and demographic gist memory.

$$(H5) \quad CP \Rightarrow R2$$

If the *CP* information impacts subjects’ gist representation, then the probability of re-

¹⁰Indeed, we deliberately chose a country with these characteristics because hot temperatures and deserts could be associated with poorer countries.

vealing a poor country as the (most-likely) described country should increase. Table 14 shows the contingency between $R2$ and CP .

	CP=0	CP=1
R2 = 0	40	135
R2 = 1	36	69
mean	47.37%	33.82%

Table 14: R2 and CP contingency

We ran a t-test between the proportions $P(R2 = 1|NP)$ and $P(R2 = 1|CP)$ and found a significant difference (p -value = 0.044). In the light of past results, we believe that cognitive capacity might modify the impact of CP information on gist memory.

H5b: Climate information impacts economic and demographic gist memory (conditional on cognitive ability).

$$(H5b) \quad CP \Rightarrow_{|CRT_{score}} R2$$

Table 15 shows the contingency table, conditional on CRT groups. Moreover, we ran a logistic regression on the probability of identifying a rich country ($R2$), as a function of CP and CRT (Table 16). We found that the effect of climate information on the gist representation is more pronounced for the *HIGH* group (coeff = -1.54 , p -value = 0.022) than for the *LOW* one (coeff = -0.37 , p -value = 0.222). This tends to support the idea that climate information more strongly impacts the gist representation of *HIGH* subjects.

	<i>LOW</i>		<i>HIGH</i>	
	CP=0	CP=1	CP=0	CP=1
R2 = 0	34	107	6	28
R2 = 1	28	61	8	8
mean	45.16%	36.31%	57.14%	22.22%

Table 15: R2 and CP contingency, conditional to CRT

	Model 17	Model 18	Model 19
(Intercept)	-0.11 (0.23)	-0.19 (0.26)	0.29 (0.54)
CP	-0.57* (0.27)	-0.37 (0.30)	-1.54* (0.67)
HIGH		0.48 (0.60)	
CP:HIGH		-1.17 (0.74)	
LOW			-0.48 (0.60)
CP:LOW			1.17 (0.74)
AIC	370.21	370.77	370.77
BIC	377.48	385.31	385.31
Log Likelihood	-183.10	-181.38	-181.38
Deviance	366.21	362.77	362.77
Num. obs.	280	280	280

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 16: Impacts of Climate Information on gist representation

4 Discussion

Our results provide new evidence of the existence of a dual memory process (gist and verbatim) in the specific context of making an evaluation with complete and complex information. In this experiment, subjects received several pieces of information on different aspects of an unknown country. After receiving the description, they were asked to evaluate the welfare of the inhabitants compared to that of their country of residence (France). We provided them complete information in the sense that the description included all the relevant information to answer correctly. We controlled both verbatim and gist memories by asking subjects to reveal: 1) recorded information about economics and demographics, and 2) the country which best fits the description according to them.

This protocol allowed us to distinguish verbatim and gist traces of economic and demographic data and to investigate which information was in line with the final evaluation. Furthermore, we controlled for subjects' cognitive abilities using a Cognitive Reflection Test. We found that subjects with low cognitive abilities did not combine the verbatim information to make the evaluation. Indeed, although they correctly recalled the gross national income and the population of the country, they did not make a consistent assess-

ment with an appropriate combination of this information. Conversely, individuals with higher cognitive abilities tended to exhibit coherence between their evaluation and verbatim memory. Furthermore, regardless of their cognitive abilities, subjects relied mainly on their gist representation.

In addition, investigating the impact of additional information on verbatim and gist memory leads to novel results. For individuals with low cognitive abilities, we did not find that climate information impacted gist and verbatim traces of economic and demographic information. However, it helped high cognitive subjects to recall verbatim information and changed their gist representation about inhabitants' welfare. These results suggest further research to better understand both the link and balance between cognitive abilities and the coexistence of gist and verbatim reasoning.

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