



**HAL**  
open science

## **A dual process in memory: how to make an evaluation from complex and complete information? - An experimental study**

Sébastien Duchêne, Eric Guerci, Ariane Lambert-Mogiliansky, Fabien Mathy, Ismaël Rafai

### **► To cite this version:**

Sébastien Duchêne, Eric Guerci, Ariane Lambert-Mogiliansky, Fabien Mathy, Ismaël Rafai. A dual process in memory: how to make an evaluation from complex and complete information? - An experimental study. 2018. hal-01954930

**HAL Id: hal-01954930**

**<https://hal.science/hal-01954930>**

Preprint submitted on 7 Jan 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**A dual process in memory:  
how to make an evaluation from  
complex and complete information?  
– An experimental study**

Ismaël Rafai,  
Sébastien Duchêne,  
Eric Guerci,  
Ariane Lambert-Mogiliansky,  
&  
Fabien Mathy



CEE-M Working Paper 2018-25

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

Ismaël Rafai\*   Sébastien Duchêne†   Eric Guerci\*   Ariane Lambert-Mogiliansky‡  
Fabien Mathy§

October 31, 2018

## 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

Nowadays, economic agents are overwhelmed by information, either as textual or visual content, which is easily and cheaply available via the Internet or social media.<sup>1</sup> 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. People in our study were requested to make a single evaluation based on complex and abundant information from different perspectives.

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

---

\*Département d'Économie, GREDEG (UMR 7321: CNRS, Université de Nice Sophia Antipolis), 250 rue Albert Einstein, 06560 Valbonne, France. E-mail: ismael.rafaï@gredeg.cnrs.fr, , eric.guerci@gredeg.cnrs.fr

†CEE-M, Université de Montpellier, CNRS, INRA, SupAgro, Montpellier. Email: sebastien.duchene@umontpellier.fr

‡Paris School of Economics, 48 boulevard Jourdain, 75014 Paris, France. E-mail: alambert@pse.ens.fr

§Département de Psychologie, Laboratoire BCL: Bases, Corpus, Langage - (UMR 7320: CNRS, Université de Nice Sophia Antipolis), Campus SJA3, 24 avenue des diables bleus, 06300 Nice, France. E-mail: fabien.mathy@unice.fr

<sup>1</sup> For example, McDonald and Cranor (2008) estimate the annual opportunity cost of all US website users reading all the privacy policy rules they face to \$781 billion, based on an average reading speed.

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 cognitive process (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 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 EUR 10, plus a performance-related amount of up to EUR 6.<sup>2</sup>

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;

---

<sup>2</sup>Correct answers were paid EUR2 for Q1; EUR1 for Q2, and EUR3, for the control questions.

- 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.<sup>3</sup>

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?”<sup>4</sup>

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. Indeed subjects can combine the information given and their belief 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, and given the definition of the GNI as “the sum of all incomes earned in a year by the inhabitants of a country”, subjects should divide the *GNI* by the population to calculate *GNI* per capita, which indicates how much an inhabitant of the country earns in average.

Potential mistakes in Q1 might be explained by the fact that subjects either did not memorize, have wrong beliefs about French average income or did not combine the verbatim 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 control of verbatim memory, we introduced the variable *MEM*, equal to 1 if the subject recalled both the population and *GNI*, and 0 otherwise.<sup>5</sup>

Finally, at the end of the experiment, we tested the subjects’ cognitive reflection abilities by means of the “*Cognitive Reflection Test*” (CRT hereafter), proposed by Frederick (2005). We adopted the

---

<sup>3</sup>See Table 7 in the appendix for the complete list of screen order. Screen shot of the different slide are available in the appendix.

<sup>4</sup>Subjects may answer either “More” or “Less” by clicking on the respecting button. We counterbalanced the spatial location of the two buttons between subjects.

<sup>5</sup>Subjects were informed that they were entitled to a maximum 10% margin of error for these two control questions.

modified version of the CRT offered by Finucane and Gullion (2010) to ensure that students had never been exposed to the questions before.<sup>6</sup> Subjects were not 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 Behavioral Hypothesis

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*”).

Since the information provided can be used to correctly compute the average income per inhabitant of the described country (Australia), we postulate that subjects who are able to recall perfectly the GNI information and the number of inhabitants are more likely to answer  $Q1$  correctly. Therefore, we expect a correlation between  $MEM$  and  $Q1$ .

Moreover, we conjecture that this correlation will be larger for subjects with a higher CRT score. Indeed, Toplak et al. (2011) have shown that the CRT score is correlated with the probability of recalling verbatim information. We argue that this effect may play a role when retrieving the stored information to make an evaluation.

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

Another source of potential mistake in evaluation is the heterogeneity of subjects’ beliefs about French average income. For example, someone with exact verbatim memory of both  $GNI$  and population of the described country, should rationally answer “*Less*” to  $Q1$  if he overestimates French average income.

Thus, a rational individual should compare the ratio between Australian’s  $GNI_1$  and  $POP_1$  he recorded in memory, with his belief about French average income ( $F$ ). Based on the belief elicited about French average income and the information revealed, we construct the variable  $R1$  which indicates the sense of the inequality:

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

Thanks to this method, we were able to distinguish if the subject’s answer is coherent with a rational combination of the memorized information and her belief. We therefore expected a positive correlation between  $R1$  and  $Q1$ .

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

---

<sup>6</sup> Indeed, the CRT is a well-known test. The modified CRT consists of three consecutive questions, 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.

The FTT suggests that individuals are using a gist representation rather than the verbatim memory to make an evaluation. To estimate the information contained in subjects' gist representation, we used the answers to *Q2* about the country described in the experiment. We are aware that even if the answer to this question did not exactly reveal the 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.<sup>7</sup>

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

Indeed, 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. These two possibilities lead to 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.

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

Verbatim reasoning about  $GNI$  and  $POP$  should not be affected by any other information. In contrast, the gist representation of inhabitants' welfare is built from all the received information (demographic, economic, climatic, and touristic descriptions).

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 should be more difficult for them to remember economic and demographic verbatim information, compared to subjects with the blank screen.

**H4: Climatic Information impacts gist and verbatim memory.**

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

---

<sup>7</sup>Therefore,  $GNI_2$  corresponds to the gross national income of the country answered in *Q2* and  $POP_2$  to the population of this country. For example, if someone answered “South Africa” to *Q2* and thought that the average income in France was \$25,400 per year, we extracted the  $GNI_2$  and  $POP_2$  (respectively  $3.233 \times 10^{11}$  and  $50.52 \times 10^6$ ) using the World Bank Data API and compared the ratio with his belief about French average income as follows:  $\frac{GNI_2}{POP_2} = 6,399 < 25,400 = F \Rightarrow R2 = 0$ . 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.).

a representation of a poorer country.<sup>8</sup>

## 4 Results

In our sample, only 28% correctly answered *Q1* and 9% found the right country.<sup>9</sup> 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 ( $n = 55$ ).

56.1% of the subjects recalled correctly the *GNI* of the country and 51.4% recalled its number of inhabitants. 32.4% of the subjects recalled both information.

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

We reported in Table 1, the cross tabulation between verbatim memorization and answer to *Q1*, depending on CRT score.

	<i>LOW</i>		<i>HIGH</i>		TOTAL	
	MEM=0	MEM=1	MEM=0	MEM=1	MEM=0	MEM=1
<i>Q1</i> = 0	135	59	24	12	159	71
<i>Q1</i> = 1	52	20	6	13	58	33
mean	27.81%	25.32%	20.00%	52.00%	26.73 %	31.73%

Table 1: *Q1* and MEM contingency

We did not find any significant difference in the probability to answer *Q1* correctly, depending on the correct recall of verbatim information (t-test:  $t = -0.911$ ,  $p = 0.363$ ). We conducted a logistic regression (Table 4) on the probability of answering *Q1* correctly, as a function of *MEM* and CRT score. We did not find any effect of recalling verbatim information on the correctness of *Q1* for *LOW* subjects (cf. Model 3, coeff =  $-0.01$ ,  $p = 0.975$ ) but found a statistically significant one for *HIGH* subjects (cf. Model 2, coeff =  $2.01$ ,  $p = 0.0027$ ). Indeed, *HIGH* subjects who recall the right verbatim information have a higher probability to answer *Q1* correctly.<sup>10</sup>

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

We reported in Table 2, the cross tabulation between *R1* and answer to *Q1*, depending on CRT score.

<sup>8</sup>Indeed, we deliberately chose a country with these characteristics because hot temperatures and deserts could be associated with poorer countries.

<sup>9</sup>Top answered countries were Brazil (30), Australia (29), “Africa” (18), China (14), Morocco (13), Egypt (12), South Africa (12), USA (12), and India (11).

<sup>10</sup> Model 2 and 3 are equivalent and statistically better than Model 1 (Likelihood ratio test:  $p = 0.012$ ).



	<i>LOW</i>		<i>HIGH</i>		<i>TOTAL</i>	
	R1=0	R1=1	R1=0	R1=1	R1=0	R1=1
Q1 = 0	92	102	18	18	110	120
Q1 = 1	34	38	5	14	39	52
mean	26.98%	27.14%	21.73%	43.75%	26.17%	30.23%

Table 2: Q1 and R1 contingency, conditional to CRT

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  $R1 = 0$ .

We did not find any significant difference in the probability to answer  $Q1$  correctly, depending on  $R1$  (t-test:  $t = -0.805$ ,  $p = 0.421$ ). We conducted logistic regressions (Table 4, Models 4,5,6) on the probability of answering  $Q1$ , as a function of  $R1$  and CRT score. We found that the results obtained in  $H1$  are robust to heterogeneity of beliefs about French average income. *LOW* subjects did not seem to process verbatim information to answer  $Q1$  (Model 6, coeff = 0.01,  $p = 0.972$ ). Conversely, *HIGH* individuals did so (Model 5, coeff = 1.68,  $p = 0.0157$ ).<sup>11</sup>

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

We reported in Table 3, the cross tabulation between  $R2$  and answer to  $Q1$ .

	<i>LOW</i>		<i>HIGH</i>		<i>TOTAL</i>	
	R2=0	R2=1	R2=0	R2=1	R2=0	R2=1
Q1 = 0	114	48	26	6	140	54
Q1 = 1	27	41	8	10	35	50
mean	19.15%	46.07%	23.52%	62.50%	20.00%	48.08%

Table 3: Q1 and R2 contingency

We found a significant difference in the probability to answer  $Q1$  correctly, depending on having a “rich-country” gist representation (t-test:  $t = -4.958$ ,  $p = 2.6 \times 10^{-6}$ ).

We conducted a logistic regression (Table 4, Models 7 to 10) on the probability of answering  $Q1$ , as a function of  $R2$ ,  $R1$  and CRT score. We found that gist representation impacted the evaluation for both *LOW* (Model 8: coeff = 1.30,  $p < 0.001$ ) and *HIGH* subjects (Model 7: coeff = 1.76,  $p = 0.021$ ). However, we found no statistical difference of this effect between the two groups ( $p = 0.58$ ).<sup>12</sup>

<sup>11</sup>We ran a likelihood ratio test, and Model 6 is statistically better than Model 4 ( $p = 0.038$ ).

<sup>12</sup>The latter regression also confirm  $H2$ . These results are robust for the use of *MEM* (see appendix) instead of  $R1$  as a control of verbatim memory, which provides support to results presented in  $H1$ .

	$P(Q1 = 1)$									
	<i>H1</i>			<i>H2</i>			<i>H3</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CRT Ref. Group	All	<i>HIGH</i>	<i>LOW</i>	All	<i>HIGH</i>	<i>LOW</i>	<i>HIGH</i>	<i>LOW</i>	<i>HIGH</i>	<i>LOW</i>
(Intercept)	-0.93**	-1.29*	-0.60	-0.94*	-1.26	-0.59	-0.56	-0.86*	-1.76*	-0.86
	(0.35)	(0.62)	(0.39)	(0.37)	(0.67)	(0.41)	(0.56)	(0.44)	(0.82)	(0.48)
<i>MEM</i>	0.45	<b>2.01**</b>	<b>-0.01</b>							
	(0.28)	(0.67)	(0.33)							
<i>R1</i>				0.30	<b>1.68*</b>	<b>0.01</b>			1.87*	-0.08
				(0.27)	(0.69)	(0.30)			(0.79)	(0.33)
<i>R2</i>							<b>1.70*</b>	<b>1.30***</b>	1.76*	1.30***
							(0.73)	(0.33)	(0.76)	(0.34)
<i>LOW</i>		0.69			0.67		-0.30		0.90	
		(0.54)			(0.61)		(0.49)		(0.78)	
<i>HIGH</i>			-0.69			-0.67		0.30		-0.90
			(0.54)			(0.61)		(0.49)		(0.78)
<i>MEM</i> × <i>LOW</i>		-2.02**								
		(0.74)								
<i>MEM</i> × <i>HIGH</i>			2.02**							
			(0.74)							
<i>R1</i> × <i>LOW</i>					-1.67*				-1.95*	
					(0.75)				(0.85)	
<i>R1</i> × <i>HIGH</i>						1.67*				1.95*
						(0.75)				(0.85)
<i>R2</i> × <i>LOW</i>							-0.39		-0.46	
							(0.81)		(0.84)	
<i>R2</i> × <i>HIGH</i>								0.39		0.46
								(0.81)		(0.84)
Logistic regressions. Treatment controls are masked.										
Log Likelihood	-176.59	-170.86	-170.86	-177.22	-172.60	-172.60	-145.37	-145.37	-142.20	-142.20
Num. obs.	321	321	321	321	321	321	280	280	280	280

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

Table 4: Impact of verbatim and gist memory on Q1

#### H4: Climate Information impacts gist and verbatim memory.

Table 5 displays the frequencies of recalling both *GNI* and *POP* verbatim information (i.e.  $MEM = 1$ ), as well as the probability of recalling a “richer country than France” (i.e.  $R2 = 1$ ), according to *CP*.

	<i>LOW</i>		<i>HIGH</i>		<i>TOTAL</i>	
	CP=0	CP=1	CP=0	CP=1	CP=0	CP=1
MEM = 0	48	139	11	19	59	158
MEM = 1	18	61	3	22	21	83
mean	27.27%	30.5%	21.42%	53.66%	26.25%	34.44%
R2 = 0	34	107	6	28	40	135
R2 = 1	28	61	8	8	36	69
mean	45.16%	36.31%	57.14%	22.22%	47.37%	33.82%

Table 5: MEM, R2 and CP contingency, conditional to CRT

We did not find any significant difference in the probability to recall verbatim information, depending on receiving the climate information (t-test:  $p = 0.1618$ ). However we found a significant difference of the effect of receiving the climate information on the probability of recalling a “rich country” (t-test:  $p = 0.044$ ).

We ran a logistic regression (Table 6, left columns) on the probability of recalling both *GNI* and *POP* verbatim information (*MEM*), as a function of the *CRT* score and receiving the climate information (*CP*).

We did not find that providing climate information to *LOW* subjects impacted their probability of recalling verbatim economic and demographic information (Model 12: coeff = 0.16,  $p = 0.62$ ), as opposed to the *HIGH* group for which it increases their recall rate (Model 13: coeff = 1.45,  $p = 0.045$ ). 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 also ran a logistic regression on the probability of identifying a richer country than France (*R2*), as a function of *CP* and *CRT* (Table 6, right columns). We found that the effect of climate information on the gist representation is more pronounced for the *HIGH* group (Model 16: coeff =  $-1.54$ ,  $p = 0.022$ ) than for the *LOW* one (Model 15: coeff =  $-0.37$ ,  $p = 0.222$ ). This tends to support the idea that climate information more strongly impacts the gist representation of *HIGH* subjects.

	$P(MEM = 1)$			$P(R2 = 1)$		
	(11)	(12)	(13)	(14)	(15)	(16)
(Intercept)	-1.03*** (0.25)	-0.98*** (0.28)	-1.30* (0.65)	-0.11 (0.23)	-0.19 (0.26)	0.29 (0.54)
<i>CP</i>	0.39 (0.29)	<b>0.16</b> (0.32)	<b>1.45*</b> (0.72)	-0.57* (0.27)	-0.37 (0.30)	-1.54* (0.67)
<i>HIGH</i>		-0.32 (0.71)			0.48 (0.60)	
$CP \times HIGH$		1.29 (0.79)			-1.17 (0.74)	
<i>LOW</i>			0.32 (0.71)			-0.48 (0.60)
$CP \times LOW$			-1.29 (0.79)			1.17 (0.74)
Log Likelihood	-201.23	-197.26	-197.26	-183.10	-181.38	-181.38
Num. obs.	321	321	321	280	280	280

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

Table 6: Impacts of Climate Information on Gist and Verbatim Memory

## 5 Discussion

To summarize the main points, results of this experiment can be accounted for 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.

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 since 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 that 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 assessment with an appropriate combination of this information. Conversely, individuals with higher cognitive abilities tended to exhibit consistency 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.

## A Appendix

### A.1 Table of Treatments

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 7: Table of Treatments

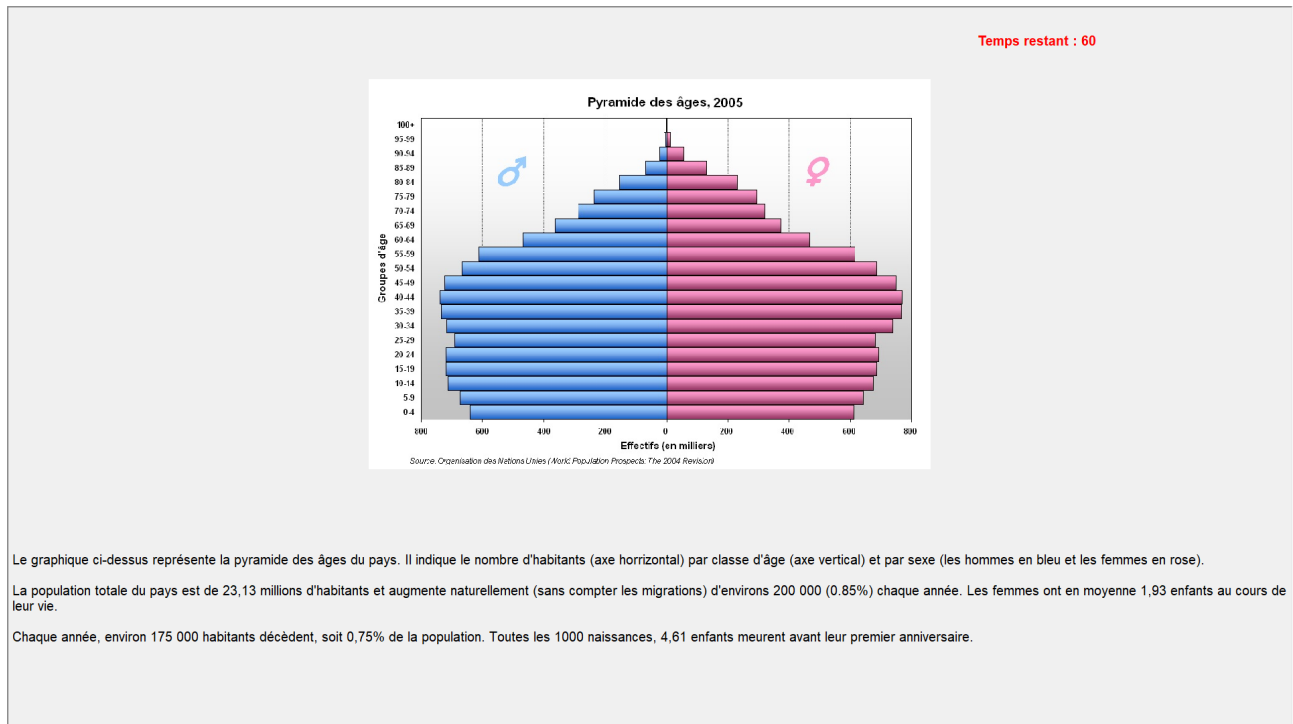
### A.2 Text of the introductory perspective (IP) in French

Le pays que nous décrivons maintenant et dans les pages suivantes recèle de trésors culturels et naturels et offre différentes saisons idéales au voyage : des sommets enneigés, des phénomènes géologiques au coeur du désert, des prouesses architecturales, des plages rouges, des montagnes rugueuses et des forêts luxuriantes...

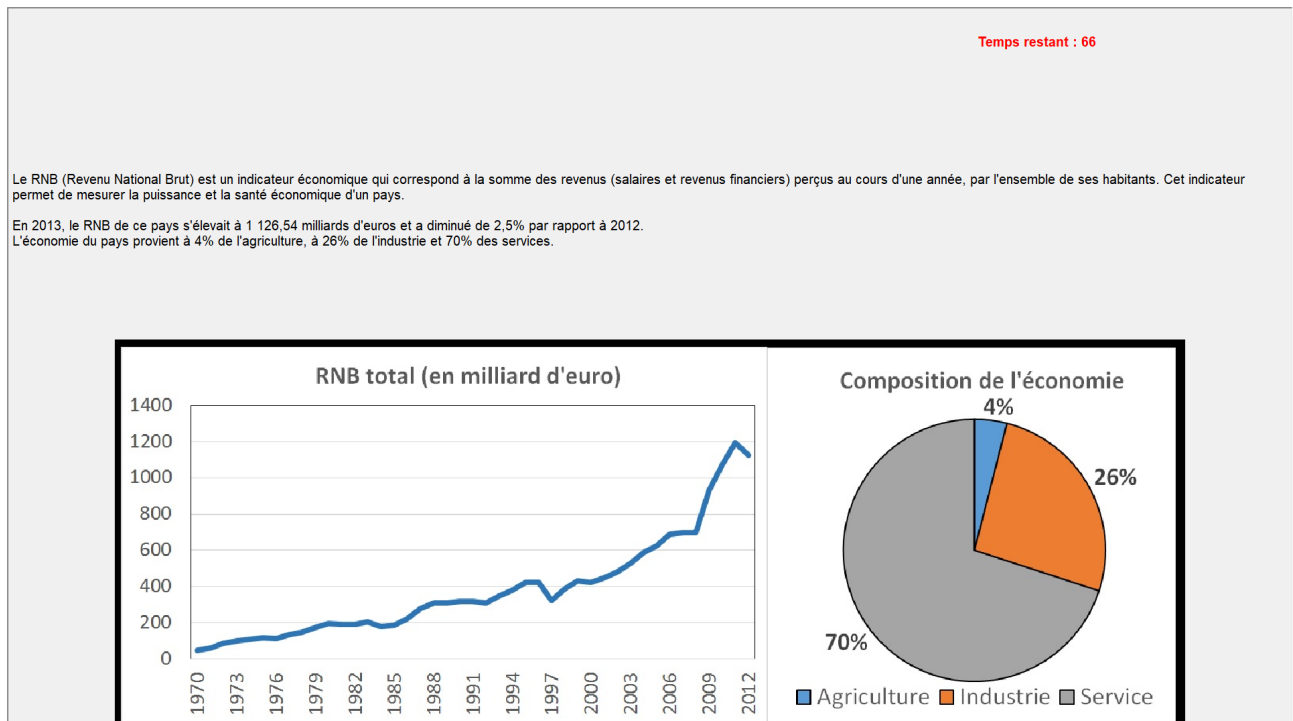
Son patrimoine riche en spectacle grandiose et en diversité nous invite au dépaysement, à l'aventure, à la découverte d'un monde à part, immense, insolite et fascinant. Le relief de ce pays a été lentement dessiné au fil du temps par l'érosion et nous parvient intact et phénoménal.

L'âge du paysage de ce magnifique pays se mesure en millions d'années. Il réunit dans son immensité une surprenante diversité de paysages et de climats, ainsi qu'une faune et flore originelles et uniques au monde.

### A.3 Screenshot of the demographic perspective (DP) in French



### A.4 Screenshot of the economic perspective (EP) in French



## A.5 Text of the climatic information (CP) in French

La majeure partie du pays est désertique ou semi-aride. Seuls les coins sud-est et sud-ouest du pays bénéficient d'un climat tempéré et d'un sol moyennement fertile. Le nord du pays, qui connaît un climat tropical, est couvert soit de forêts tropicales humides, soit de prairies, soit de déserts.

Les précipitations sont extrêmement variables, avec de fréquentes sécheresses qui durent plusieurs saisons. Une tempête de poussière est parfois capable de s'étendre sur toute une région et il y a des cas de tornades de grande ampleur. Dans certaines zones, l'élévation de la salinité et la désertification causent des dégâts importants au paysage.

Dans l'année, les températures les plus hautes peuvent atteindre les 50°C, tandis que les minimums peuvent descendre en dessous de 0°C.

## A.6 Screenshot of the control questions in French

Temps restant : 77

Chacune des questions suivantes est rémunérée à hauteur de 5 ECU par bonne réponse.  
Pour les réponses chiffrées, une marge d'erreur de 10% est acceptée.

Selon vous, quelle est la part (en pourcentage) de l'industrie dans l'économie du pays présenté ?

Quelle est la population du pays présenté (en millions d'habitants) ?

Jusqu'à combien de degrés peuvent atteindre les températures les plus élevées du pays présenté ?

Quel était, en 2013, le revenu national brut du pays présenté (en milliards d'euros) ?

Quel sont les coins du pays qui disposent du climat le plus tempéré et d'un sol fertile ? (Merci de cocher les deux bonnes réponses)

Nord-Ouest  
 Nord-Est  
 Centre  
 Sud-Ouest  
 Sud-Est

Combien les femmes du pays présenté ont-elles d'enfants en moyenne ?

Merci d'indiquer ci-dessous toutes les informations qui ont pu influencer ou guider vos réponses

OK

## References

- Brainerd, C. J. and Reyna, V. F. (2001). Fuzzy-trace theory: Dual processes in memory, reasoning, and cognitive neuroscience. *Advances in child development and behavior*, 28:42–100.
- Finucane, M. L. and Gullion, C. M. (2010). Developing a tool for measuring the decision-making competence of older adults. *Psychology and aging*, 25(2):271.
- Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, 10(2):171–178.
- Frederick, S. (2005). Cognitive reflection and decision making. *The Journal of Economic Perspectives*, 19(4):25–42.
- Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with orsee. *Journal of the Economic Science Association*, 1(1):114–125.

- Liberali, J. M., Reyna, V. F., Furlan, S., Stein, L. M., and Pardo, S. T. (2012). Individual differences in numeracy and cognitive reflection, with implications for biases and fallacies in probability judgment. *Journal of behavioral decision making*, 25(4):361–381.
- McDonald, A. M. and Cranor, L. F. (2008). The cost of reading privacy policies. *ISJLP*, 4:543.
- Reyna, V. F. (2012). A new intuitionism: Meaning, memory, and development in fuzzy-trace theory. *Judgment and decision making*, 7(3):332.
- Reyna, V. F. and Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and individual Differences*, 7(1):1–75.
- Reyna, V. F., Corbin, J. C., Weldon, R. B., and Brainerd, C. J. (2016). How fuzzy-trace theory predicts true and false memories for words, sentences, and narratives. *Journal of applied research in memory and cognition*, 5(1):1–9.
- Toplak, M. E., West, R. F., and Stanovich, K. E. (2011). The cognitive reflection test as a predictor of performance on heuristics-and-biases tasks. *Memory & Cognition*, 39(7):1275.



## CEE-M Working Papers<sup>1</sup> – 2018

- WP 2018 – 01: **Ilaria Brunetti, Mabbel Tidball, & Denis Couvet**  
« Relationship Between Biodiversity and Agricultural Production »
- WP 2018 – 02: **Phillippe Le Coent, Raphaële Préget & Sophie Thoyer**  
« Do farmers follow the herd? The influence of social norms in the participation to agri-environmental schemes »
- WP 2018 – 03: **Ludivine Roussey & Raphaël Soubeyran**  
« Overburdened judges »
- WP 2018 – 04: **Nicolas Quérou**  
« Interacting collective action problems in the Commons »
- WP 2018 – 05: **Karine Constant & Marion Davin**  
« Unequal vulnerability to climate change and the transmission of adverse effects through international trade »
- WP 2018 – 06: **Henrik Andersson & Emmanuelle Lavaine**  
« Nitrates and property values: evidence from a french market intervention »
- WP 2018 – 07: **Mamadou Gueye, Nicolas Querou & Raphaël Soubeyran**  
« Does equity induce inefficiency? An experiment on coordination »
- WP 2018 – 08: **Douadia Bougherara & Laurent Piet**  
« On the role of probability weighting on WTP for crop insurance with and without yield skewness »
- WP 2018 – 09: **Douadia Bougherara, Carole Ropars-Collet & Jude Saint-Gilles**  
« Impact of private labels and information campaigns on organic and fair trade food demand »
- WP 2018 – 10: **Sylvain Chabé-Ferret, Philippe Le Coent, Arnaud Reynaud, Julie Subervie & Daniel Lepercq**  
« Can we nudge farmers into saving water? Evidence from a randomized experiment »
- WP 2018 – 11: **Dimitri Dubois, Stefano Farolfi, Phu Nguyen-Van & Juliette Rouchier**  
« Information sharing is not always the right option when it comes to CPR extraction management: experimental finding »
- WP 2018 – 12: **Tristan Le Cotty, Elodie Maitre d'Hotel, Raphaël Soubeyran & Julie Subervie**  
« Inventory credit as a commitment device to save grain until the hunger season »

---

<sup>1</sup> CEE-M Working Papers

Contact : [laurent.garnier@inra.fr](mailto:laurent.garnier@inra.fr) / 04 99 61 31 21

- WP 2018 - 13: **Brice Magdalou**  
« An abstract model of welfare-improving transfers »
- WP 2018 - 14: **Mickael Beaud, Mathieu Lefebvre & Julie Rosaz**  
« Other-regarding preferences and giving decision in risky environments: experimental evidence »
- WP 2018 - 15: **Kate Farrow, Lisette Ibanez & Gilles Grolleau**  
« Designing more effective norm interventions: the role of valence »
- WP 2018 - 16: **Yu-Jui Huang, Adrien Nguyen-Huu & Xun Yu Zhou**  
« General stopping behaviors of naïve and non-committed sophisticated agents, with application to probability distortion »
- WP 2018 - 17: **Sophie Clot, Gilles Grolleau, Lisette Ibanez**  
« What did you do before? Moral (in)consistency in pro-environmental choice »
- WP 2018 - 18: **Sébastien Duchêne, Eric Guerci, Nobuyuki Hanaki & Charles N. Noussair**  
« The effect of short selling and borrowing on market prices and traders' behavior »
- WP 2018 - 19: **Philippe Delacote, Gwenolé Le Velly & Gabriela Simonet**  
« The effect of short selling and borrowing on market prices and traders' behavior »
- WP 2018 - 20: **Luc Behaghel, Karen Macours & Julie Subervie**  
« Can RCTs help improve the design of CAP? »
- WP 2018 - 21: **Tristan Roger, Wael Bousselmi, Patrick Roger & Marc Willinger**  
« Another law of small numbers: Patterns of trading prices in experimental markets »
- WP 2018 - 22: **Nobuyuki Hanaki, Yukio Koriyama, Angela Sutan & Marc Willinger**  
« The strategic environment effect in beauty contest games »
- WP 2018 - 23: **Wael Bousselmi, Patrick Sentis & Marc Willinger**  
« Impact of the Brexit vote announcement on long-run market performance »
- WP 2018 - 24: **Tristan Roger, Wael Bousselmi, Patrick Roger & Marc Willinger**  
« The effect of price magnitude on analysts' forecasts: evidence from the lab »

WP 2018 - 25

Ismaël Rafai, **Sébastien Duchêne**, Eric Guerci, Ariane Lambert-Mogiliansky  
& Fabien Mathy  
« A dual process in memory: how to make an evaluation from complex and  
complete information? – An experimental study »