Measuring natural source dependence (Online Appendix)

Appendix A: Descriptive statistics of the original experiments

Study B

In Table A.1, we report the approval ratings $v_{k,S}$, such that the events $E_{k,S} = [0,v_{k,S}]$ have a-neutral probabilities $\mu(E_{k,S})$ of 0.125, 0.25, 0.5, 0.75, and 0.875, respectively. In Table A.2, we report the matching probabilities $mp_{k,S}$ of events $E_{k,S}$.

$\mu(E_{k,S})$	US president's approval rating				French president's approval rating			
	Mean	Median	Std. Dev.	IQR	Mean	Median	Std. Dev.	IQR
0.125	29.90	24.50	21.76	[14.50; 39.50]	37.95	36.50	21.21	[24.50; 49.50]
0.25	34.44	25.50	23.51	[18.50; 46.25]	43.68	40.50	23.47	[25.75; 54.25]
0.50	47.38	43.50	22.62	[31.00; 61.25]	58.21	52.50	21.42	[45.75; 75.50]
0.75	57.78	54.50	21.75	[42.75; 75.50]	66.73	69.50	19.31	[50.50; 78.25]
0.875	63.02	62.50	22.08	[49.50; 80.25]	71.70	75.50	19.34	[54.50; 87.50]

Table A.1: Descriptive statistics of the attitude data (matching probabilities) for Study B

$\mu(E_{k,S})$	US president's approval rating				French president's approval rating			
	Mean	Median	Std. Dev.	IQR	Mean	Median	Std. Dev.	IQR
0.125	25.51	25.00	12.01	[19.50; 32.50]	41.64	42.00	12.41	[33.50; 50.50]
0.25	28.88	29.50	11.88	[21.50; 35.50]	45.50	46.00	12.26	[36.50; 53.50]
0.50	33.49	34.00	12.32	[24.50; 39.50]	50.65	50.50	12.68	[42.50; 57.50]
0.75	38.91	38.50	12.54	[30.50; 45.50]	56.05	55.50	12.49	[47.50; 64.50]
0.875	42.62	41.50	13.89	[32.50; 51.50]	59.49	58.50	12.97	[50.50; 67.50]

Note: The matching probabilities are expressed in percentages.

Table A.2: Descriptive statistics of the beliefs (EE) data for Study B

Study C

The three exclusive events, constituting an exhaustive partition are $E_1 = (-\infty, 18]$, $E_2 =]18, 22]$ and $E_3 =]22, \infty)$.

Source	Event	Mean	Median	Std. Dev.	IQR
Paris	E_1	10.38	9.50	4.96	[6.50; 13.50]
	E_3^c	13.44	14.50	4.66	[9.50; 17.50]
	E_2	8.05	8.50	4.56	[4.50; 10.50]
	E_1^c	10.07	9.50	5.17	[6.50; 14.50]
	E_3	6.73	6.50	4.53	[3.50; 9.50]
	E_2^c	12.44	13.50	4.31	[9.50; 15.50]
Belgrade	E_1	10.19	9.50	4.92	[6.50; 13.50
	E_3^c	12.38	12.50	4.64	[9.50; 16.50]
	E_2	7.30	7.50	4.30	[4.50; 9.50]
	E_1^c	9.40	9.50	5.08	[5.50; 13.50
	E_3	7.12	7.50	4.54	[3.50; 9.50]
	E_2^c	12.32	12.50	4.53	[9.50; 15.50]

Table A.3: Descriptive statistics on beliefs and attitude data (CEs) for Study C

Appendix B: Estimations of beliefs and attitudes for study C

For study C, we estimated probabilities (beliefs) jointly with the parameters of uncertainty functions. For each source (A and B), we considered a three-event partition $\{E_1,E_2,E_3\}$, with beliefs characterized by two values $\mu_1 = \mu(E_1)$ and $\mu_3 = \mu(E_3)$ (given that $\mu(E_2) = 1 - \mu(E_1) - \mu(E_3)$). In order to ensure that $0 < \mu(E_1) + \mu(E_3) < 1$, we used a multinomial logit transformation $\mu_1 = \frac{exp(\nu_1)}{1+exp(\nu_1)+exp(\nu_3)}$ and $\mu_3 = \frac{exp(\nu_3)}{1+exp(\nu_1)+exp(\nu_3)}$.

The likelihood of event E_2 was the reference, and ν_1 and ν_3 measured the log odd-ratios with reference to this likelihood. Concretely, if $\nu_1 = 0$ then $\mu_1 = \mu_2$, and if $\nu_1 > 0$ ($\nu_1 < 0$) then $\mu_1 > \mu_2$ ($\mu_1 < \mu_2$). The same applied to ν_3 and μ_3. For random-coefficient estimations that account for heterogeneity in beliefs (and attitudes), ν_1 and ν_3 were considered as (possibly correlated) random variables that vary across subjects.

	Prelec		GE	
$\nu_{1,\bar{S}=A}$	0.487	[0.199; 0.780]	0.524	[0.236; 0.817]
$\nu_{3,\bar{S}=A}$	-0.466	[-0.709;-0.236]	-0.366	[-0.521; -0.200]
$\nu_{1,\bar{S}=B}$	0.719	[0.497; 0.935]	0.456	[0.187; 0.726]
$\nu_{3,\bar{S}=B}$	0.091	[-0.128; 0.307]	-0.037	[-0.173; 0.110]
$\bar{a}$	0.570	[0.532; 0.607]	0.567	[0.518; 0.614]
$\bar{b}$	-0.007	[-0.050; 0.036]	-0.007	[-0.050; 0.036]
$\bar{\alpha}$	0.051	[0.012; 0.091]	0.059	[-0.007; 0.119]
$\bar{\beta}$	0.059	[0.032; 0.085]	0.060	[0.039; 0.079]
$\sigma_{\nu_{1,S=A}}$	1.638	[1.381; 1.929]	1.537	[1.268; 1.846]
$\sigma_{\nu_{3,S=A}}$	1.110	[0.902; 1.349]	0.878	[0.754;1.022]
$\sigma_{\nu_{1,S=B}}$	1.293	[1.127; 1.489]	1.504	[1.287; 1.752]
$\sigma_{\nu_{3,S=B}}$	1.028	[0.832; 1.249]	0.724	[0.613; 0.852]
σ_a	0.207	[0.180; 0.238]	0.209	[0.161; 0.257]
σ_b	0.285	[0.255; 0.319]	0.281	[0.249; 0.319]
σ_α	0.229	[0.200; 0.264]	0.283	[0.245; 0.326]
σ_β	0.125	[0.101; 0.164]	0.071	[0.046; 0.099]
LL	-3449.682		-3468.245	

Note: 95% credible intervals between brackets. a and b are the likelihood insensitivity and uncertainty aversion parameters of the reference source.

Table A.4: HB estimations on study C

Appendix C: Estimations with other specifications

	Study A		Study A (only real incentives)		Study B		Study C	
$\bar{a}$	0.281	[0.183; 0.375]	0.314	[0.166; 0.453]	0.544	[0.484; 0.601]	0.570	[0.532; 0.607]
$\bar{b}$	0.149	[0.032; 0.266]	0.193	[0.043; 0.341]	-0.105	[-0.185; -0.025]	-0.007	[-0.050; 0.036]
$\bar{\alpha}$	0.000	[-0.054; 0.055]	-0.205	[-0.286; -0.096]	0.353	[0.251; 0.449]	0.051	[0.012; 0.091]
$\bar{\beta}$	0.028	[-0.071; 0.129]	0.104	[0.030; 0.176]	0.277	[0.171; 0.377]	0.059	[0.032; 0.085]
σ_a	0.345	[0.281; 0.425]	0.362	[0.273; 0.479]	0.250	[0.207; 0.300]	0.207	[0.180; 0.238]
σ_b	0.440	[0.368;0.529]	0.394	[0.306; 0.509]	0.371	[0.320; 0.431]	0.285	[0.255; 0.319]
σ_α	0.163	[0.125; 0.212]	0.181	[0.115; 0.279]	0.319	[0.255; 0.396]	0.229	[0.200; 0.264]
σ_β	0.335	[0.268; 0.416]	0.137	[0.086; 0.198]	0.360	[0.294; 0.436]	0.125	[0.101; 0.164]
LL	-1817.354		-982.404		-3313.293		-3449.682	

Note: 95% credible intervals between brackets.

a and b are the likelihood insensitivity and uncertainty (ambiguity) aversion parameters of the reference source.

Table A.5: Summary of HB estimations with Prelec specification - Studies A, B and C

	Study A		Study A incentives only (only real incentives)		Study B		Study C	
$\bar{a}$	0.310	[0.210; 0.405]	0.338	[0.189; 0.483]	0.572	[0.520; 0.622]	0.567	[0.518; 0.614]
$\bar{b}$	0.164	[0.047; 0.280]	0.172	[0.016; 0.326]	-0.119	[-0.200;-0.039]	-0.007	[-0.050; 0.036]
$\bar{\alpha}$	0.020	[-0.039; 0.085]	-0.268	[-0.397; -0.145]	0.456	[0.365; 0.545]	0.059	[-0.007; 0.119]
$\bar{\beta}$	-0.005	[-0.104; 0.093]	0.143	[0.081; 0.202]	0.303	[0.191; 0.408]	0.060	[0.039; 0.079]
σ_a	0.345	[0.278; 0.428]	0.379	[0.292; 0.494]	0.212	[0.176; 0.254]	0.209	[0.161; 0.257]
σ_b	0.440	[0.368; 0.529]	0.408	[0.319; 0.526]	0.372	[0.321; 0.433]	0.281	[0.249; 0.319]
σ_α	0.183	[0.144; 0.231]	0.297	[0.198; 0.411]	0.312	[0.254; 0.381]	0.283	[0.245; 0.326]
σ_β	0.333	[0.270; 0.410]	0.106	[0.066; 0.159]	0.363	[0.292; 0.446]	0.071	[0.046; 0.099]
LL	-1815.071		-953.680		-3297.273		-3468.245	

Note: 95% credible intervals between brackets.

a and b are the likelihood insensitivity and uncertainty (ambiguity) aversion parameters of the reference source.

Table A.6: HB estimations with GE specification - Studies A, B and C

Appendix D: Instructions of the experiments

D1 - Instructions for experiment B (translated in English)

General information

- The study will last approximately 1 hour
- You will receive 10€ for your participation
- You will also have the possibility of earning an extra monetary amount
- There are no right or wrong answers
- We are trying to measure your preferences in situations of uncertainty

1

Course of the experiment

1. Instructions
2. Training
3. Experiment
4. Draw with the possibility of additional payment

Please don't hesitate to ask us questions anytime. The experimenter will remain by your side throughout the experiment.

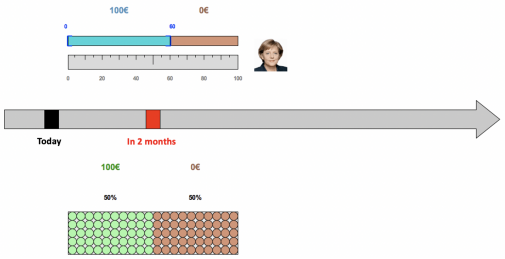
2

Example of choices

First example

What would you prefer between:

- Option at the top: win 100€ if Angela Merkel's approval rating in two months is lower than 60% and nothing otherwise.
- Option at the bottom: a draw, played in 2 months, that offers a 50% chance of winning 100€ and a 50% chance of winning nothing.



4

First example: illustration

We are not interested in your political preferences.

We use the approval ratings of politicians as a source of uncertainty.

5

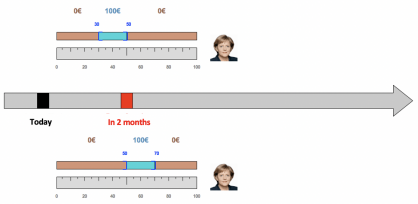
Second example

Example of a choice in which both options involve the same variable:

Do you prefer:

- Option at the top: an option that offers 100€ if Angela Merkel's approval rating in two months is between 30% and 50%.
- Option at the bottom: an option that offers 100€ if Angela Merkel's approval rating in two months is between 50% and 70%.

Here, you should choose the interval in which you believe Angela Merkel's approval rating is the most likely to fall.



6

The different sources of uncertainty

The previous examples involved Angela Merkel's approval rating in two months and the color of a ball drawn from a bag, also in two months.

In this experiment, we will consider 4 sources on which you will be able to bet, and each source will be considered at two periods of time.

7

The different sources of uncertainty

The four sources of uncertainty are:

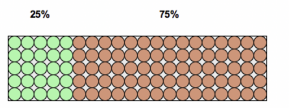
1. The color of a ball drawn from a bag with a known composition
2. The color of a ball drawn from a bag with an unknown composition
3. The approval rating of Donald Trump (US president), measured by a monthly survey, official source: http://elections.huffingtonpost.com/pollster/donald-trump-favorable-rating
4. The approval rating of Emmanuel Macron (French president), measured by a monthly survey, official source: http://www.tns-sofres.com

8

The bag with a known composition: known probabilities

The bag with a known composition contains 100 balls that are either green or brown.

- You know the number of green and brown balls.
- You know the probability of drawing a green ball from the bag.



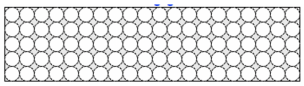
9

The bag with an unknown composition: unknown probabilities

The bag with unknown composition contains 100 balls of 8 different colors: blue, purple, red, orange, yellow, green, grey and black

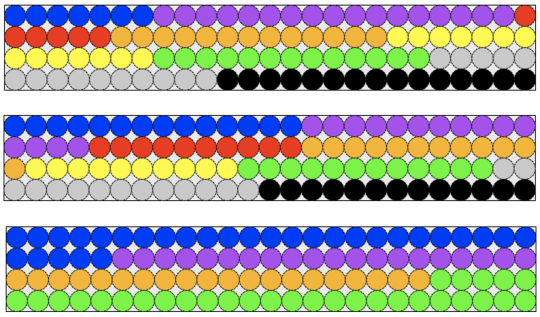
You do not know the exact number of each color. There can be:

- 0,1… even 100 blue balls,
- 0,1… even 100 purple balls,
- 0,1… even 100 red balls,
- 0,1… even 100 orange balls,
- 0,1… even 100 yellow balls,
- 0,1… even 100 green balls,
- 0,1… even 100 grey balls,
- 0,1… even 100 black balls.



10

The bag with an unknown composition: unknown probabilities - Illustrations

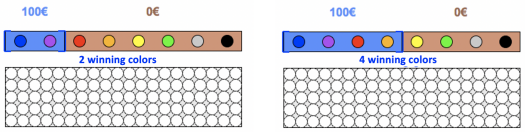


11

The bag with an unknown composition: unknown probabilities

Consider the following situations:

- You win 100€ if the ball drawn from the bag is of one of the winning color.



Note that the higher the number of winning colors, the higher your chances of winning.

What matters is the number of winning colors. In practice, you will be able to choose the winning colors.

12

Approval rating of a personality

In this experiment, we will also consider two "natural" sources of uncertainty:

The approval rating of:

the US president, Donald Trump

the French president, Emmanuel Macron

Here, we are not interested in your political preferences.

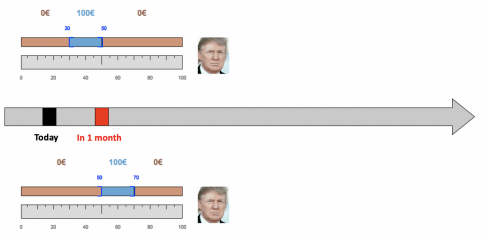
We consider these variables as sources of uncertainty:

- that nobody can predict with certainty
- On which everybody can have an opinion.

13

Examples

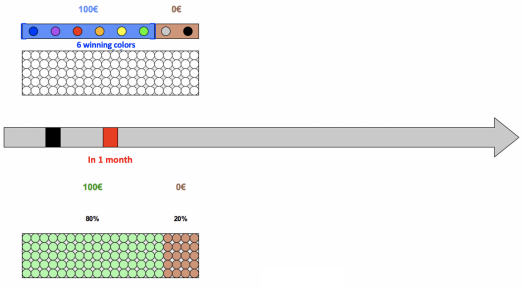
- Each of these sources will be considered at different periods of time.
- When you choose between two sources, they will always refer to the same period.
- In all cases, in case of monetary gain, you will receive the payment for any monetary gain 12 months from now.



14

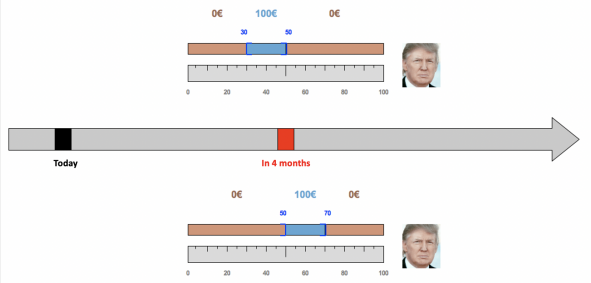
The software

Examples



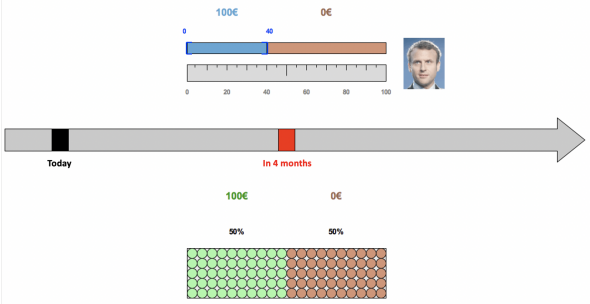
16

Examples



17

Examples



18

General principles

For each choice, it is important to look at:

- What sources are concerned
- The dates

Note that the uncertainty about the two options is always resolved at the same time and, in case of monetary gain, you will receive payment the same date for both options: in 12 months. Your choice should therefore focus on the event on which you prefer to bet.

19

Choice lists

You will have to make a large number of choices.

To facilitate the choices, we have grouped them in lists. Within a choice list.

- The sources and their dates are fixed.
- Only the winning event varies.

20

Filling in a choice list

- We will continue the procedure until all the choices on the list are filled.
- At the end of the procedure, you will need to verify all the choices on the list and validate or modify them before confirmation.
- Be careful, once the choices of a list are validated, you move on to the next list and will not be able to go back.
- Note that this procedure should not influence your preferences; it is simply meant to speed up the filling out of the list.
- You will have the opportunity to familiarize yourself with the procedure during the training phase.

21

Real incentives

Real incentives

In order to encourage sincere answers, we will use a real incentive system.

Every subject will have a 10% chance of having one of his/her choices randomly selected and played for real.

- Before the experiment, we created a list of envelopes. 1 out of 10 envelopes contains a winning ticket.
- You will receive a random envelope: you therefore have a 10% chance of getting a winning ticket.

23

Real incentives

At the end of the session, you will open the envelope and discover if you have been selected to have one of your choices played for real.

If this is the case, a computer program will randomly choose one of the choices that you have made during the session.

We will look at your answer to this question to determine your gains.

Note that:

- You will not be able to modify your answer.
- It is therefore in your interest to answer each question sincerely in order not to regret your choices at the moment of the random draw.

24

Real incentives

- We will organize a Skype call at the time indicated in the question.
- For instance, if you answer the questionnaire in June and the question refers to an event occurring in one month, we would organize a Skype call in July.

- Depending on the question randomly selected and on the answer to this question, your gain will depend on:




25

Real incentives

The gain depends on the **color of the ball drawn from a bag with a known composition:**

- We will fill up a bag with the number of green balls and brown balls as indicated in the selected question.
- We will randomly draw a ball.
- The color of the ball will determine your gain.

The gain depends on the **color of the ball drawn from a bag with an unknown composition:**

- We will fill up the bag with 100 balls
- You will know that the balls can be of 8 different colors but you won't know the exact composition of the bag
- You will choose a certain number of winning colors depending on the number indicated in the question.
- We will randomly draw a ball.
- The color of the ball will determine your gain.

26

Real incentives

The gain depends on **Donald Trump's approval rating**:

- We will visit the website:
  - http://elections.huffingtonpost.com/pollster/donald-trump-favorable-rating.
- We will use the percentage of favorable opinions as a measure of Donald Trump's approval rating.
- The gain will depend on your answer and the approval rating.

The gain depends on **Emmanuel Macron's approval rating**:

- We will visit the website:
  - http://www.tns-sofres.com/cotes-de-popularites.
- We will use the percentage of French people who trust Emmanuel Macron as a measure of approval rating.
- The gain will depend on your answer and the approval rating.

27

Payment of the gains

In any case, all the gains will be **paid 12 months after the date of the session:**

- Regardless of the period indicated in the selected question
- Regardless of the source used to determine your gain

- The amount of the prize will be given to you in cash at the INSEAD Lab, in 12 months.
- In the event of a win, you will receive a voucher, certifying your right to receive the prize, stating the first name, last name, email address, and professional address of the CNRS researcher in charge of the experiment, guaranteeing the adherence to the payment procedure.

28

D2 - Instructions of experiment C

Experiment C was run online, and started with a video presenting the instructions. The video is available upon request. In what follows, we report screenshots from the video (translated) and a

translation of the verbatim that came with each part of the video.

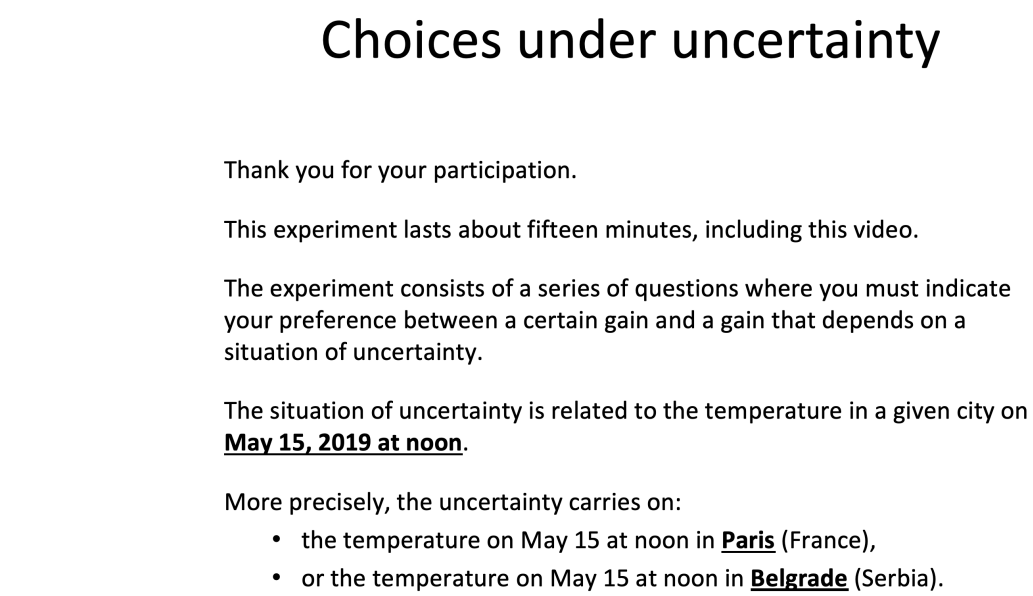


Figure A.1: Instructions of Study C: slide 1

Translation of the script:
Thank you for your participation. This experiment lasts about fifteen minutes, including this video. The experiment consists of a series of questions where you must indicate your preference between a certain gain and a gain that depends on a situation of uncertainty. The situation of uncertainty is related to the temperature in a given city on May 15 at noon. More precisely, the uncertainty carries on:

- *the temperature on May 15 at noon in Paris (France)*
- *or the temperature on May 15 at noon in Belgrade (Serbia).*

Figure A.2: Instructions of Study C: slide 2

Translation of the script:
Here is an example of a question. You must indicate your preference between option A, on the left, and option B, on the right. Option A gives 10 euros for sure. Option B gives 20 euros only if the temperature on May 15 at noon in Paris is below or equal to 22 degrees. If the temperature is strictly higher than 22 degrees, you do not win anything.

Figure A.3: Instructions of Study C: slide 3

Translation of the script:
Here is another example of a question. You must indicate your preference between option A on the left and option B on the right. Option A gives you 15 euros for sure. Option B gives you 20 euros only if the temperature on May 15 at noon in Belgrade is strictly higher than 22 degrees. If the temperature is below or equal to 22 degrees, you do not win anything.

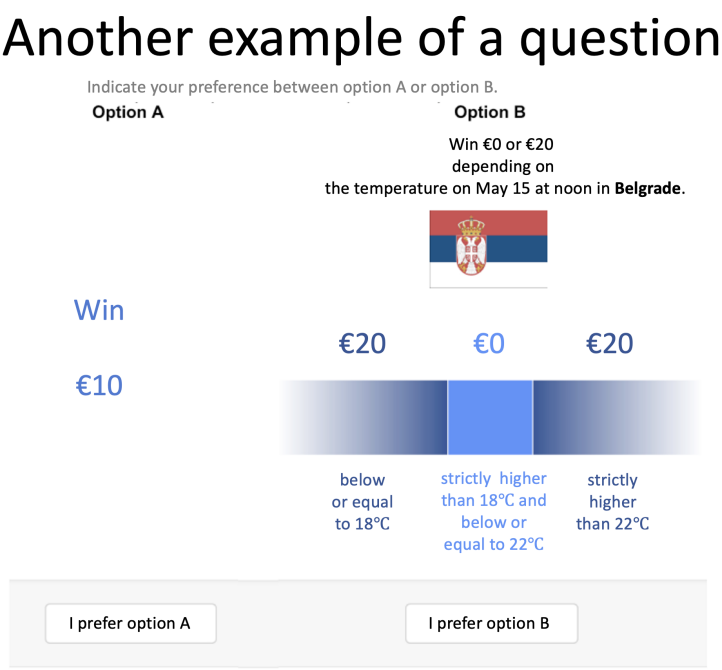


Figure A.4: Instructions of Study C: slide 4

Translation of the script:
Here is a final example of a question. Option A gives 10 euros for sure. Option B gives 20 euros only if the temperature on May 15 at noon in Belgrade is below or equal to 18 degrees, or strictly higher than 22 degrees. If the temperature is between 18 degrees and 22 degrees, you do not win anything.

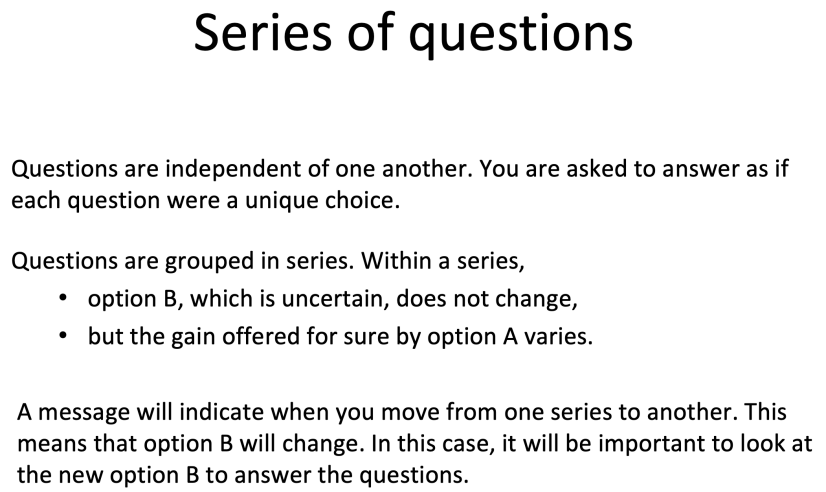


Figure A.5: Instructions of Study C: slide 5

Translation of the script:
Questions are independent of one another. You are asked to answer as if each question were a unique choice. Questions are grouped in series. Within a series, option B, which is uncertain does not change, but the gain offered for sure by option A varies. A message will indicate when you move from one series to another. This means that option B will change. In this case, it will be important to look at the new option B to answer the questions.

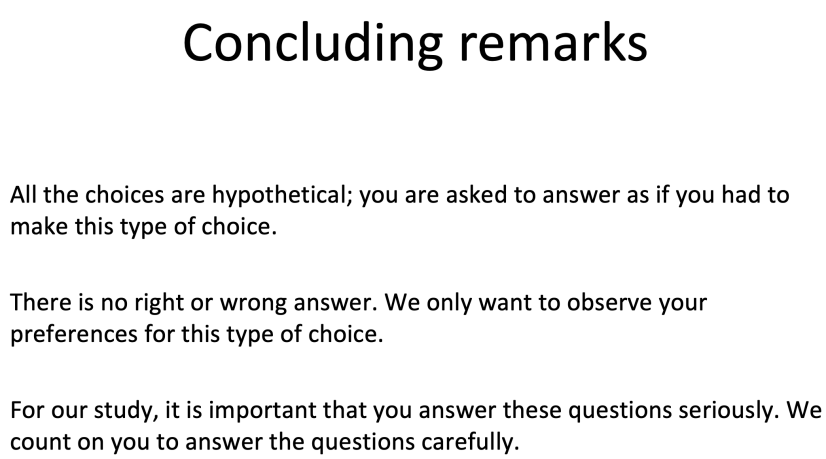


Figure A.6: Instructions of Study C: slide 6

Translation of the script:
Concluding remarks. All the choices are hypothetical; you are asked to answer as if you had to make this type of choice.
There is no right or wrong answer. We only want to observe your preferences for this type of choice. For our study, it is important that you answer these questions seriously. We count on you to answer the question carefully.