Interference between cues in human contingency learning: A review, new data and a potential general explanation based on propositional models

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Interference between cues (IbC)

Design

	Phase 1	Phase2	Test
Same Outcome (Experimental)	**A → O1** C → O3	**B → O1** C → O3	**A → ?**
Different Outcome (Control)	**A → O1** C → O3	**B → O2** C → O3	**A → ?**

IbC: Number of responses to O1 lower in the Experimental than in the Control Group

A potential general explanation based on top-down processes

- Priors and beliefs can top-down modulate bottom-up HCL (e.g., Waldmann, Hagmayer & Blaisdell, 2006).

- Obtaining IbC would requires:
- Univocity of the inverse correspondence between the set of cues and the set of outcomes, that is...
  - *outcome-cue univocity*

- If new data is inconsistent with this belief, cognizers try to incorporate the new knowledge without changing the *outcome-cue univocity* prior. For this...
  - *participants can use the context as logic gate*

A potential general explanation based on top-down processes

If we apply these assumptions to a IbC design…

- In the first learning phase [Cue A → O1]

1. Given an Outcome O1, then Cue A must be true.

- In the second learning phase [Cue B → O1]

2. Given an Outcome O1, then Cue B must be true.

Inconsistency

If possible, participants use the context as a logical gate

3. In Context X: Given an Outcome O1, then Cue A must be true
   In context Y: Given an Outcome O1, then Cue B must be true

Outcome-cue univocity: Previous clues

- Previous experiments have shown that IbC is easier to obtain in diagnostic causal learning task (from Effects to Causes, Cobos et al., 2007; Luque et al., 2008).

- Previous experiments have shown that IbC is easier to obtain in tasks with multiple response options easily distinguishable from each other (Luque et al., 2008; 2009; 2012).

Outcome-cue univocity: Previous clues - Diagnostic task effect

- Previous experiments have shown that IbC is easier to obtain in diagnostic causal learning task (from Effects to Causes, Cobos et al., 2007; Luque et al., 2008).
- In this task, priors about how causal relations work facilitate outcome-cue univocity (Waldmann & Holyoal, 1992):
  - All other things held constant, given a Cause the Effect must be true.

…

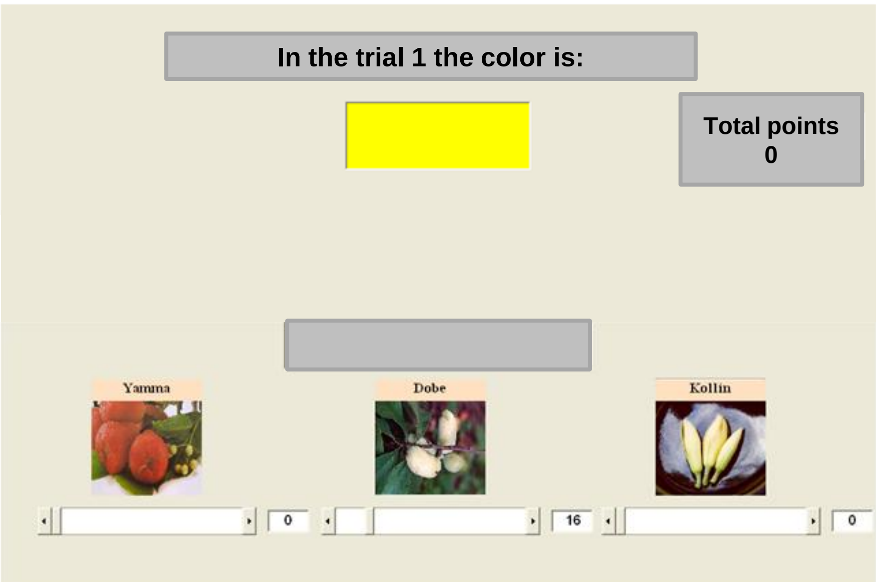
In the first learning phase [Effect A → Cause1]

- Given the Cause O1, then Effect A must be true.

- In the second learning phase [Effect B → Cause1]
- Given the Cause O1, then Effect B must be true.

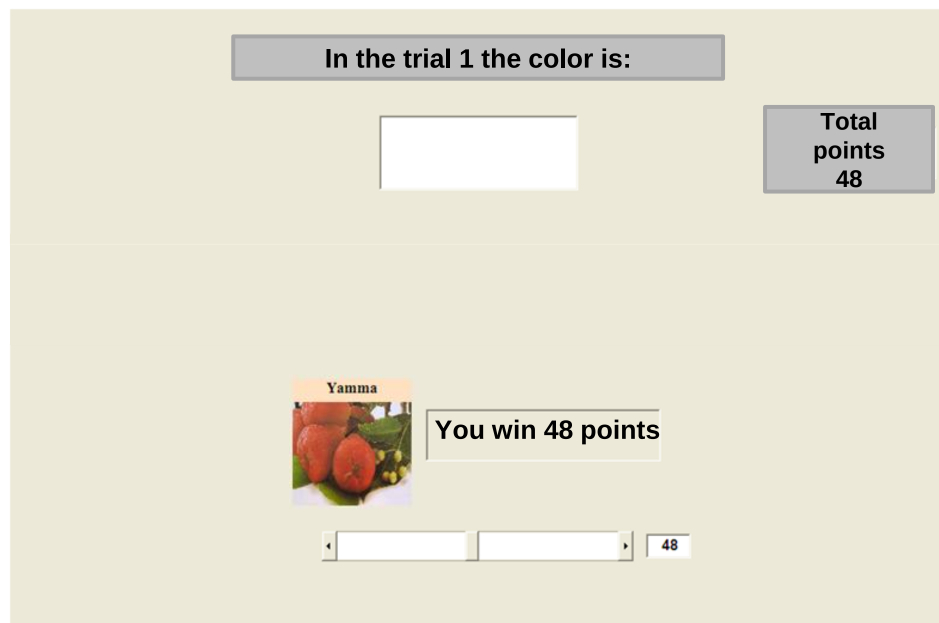
Inconsistency
↓
Context-dependency
↓
IbC

Outcome-cue univocity: Previous clues - Multiple response options effect



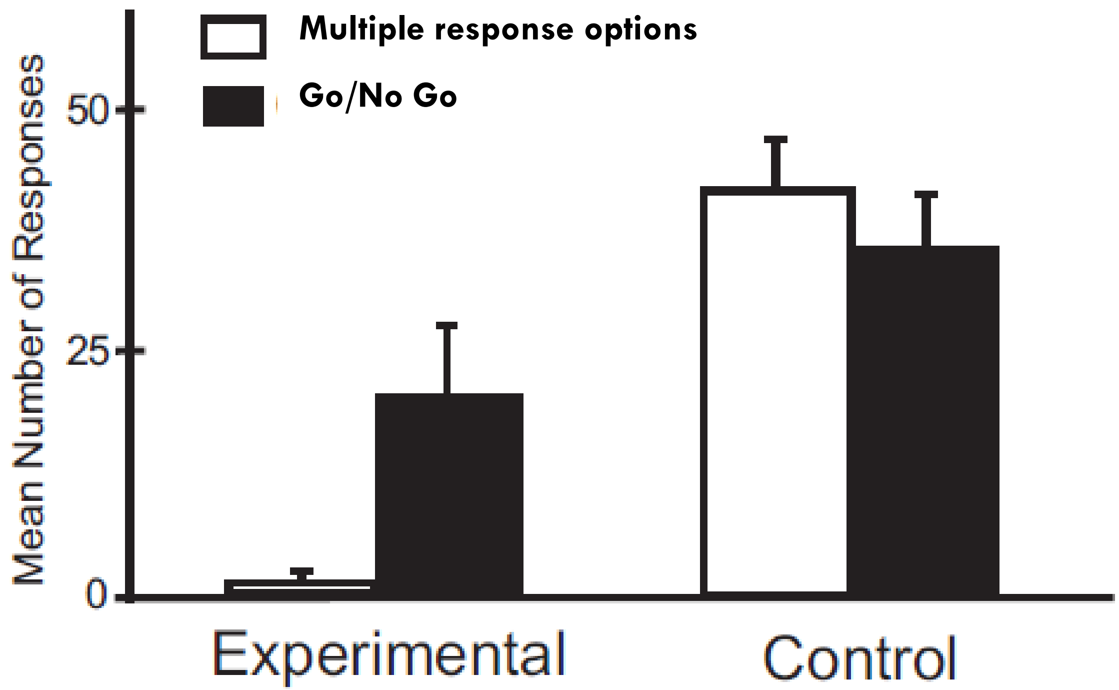
3 response options

NO CAUSAL COVER STORY



Go/No Go

Outcome-cue univocity: Previous clues - Multiple response options effect

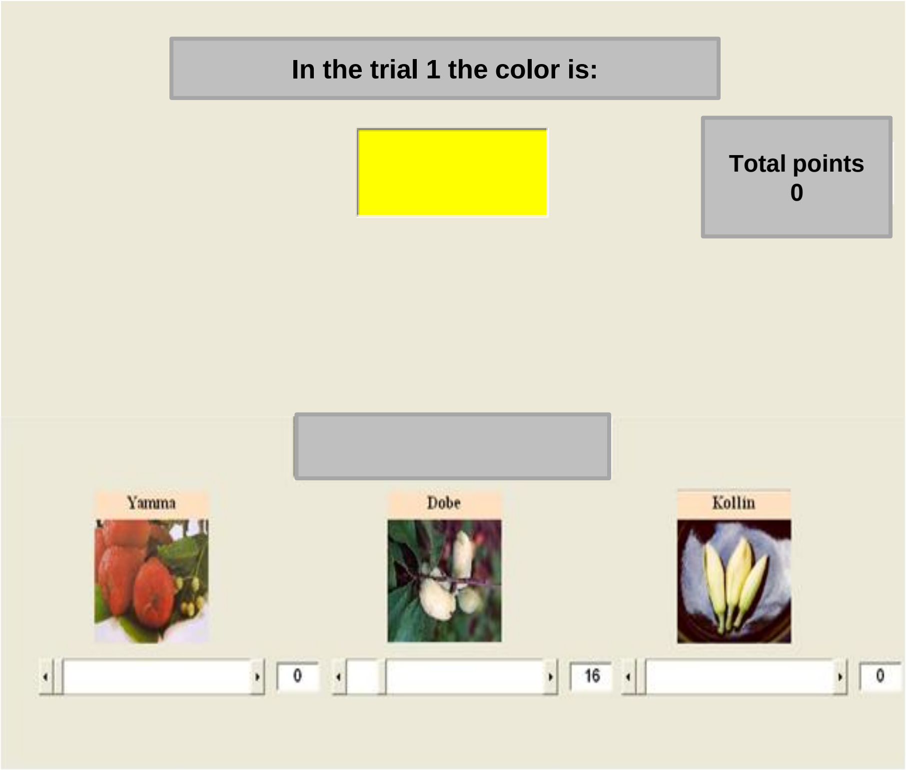


A→O1; B→O1; A?

A→O1; B→O2; A?

Outcome-cue univocity: Previous clues - Multiple response options effect

- It would be easier to assume that the cues do not share the outcome when outcomes are easily distinguishable.



Outcome-cue univocity: Previous clues - Multiple response options effect

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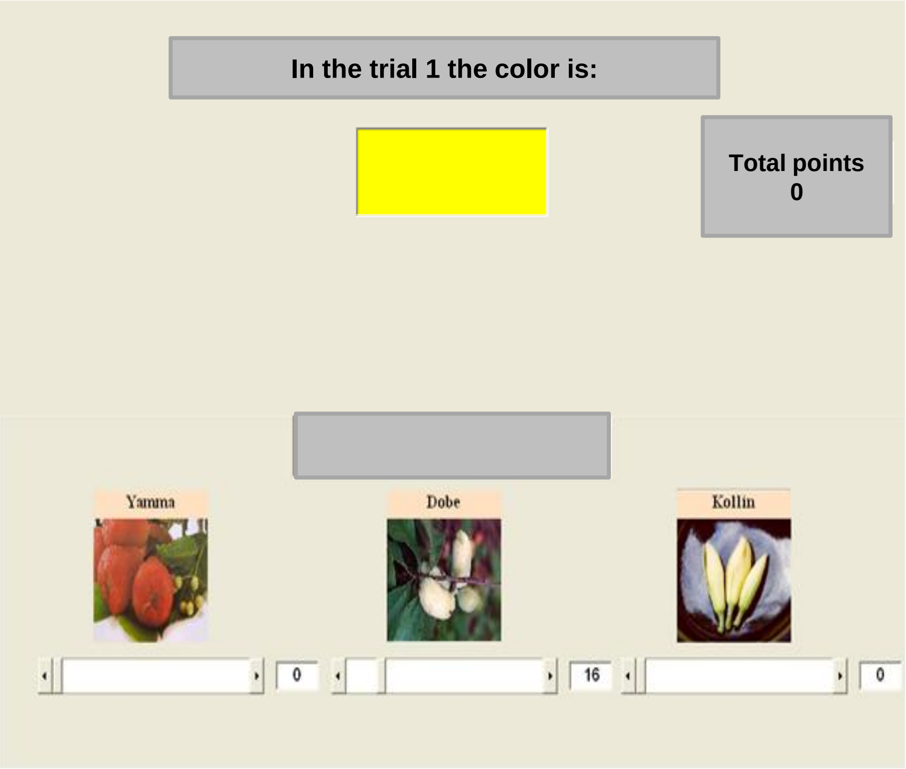
Inconsistency

↓

Context-dependency

↓

IbC



New data
- Overview

- First experiment: To test the effect of the outcome-cue univocity belief in the IbC.
- Second experiment: To test whether the top-down process engage in IbC is

New data
- Experiment 1. Univocity belief

- In the 'Biunivocity group', we introduced trials than contradicted the outcome-cue univocity belief, *in a non separable way: they could not use the context as a logic gate.*

Group	Phase 1	Phase 2	Phase 3	Test
Biunivocity group	D→O3 (x10) F→O3 (x10) C→O2 (x10)	A→O1 (x10) C→O2 (x10)	B→O1 (x10) C→O2 (x10)	A?
Univocity group	D→O3 (x20) C→O2 (x10)	A→O1 (x10) C→O2 (x10)	B→O1 (x10) C→O2 (x10)	A?

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Univocity group	D→O3 (x20) C→O2 (x10)	A→O1 (x10) C→O2 (x10)	B→O1 (x10) C→O2 (x10)	A?

It is not possible to keep the outcome-cue univocity belief

New data

- Experiment 1. Univocity belief

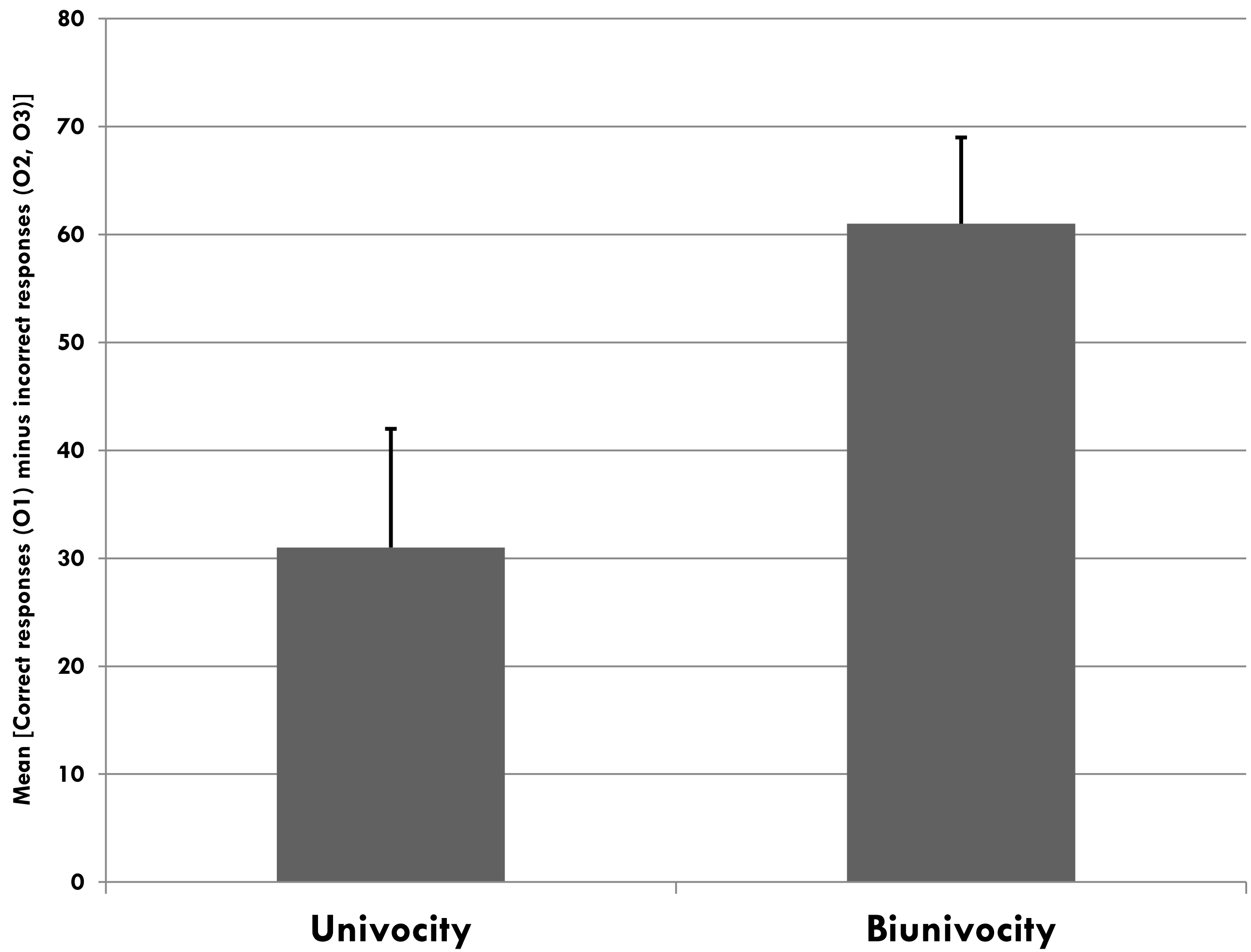
Univocity N = 32
Biunivocity N = 29

DV = O1- (O2+O3) →
t(59) = 2.1; p = 0.038

DV = O1 (correct responses)
Univocity (Mean) = 54
Biunivocity (Mean) = 69
t(59) = 1.8; p = 0.076

DV = O2
Univocity (Mean) = 21
Biunivocity (Mean) = 6
t(59) = 2.2; p = 0.034

DV = O3
t(59) = 0.5; p > 0.5



New data
- Experiment 1. Univocity belief

- The 'Univocity' treatment produce:
  - Less correct responses in the Univocity than in the Biunivocity group.
  - More incorrect responses in the Univocity then in the Biunivocity group.

IbC

Why was the differences in the O2 number of responses (and not in O3)?

Outcome-cue univocity: The O3 had a related Cue (Cue C) and this relation was valid in the test context. Thus, the only 'free' outcome in the test context was O2.

				Test		
Univocity group	D→O3 (x20)	A→O1 (x10)	B→O1 (x10)		A	
	C→O2 (x10)	C→O2 (x10)	C→O2 (x10)	O1?	O2?	O3?

New data
- Experiment 2. Propositional processes

- IbC as a consequence of
1. To assume a prior (univocity)….and
2. To change this prior (context-dependency).
- What kind of cognitive process is computing these operations?
- Propositional reasoning: A good candidate.
  - Top-down.
  - Flexible: Priors can be assumed/changed via instructions (Cobos et al., 2007) or via feedback-driven learning.

New data
- Experiment 2. Propositional processes

- Propositional reasoning: A good candidate.
  - Top-down.
  - Flexible: Priors can be assumed via instructions (Cobos et al., 2007). Also, these priors can changed via feedback-driven learning (Experiment 1).

➢ Experiment 2's aim: To directly assess the propositional processes' engagement in the IbC effect.

New data
- Experiment 2. Propositional processes

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  - IbC, second learning stage: Instructional vs. Trial-by-trial experienced.

New data
- Experiment 2. Propositional processes

- Experiment 2's aim: To directly assess the propositional processes' engagement in the IbC effect.
  - IbC, second learning stage: Instructional vs. Trial-by-trial experienced.
- *Predictions:*
  - Associative models: More IbC in the Trial-by-trial condition (associative models are silent about instructions, though).
  - Propositional theory: The same o more IbC in the Instructional condition.

New data

- Experiment 2. Propositional processes

Group		Phase 1	Phase 2	Test
Instructional	Experimental	A→O1 (x10) C→O3 (x10)	‘Hereafter, given the Cue B, respond O1’	A?
	Control	A→O1 (x10) C→O3 (x10)	‘Hereafter, given the Cue B, respond O2’	A?
Trial-by-trial	Experimental	A→O1 (x10) C→O3 (x10)	B→O1 (x10) C→O3 (x10)	A?
	Control	A→O1 (x10) C→O3 (x10)	B→O2 (x10) C→O3 (x10)	A?

New data

- Experiment 2. Propositional processes

- In addition to the usual test (Time for responding = 5 s; unwarned), we an additional test without time pressure (Time for responding = ∞) and with a previous instruction warned that a test was next.
- This test included three trials one per each Cue.

➢ This test had to be very sensitive measuring the outputs of propositional reasoning processes.

Two different measures: Test-5s and Test-∞

New data
- Experiment 2. Results Test-5s

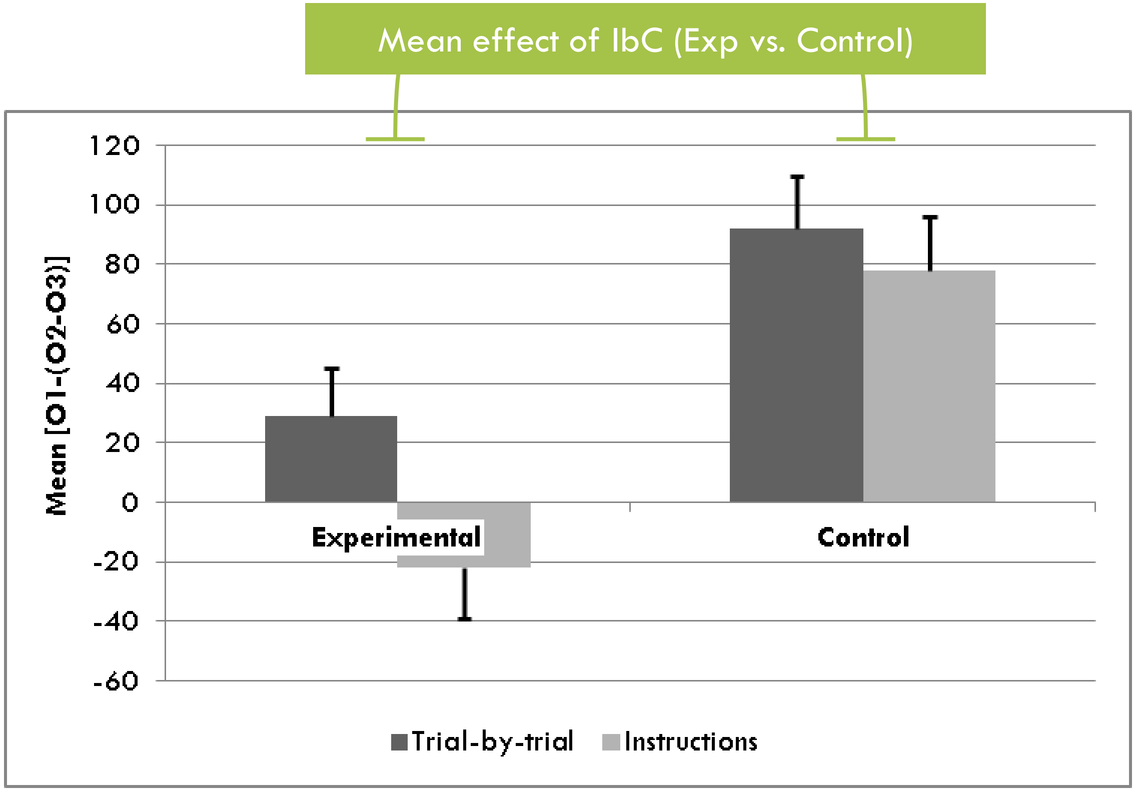
T-b-T	**Exp N = 14**	
	Con N = 12	
Instr	**Exp N = 12**	
	Con N = 11	

DV = O1- (O2+O3)

IbC: $F(1, 45) = 22$; $p<.001$* →

Instr: $F(1, 45) = 3.6$; $p=.06$

IbC * Instr: $F(1, 45) = 1$; ns.



New data

- Experiment 2. Results Test-5s

T-b-T	Exp N = 14	Con N = 12
Instr	Exp N = 12	Con N = 11

<u>DV = O1 (correct responses)</u>

IbC: F(1, 45) = 22; p<.001*

Instr: F(1, 45) = 3.6; p=.04*

IbC * Instr: F(1, 45) = 2.5; p=.12

<u>DV = O2</u>

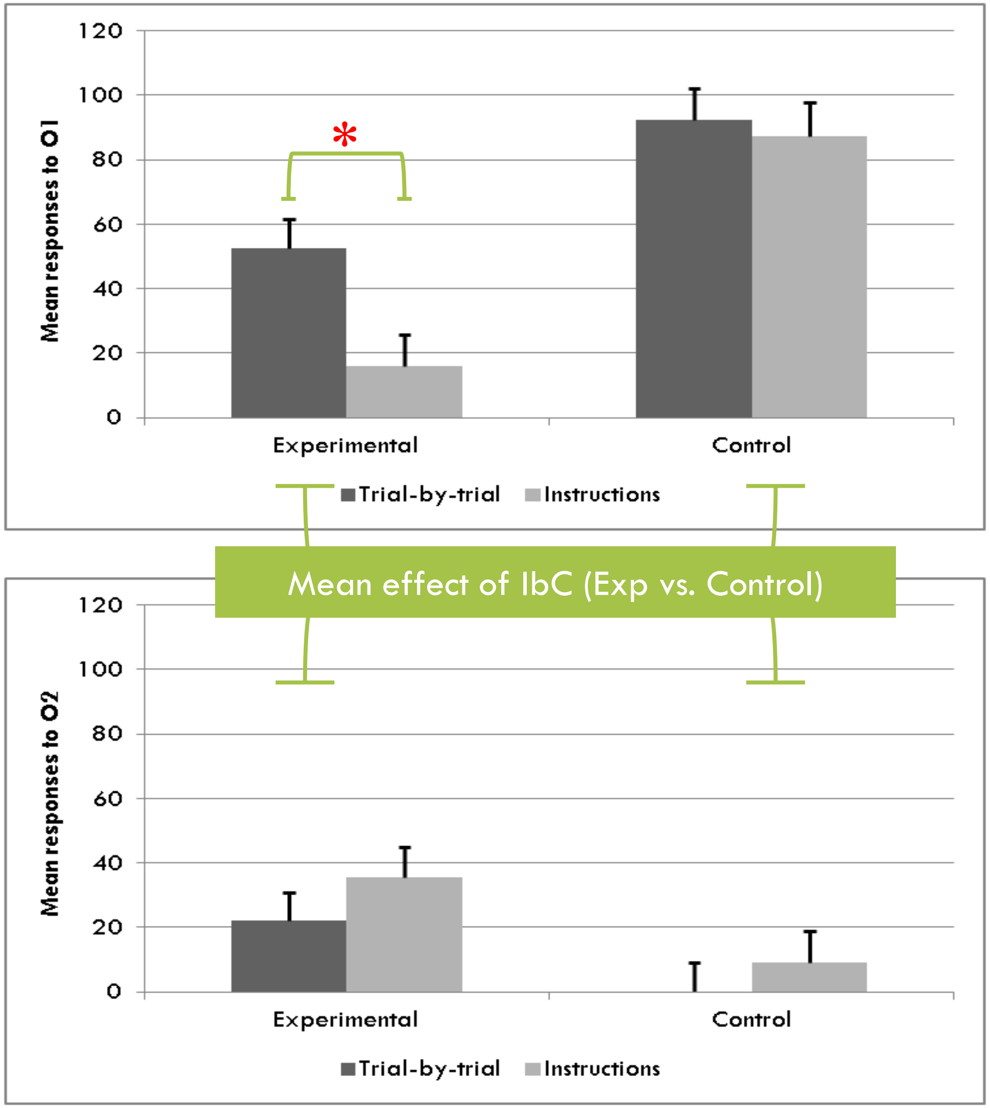
IbC: F(1, 45) = 7; p=.01*

Instr: F(1, 45) = 1.5; p=.22

IbC * Instr: F(1, 45) < 1

<u>DV = O3</u>

Nothing significant (means < 2)



New data
- Experiment 2. Results Test∞

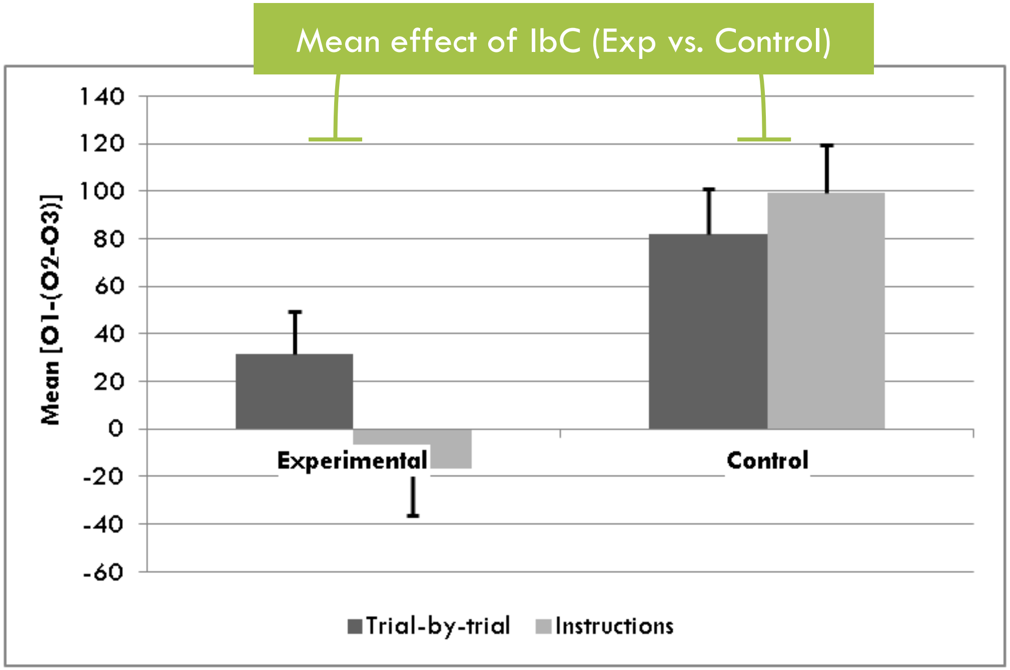
T-b-T	Exp N = 14	
	Con N = 12	
Instr	Exp N = 12	
	Con N = 11	

DV = O1- (O2+O3)

IbC: $F(1, 45) = 18$; $p<.001$* ⟶

Instr: $F(1, 45) < 1$

IbC * Instr: $F(1, 45) = 2.9$; $p=.09$



New data

- Experiment 2. Results Test∞

T-b-T	Exp N = 14
	Con N = 12
Instr	Exp N = 12
	Con N = 11

DV = O1 (correct responses)

IbC: $F(1, 45) = 30$; $p<.001$*

Instr: $F(1, 45) = 2.5$; $p=.12$

IbC * Instr: $F(1, 45) = 5.8$; $p=.02$*

DV = O2

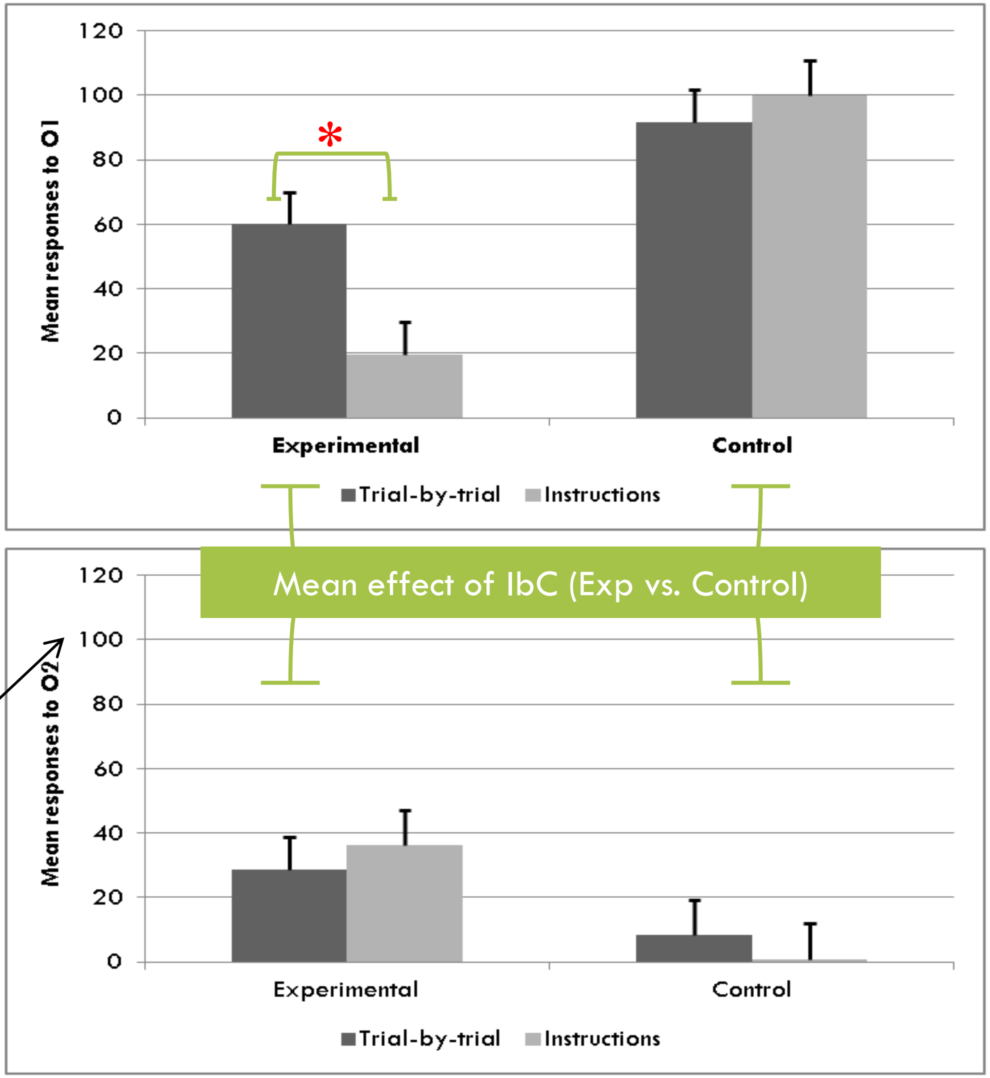
IbC: $F(1, 45) = 6.9$; $p=.01$*

Instr: $F(1, 45) < 1$

IbC * Instr: $F(1, 45) < 1$

DV = O3

Nothing significant (means < 2)



New data
- Experiment 2. Discussion

- Manipulation of the format of the interfering information (second learning stage).
- IbC in both conditions (Trial-by-trial and Instructions).
  - Additionally, a main effect of IbC in the number of responses to O2: more responses in the Experimental groups.
- The IbC was larger in the Instructions group.

➢ Compatible with a propositional account of IbC.

New data
General discussion

- **Experiment 1.** Previously to the beginning of the IbC design, we taught our participants that outcome-cue univocity was not a valid belief. As a result we obtained less interference.

➢ Top-down modulation produces the IbC effect.

- **Experiment 2.** The IbC effect was larger when the interfering information is provided via instructions than the usual trial-by-trial treatment.

➢ Top-down modulation, that is compatible with a propositional account, produces the IbC effect.

A (mini)review

- Main effects related with IbC:

1. The IbC itself.
2. Contextual effects.
3. Diagnostic causal learning effect.
4. Number of response options effect.

1.- E.g. Matute & Pineño (1998a,b).
2.- Luque et al. (2010); Matute & Pineño (1998a,b); Ortega y Matute (2000); Pineño et al. (2000); Pineño y Matute (2000).
3.- Cobos et al. (2007); Luque et al. (2008).
4.- Luque et al. (in preparation).

A (mini)review

- Main effects related with IbC:

1. The IbC itself. ☑
2. Contextual effects. ☑
3. Diagnostic causal learning effect. ☑
4. Number of response options effect. ☑

The explanation of IbC defended in this presentation could account all these effects.

A (mini)review

- Main effects related with IbC:

1. The IbC itself.
2. Contextual effects.
3. Diagnostic causal learning effect.
4. Number of response options effect.

➢ ...and the responses to O2 in the experimental group!

The explanation of IbC defended in this presentation could account all these effects.

Many thanks!



Causal Cognition Group

References

- Slide 2. Waldmann, M. R., Hagmayer, Y, & Blaisdell, A. P. (2006). Beyond the information given: Causal models in learning and reasoning. Current Directions in Psychological Science, 15 (6), 307-311.

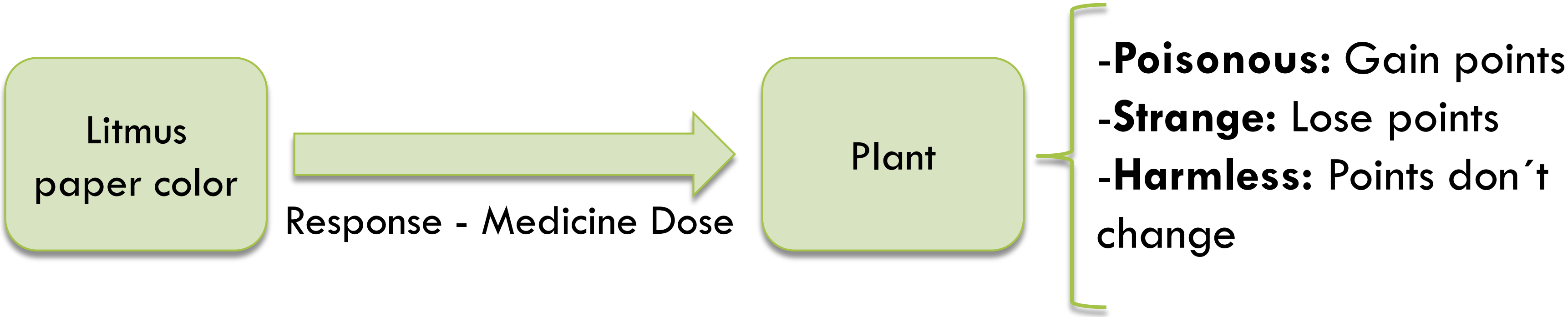
Additional slides

The plants learning task explained

Diagnostic causal learning task

Diagnostic causal learning task:
LEARNING FROM EFFECTS (cues) to CAUSES (outcomes).

- The "plants" learning task
  - Cues: Rectangules of color
  - Outcomes: Different plants

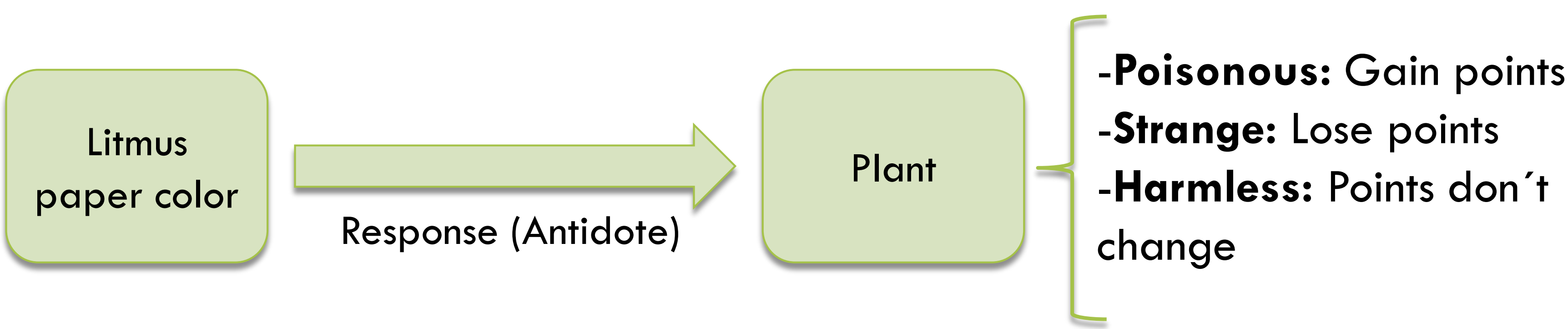


Diagnostic causal learning task

- Poisoned plants cover history

LEARNING FROM EFFECTS (cues) to CAUSES (outcomes).

  - The participants had to learn the origin of a series of poisoning after eating different plants and had to decide if an antidote should be administered.
  - Each plant caused a particular pH in the patients' saliva.
  - There were three types of plants: a **POISONOUS** plant for which an antidote was effective; a **STRANGE** plant for which the antidote was in fact poisoning and a **HARMLESS** plant for which the antidote had no effect.
  - On each trial, then, the participants had to decide the dose of antidote administered.



The "Plants" learning task

Points were the amount of antidote provided to the patient…

O1: **POISONOUS** plant for which an antidote was effective Participants gained the points.

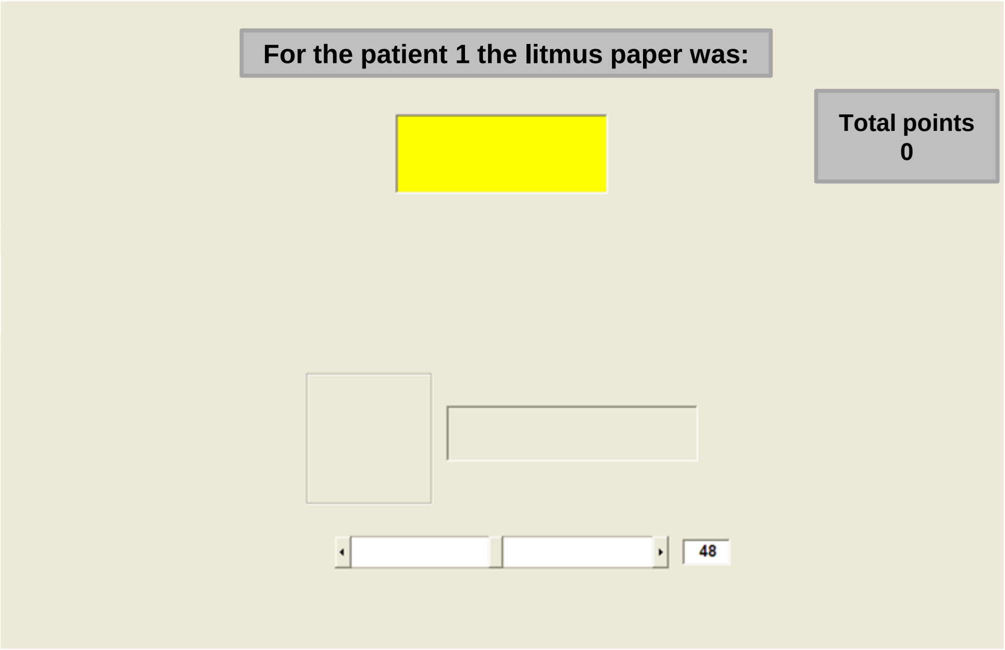
O2: **HARMLESS** plant for which the antidote had no effect. Participants didn´t gain or lose.

O3: **STRANGE** plant for which the antidote was in fact poisoning. Participants losed the points

	Phase 1	Phase2	Test
Same Outcome (Interference)	**A → O1** C → O3	**B → O1** C → O3	A → ?
Different Outcome (Control)	**A → O1** C → O3	**B → O2** C → O3	A → ?

It was expected that participants pressed the space bar as much as possible in the Test Phase

The “Plants” learning task



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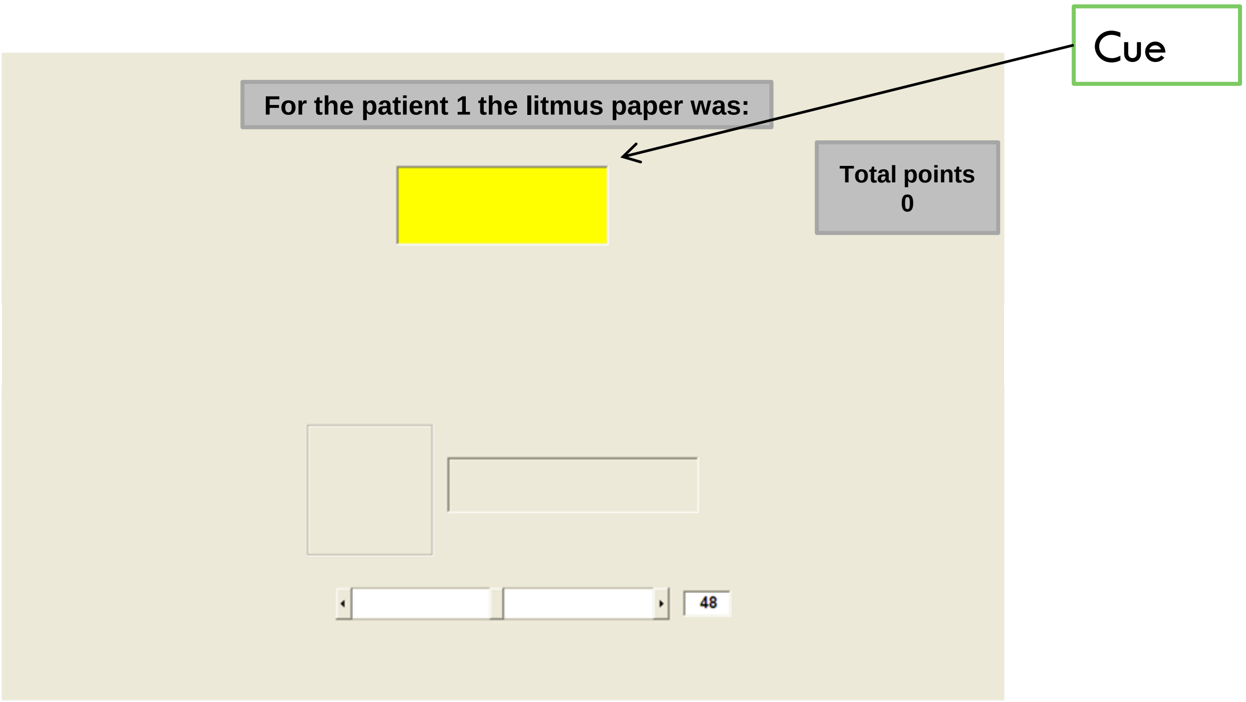
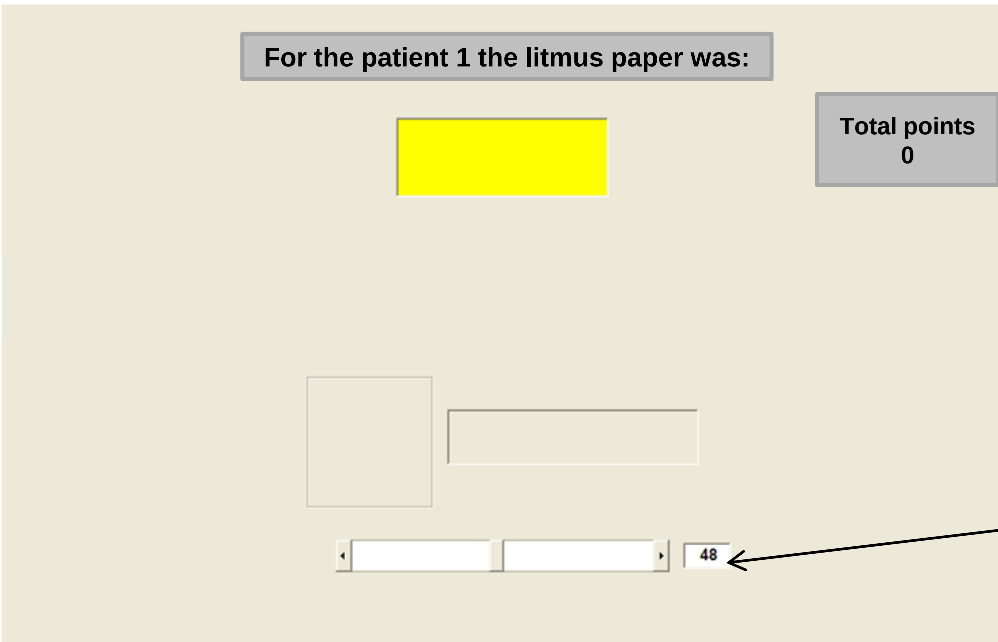
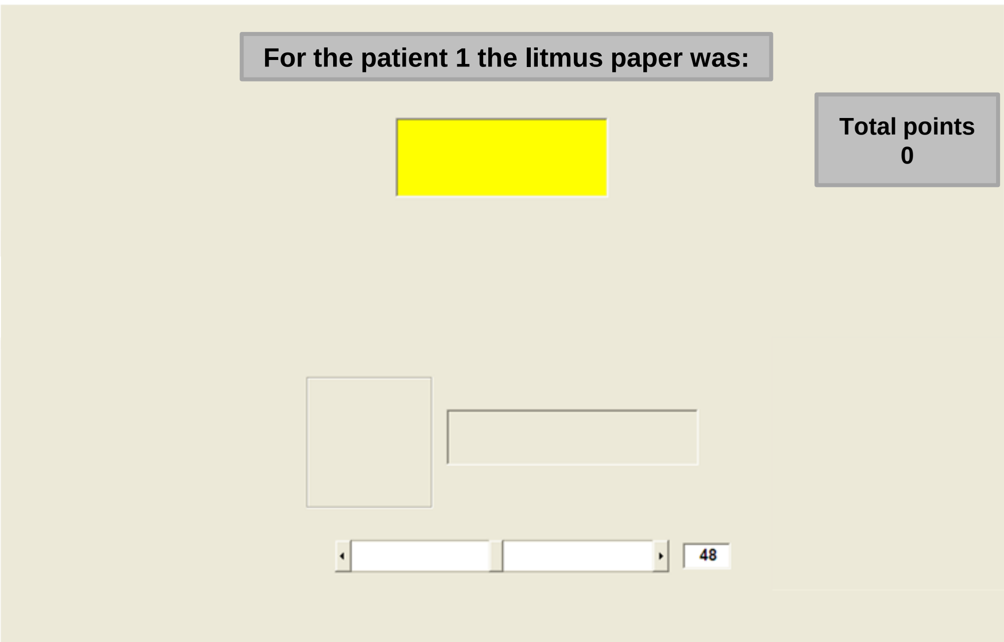


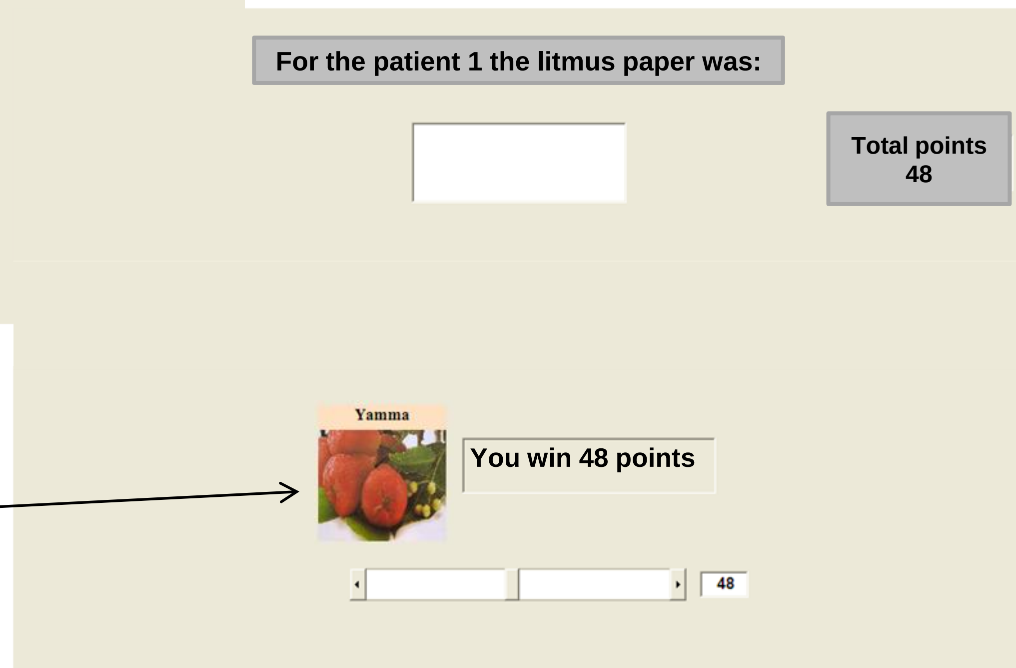
The “Plants” learning task



Number of responses by pressing the space bar e.i., The Antidote dose

The "Plants" learning task





The Outcome, in this case indicating that the participant gain all the points (poisoned plant).