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Theories of linguistic inferences: What experiments can tell us

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Linguistic inferences

- Natural languages can be modelled as logical languages with an explicit semantics (Russell 1905; Tarski 1943; Montague 1970)
- Unlike standard logics, natural languages do not just convey information by way of entailments, but rather have a rich array of inference types
- What can experiments tell us about linguistic inferences?



Experiments on linguistic inferences: Part 1

- Experimental comparisons of specific inference types
- In terms of **processing**:
 - E.g., **scalar implicatures** vs. **free choice inferences** (Chemla & Bott 2014)
 - E.g., **scalar implicatures** vs. **presuppositions** (Bill, Romoli, Schwarz 2018)
- In terms of **acquisition**
 - E.g., **scalar implicatures** versus: **presuppositions** (Bill, Romoli, Schwarz, & Crain 2016), **free choice** (Tieu, Romoli, Zhou & Crain 2016), **plurality inferences** (Renans, Romoli, Makri, Tieu, de Vries, Folli & Tsoulas 2018; Tieu, Bill, Romoli & Crain 2020), **temporal inferences** (Cremers, Kane, Tieu, Kennedy, Sudo, Folli & Romoli 2018), **homogeneity inferences** (Tieu, Križ & Chemla 2019)

Experiments on linguistic inferences: Part 2

- Experimental investigations of linguistic inferences across modalities
 - E.g., **gestures** trigger: scalar implicatures, homogeneity inferences, cosuppositional inferences, presuppositions, supplements (Tieu, Pasternak, Schlenker & Chemla 2017, 2018; Tieu, Schlenker & Chemla 2019)
 - E.g., **visual animations** trigger: scalar implicatures, homogeneity inferences, presuppositions, supplements (Tieu, Schlenker & Chemla 2019)
 - E.g., **sound effects** trigger: cosuppositional inferences (Pasternak & Tieu 2022)
 - E.g., **emoji** trigger: scalar implicatures, cosuppositional inferences, presuppositions, supplements (Pasternak & Tieu 2022; Tieu, Qiu, Puvipalan & Pasternak 2023; Tieu, Faehndrich & Puvipalan, in progress)

An abstract painting within a circular frame, featuring thick, expressive brushstrokes in various shades of green, from dark forest green to bright lime green, and some yellow and blue accents. The texture is visible, suggesting a canvas or heavy paper. The overall composition is dynamic and layered.

**Is free choice an
implicature?**

Free choice

- Mary is allowed to buy the car or the boat.
≈ Mary can choose between the two
- Mary is not allowed to buy the car or the boat.
≠ It's not true that Mary can choose between the two
≈ Mary cannot buy either

- Schematically:

$$\diamond(A \vee B) \approx \diamond A \wedge \diamond B$$

Free choice

$$\neg \diamond(A \vee B) \approx \neg \diamond A \wedge \neg \diamond B$$

Double prohibition

The empirical puzzle

- How does free choice arise in positive contexts?
- How does double prohibition arise in negative contexts?
- Two main approaches:
 - Implicature-based
 - Non-implicature-based

Implicature approach

- Free choice is an implicature (Kratzer & Shimoyama 2002; Alonso-Ovalle 2006; Fox 2007; Klinedinst 2007; Chemla 2010; Franke 2011; Chierchia 2013; Santorio & Romoli 2017; Bar-Lev 2018; Bar-Lev & Fox 2020, Del Pinal et al. 2022)
- Double prohibition is just part of the literal meaning

- a. $\diamond(A \vee B) = \diamond A \vee \diamond B$ Literal meaning
- b. $\neg \diamond(A \vee B) = \neg \diamond A \wedge \neg \diamond B$ Double prohibition
- c. $\text{EXH}[\diamond(A \vee B)] = \diamond A \wedge \diamond B$ Free choice
- d. $*\neg[\text{EXH}[\diamond(A \vee B)]] = \neg \diamond A \vee \neg \diamond B$ Negated free choice

Homogeneity approach

- **Non-implicature accounts** (e.g., Aloni 2007; Fusco 2015; Starr 2016; Willer 2017; Rothschild & Yablo 2018; Goldstein 2019; Aloni 2022)
- Free choice is just part of the literal meaning (a), and triggers a homogeneity presupposition (b)
- Negated free choice (c) plus projection of the homogeneity presupposition (b) yields double prohibition (d) (Goldstein 2018)

- | | | |
|----|--|---------------------|
| a. | $\diamond(A \vee B) = \diamond A \wedge \diamond B$ | Free choice |
| b. | $\diamond A \leftrightarrow \diamond B$ | Homogeneity |
| c. | $\neg \diamond(A \vee B) = \neg(\diamond A \wedge \diamond B)$ | Negated free choice |
| d. | $\neg \diamond A \wedge \neg \diamond B$ | Double prohibition |

Implicature approach

- **Prediction:** difference in status of positive and negative
- **Context:** Mary is only allowed to buy the boat.
 - a. Mary is allowed to buy the car or the boat.
↷ Mary can choose between the two *Positive*
(False implicature)
 - b. Mary is not allowed to buy the car or the boat.
↷ Mary cannot buy either one *Negative*
(Plainly false)

Homogeneity approach

- **Prediction:** no difference in status of positive and negative
- **Context:** Mary is only allowed to buy the boat.
 - a. Mary is allowed to buy the car or the boat. *Positive*
~ Mary can buy one iff she can buy the other (Presupposition failure)
 - b. Mary is not allowed to buy the car or the boat. *Negative*
~ Mary can buy one iff she can buy the other (Presupposition failure)

Predictions, summarized

	Implicature	Homogeneity
Positive	Implicature violation	Presupposition failure
Negative	Falsity	Presupposition failure

Three experiments (Tieu, Bill, Romoli 2023)

- Compared free choice to scalar implicature baselines
- Exp. 1: FC vs. exclusivity implicature of plain disjunction
- Exp. 2: FC vs. implicature of modal *is allowed to*
- Exp. 3: FC ‘any’ vs. implicature of ‘some’

Methods (across 3 experiments)

- Experimental set-up: a series of characters go to the store
- In the FC conditions, there are rules about what each character is allowed or not allowed to buy
- Puppet makes a statement about:
 - What the character is allowed/not allowed to buy (FC disjunction, modal, FC 'any')
 - What the character does/does not buy ('or', 'some')

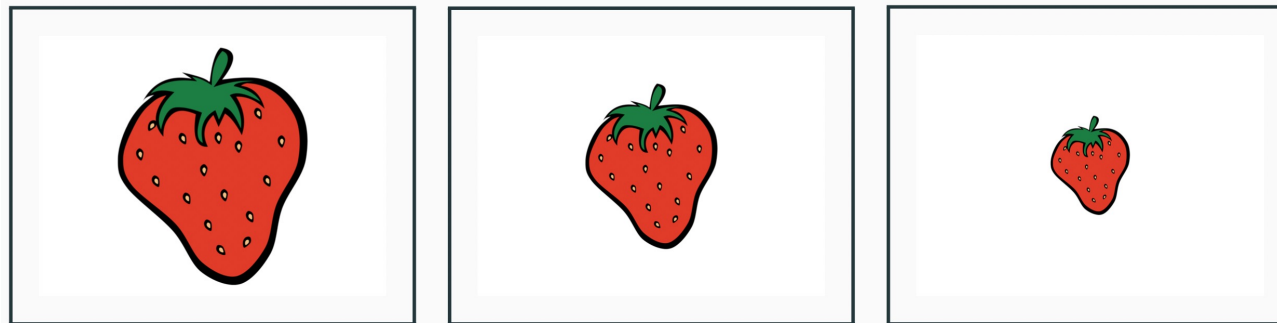


Example of instructions

- “...In each story, there is a character who is shopping at the store. Mom has set some rules on what the character is allowed or not allowed to buy. A puppet named Raffie will try to tell us what the rules are. Your job is to decide if Raffie is right or wrong.”

Ternary judgment task (Katsos & Bishop 2011)

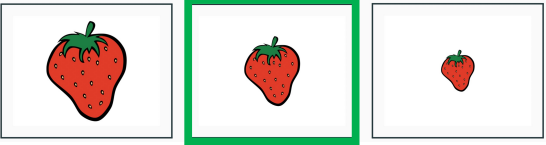
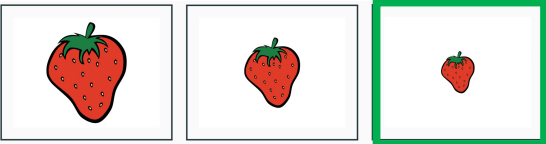
- Read a puppet's guess/description before seeing a picture of the outcome
- Then choose the appropriate reward given the statement

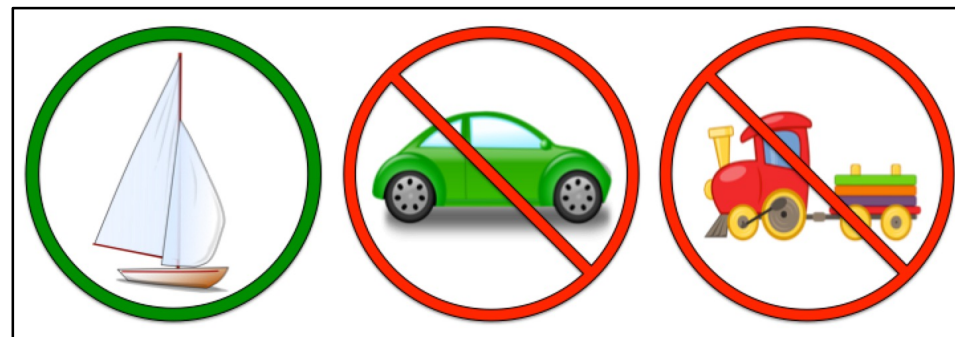


The implicature baselines


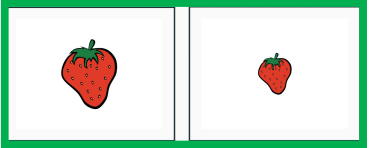
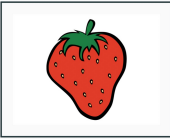
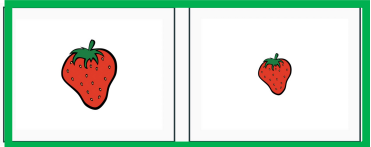
- **Exp. 1: Exclusivity inference of ‘or’**
 - Mary bought the car or the boat. \sim *Mary didn't buy both the car and the boat*
 - Mary didn't buy the car or the boat.
- **Exp. 2: Scalar inference of ‘is allowed to’**
 - Mary is allowed to buy the boat. \sim *Mary isn't required to buy the boat*
 - Mary is not allowed to buy the boat.
- **Exp. 3: Scalar inference of ‘some’**
 - Mary bought some of the items. \sim *Mary didn't buy all of the items*
 - Mary didn't buy any of the items.

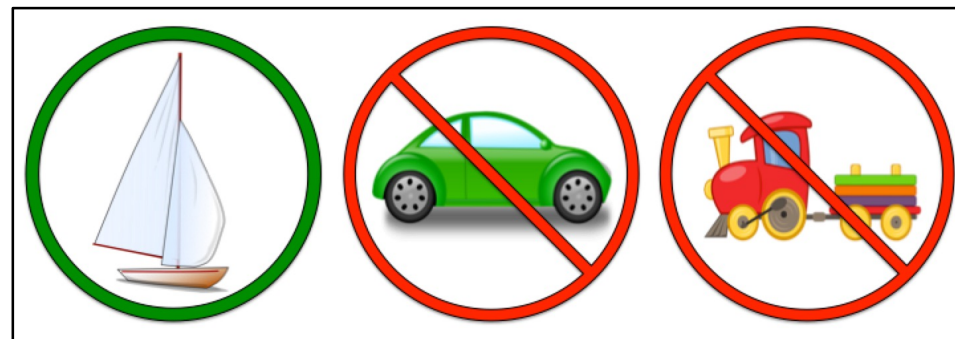
Exp.1: Predictions of implicature account for free choice

Polarity	Sentence	Predicted response
Positive	Mary is allowed to buy the car or the boat.	
Negative	Mary is not allowed to buy the car or the boat.	

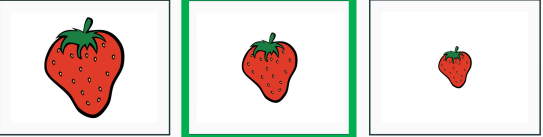



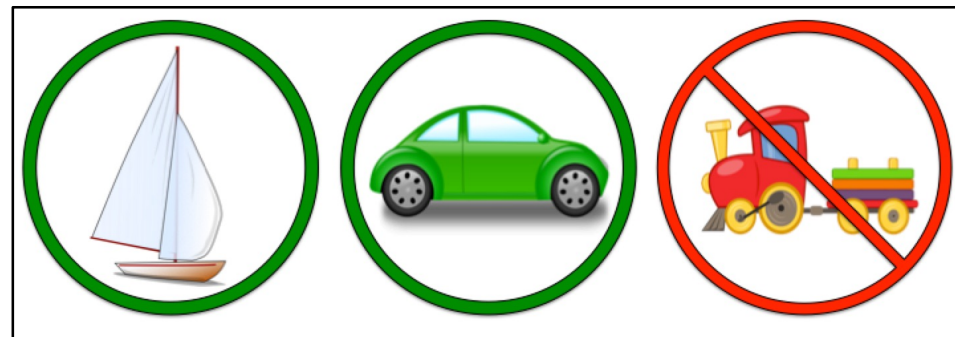
Exp.1: Predictions of homogeneity account for FC

Polarity	Sentence	Predicted response
Positive	Mary is allowed to buy the car or the boat.	 
Negative	Mary is not allowed to buy the car or the boat.	 

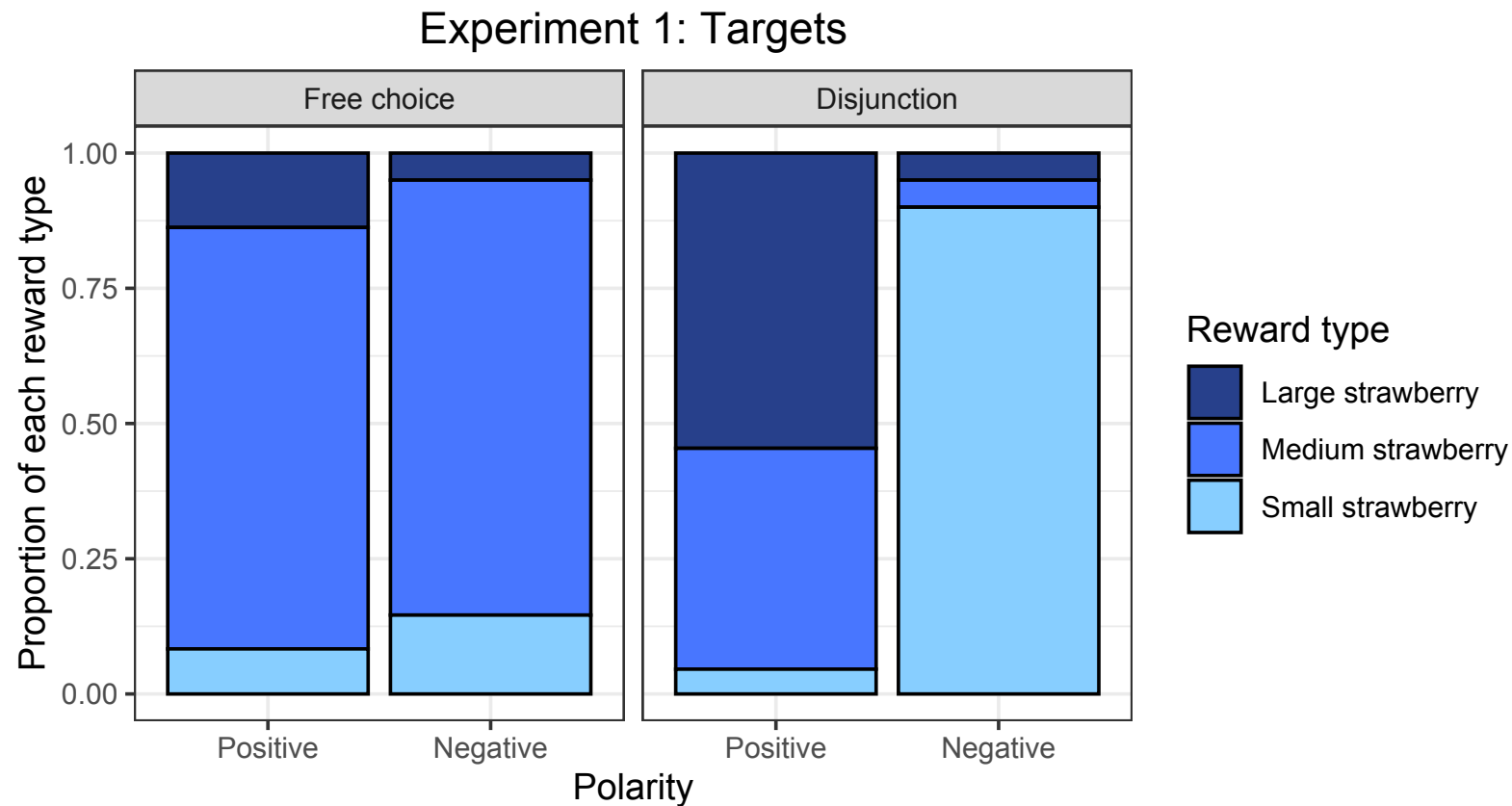


Exp.1: Predictions of implicature account for 'or'

Polarity	Sentence	Predicted response
Positive	Mary will buy the car or the boat.	
Negative	Mary will not buy the car or the boat.	



Exp.1: Results



- 120 participants (60 FC, 60 OR)
- Significant interaction between Inference type and Polarity ($\chi^2(1)=92$, $p<.001$)
- Interaction poses a problem for the implicature approach

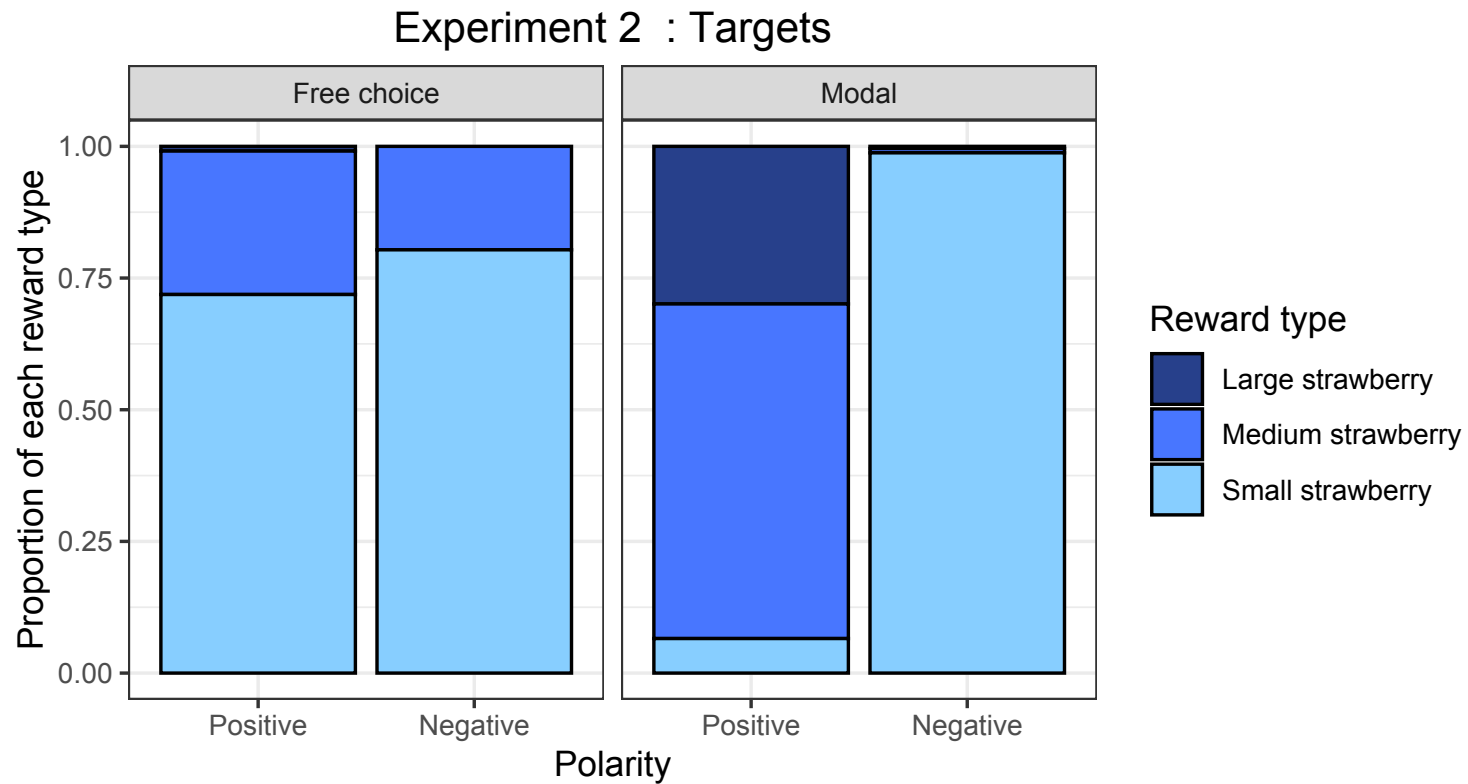
Exp.2: Predictions for modal

(Predictions for FC same as in Exp.1)



	Sentence	Predicted response
Positive	Mary is allowed to buy the boat.	Three strawberry icons are shown in separate boxes. The middle strawberry is enclosed in a green square border, while the other two are in plain white boxes.
Negative	Mary is not allowed to buy the boat.	Three strawberry icons are shown in separate boxes. The rightmost strawberry is enclosed in a green square border, while the other two are in plain white boxes.

Exp.2: Results



- FC n=56, Modal n=61
- Significant interaction between Inference type and **Polarity** ($\chi^2(1)=97, p<.001$)
- Interaction poses a challenge for the implicature approach

Exp.3: Free choice ‘any’

- Same logic from FC disjunction extended to FC ‘any’ (Aloni 2007; Chierchia 2013)

a. Mary is allowed to buy any of the items.

↗ *Mary can freely choose amongst all the items*

Free choice

b. Mary is not allowed to buy any of the items.

Negated literal meaning

c. Mary is allowed to buy some of the items.

↗ *Mary is not allowed to buy all of the items*

Implicature

d. Mary is not allowed to buy any of the items.

Negated literal meaning

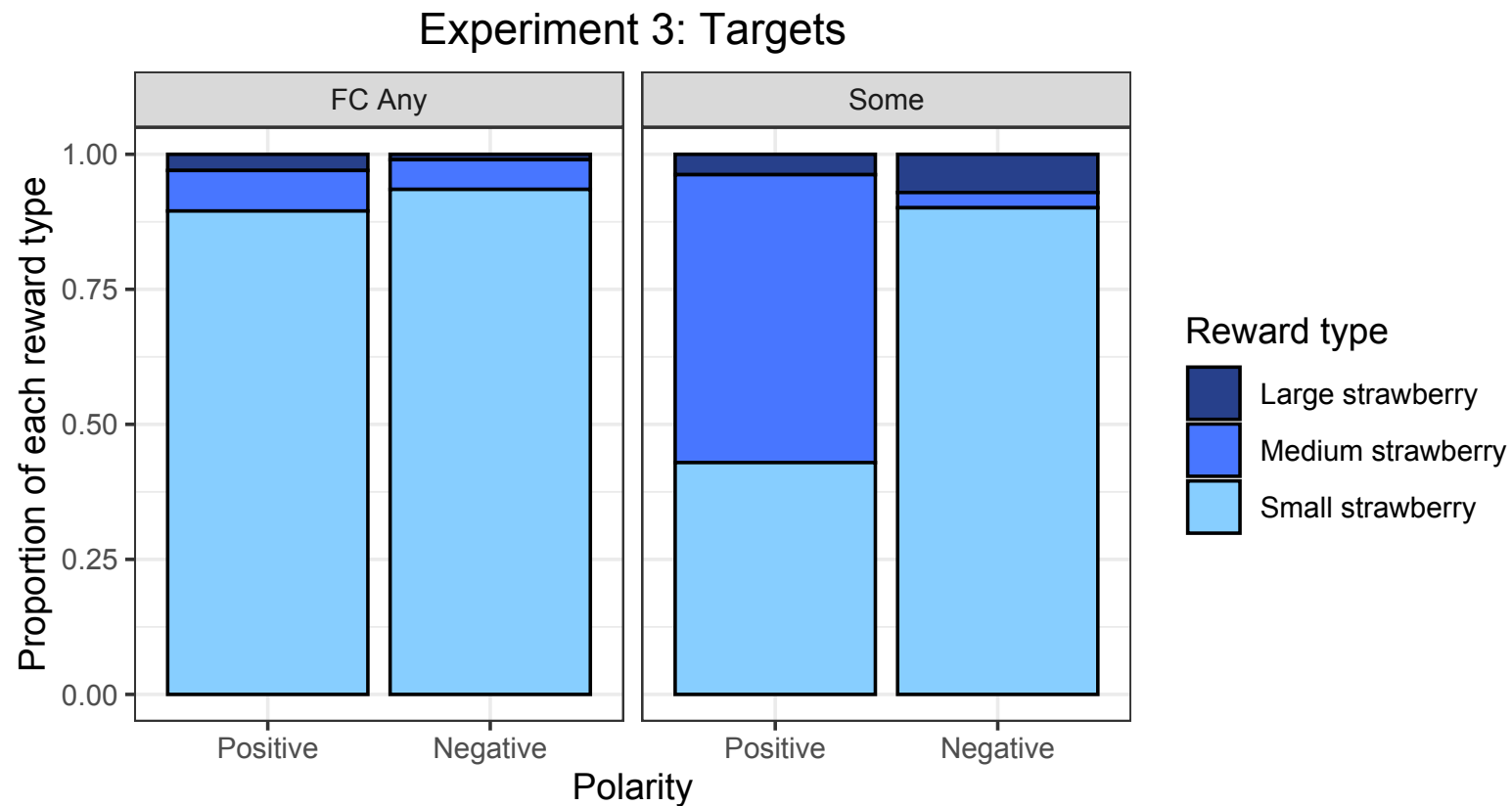
Exp.3: Predictions for 'some'

(Predictions for FC same as in Exps.1-2)



	Sentence	Predicted response
Positive	Mary bought some of the items.	
Negative	Mary didn't buy any of the items.	

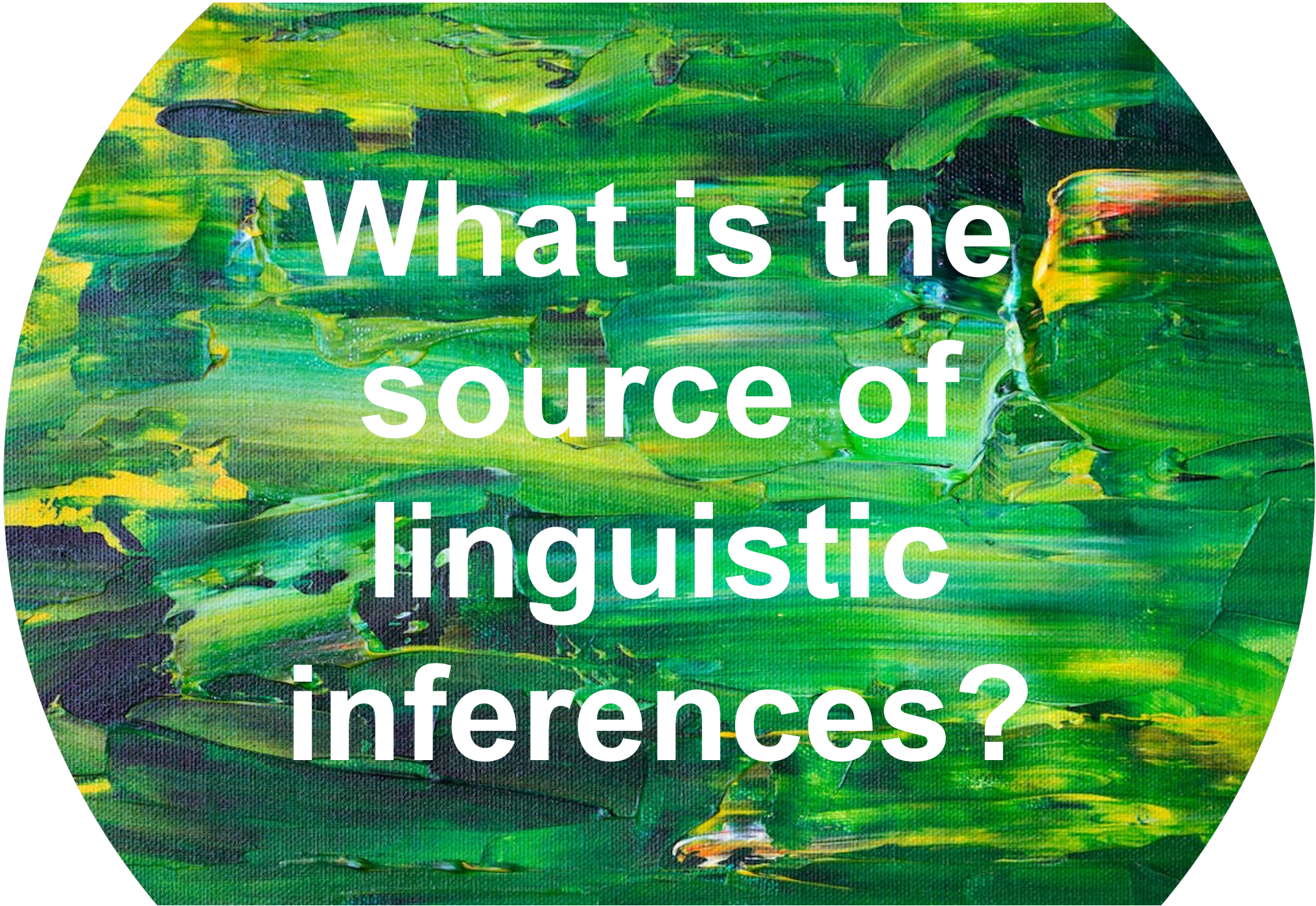
Exp.3: Results



- FC n=50, Some n=53
- Significant interaction between Inference type and Polarity poses a challenge for the implicature approach

Summary

- Implicature and non-implicature/homogeneity accounts of free choice make divergent predictions about the status of positive and negative FC sentences
- Ternary judgment task revealed asymmetries between free choice and 3 different implicature baselines
- Taken together, the experiments provide a challenge for the implicature approach

An abstract painting with a circular frame, featuring thick, expressive brushstrokes in various shades of green, yellow, and dark blue. The composition is layered and textured, with some areas appearing more saturated than others. The overall effect is one of dynamic energy and depth.

**What is the
source of
linguistic
inferences?**

Source of linguistic inferences

- Usually thought to be specific to language, possibly lexical in nature
- What if the inferential typology can be replicated – with unfamiliar gestures, animations, sound effects, emoji – in place of words?



Experimental evidence

	Gestures	Visual animations	Emoji	Sound effects
Scalar implicatures	✓	✓	✓	(Not tested)
Presuppositions	✓	✓	✓	(Not tested)
Cosuppositions	✓	(Not tested)	✓	✓
Homogeneity	✓	✓	(Not tested)	(Not tested)
Supplements	✓	✓	✓	(Not tested)

Method: Embedded iconic depictions

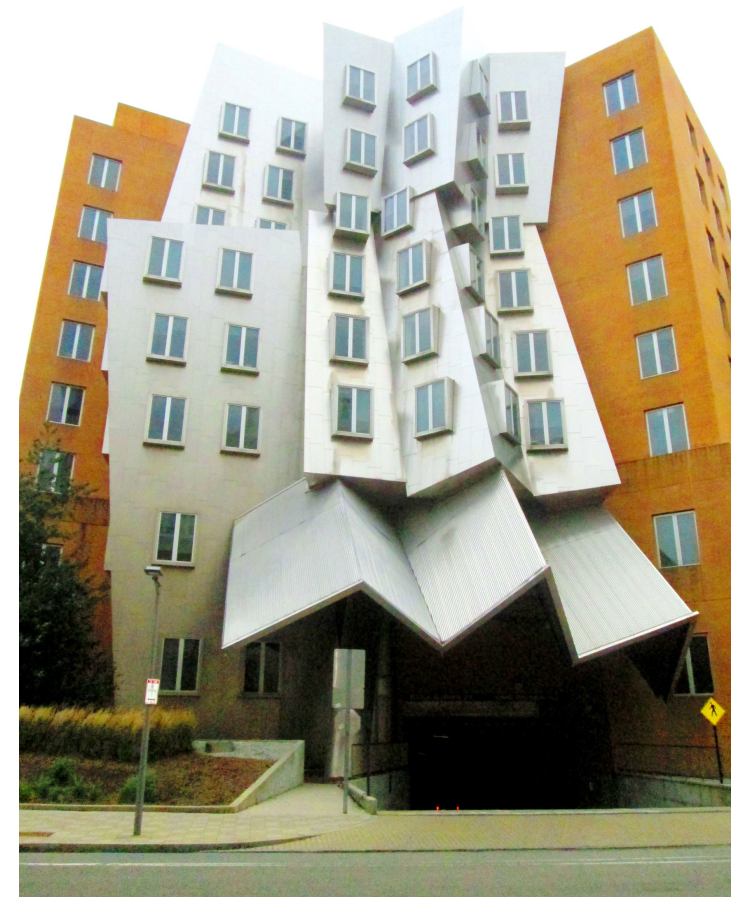
- Semantic typology of gestures depends on whether gestural depictions co-occur with, follow, or replace words (Ebert & Ebert 2014; Schlenker 2018, 2019)
- **Pro-speech gestures** fully replace a part of speech (Schlenker 2018) (referred to by Clark 2016 as an “embedded depiction”), e.g., “Jane will TURN-WHEEL”
- **Pro-speech animations:** animations replace part of the written text
- **Pro-text emoji** fully replace a word or phrase in the written text (Pierini 2021)
- Pro-speech gestures (Barnes & Ebert 2023; Schlenker 2023) and pro-text emoji (Pierini 2021) are argued to make an at-issue contribution



Scalar implicatures

Scalar implicatures

- Scalar implicatures typically arise when an utterance competes with a more informative alternative, which is then understood to be false (Grice 1975; Horn 1972; Chierchia, Fox & Spector 2012)
- a. Some linguists attended NELS.
c. *Alternative*: All linguists attended NELS.
d. *Inference*: Not all linguists attended NELS.
- Once alternatives are provided, implicatures follow a productive algorithm
- But how are alternatives generated?



Alternative generation

- Katzir (2007), Katzir & Fox (2011): alternatives are provided by the **context** or by **syntactic manipulations** that replace/simplify parts of the target clause
- By structural complexity/replacement:
 - a. The linguists ate. \nRightarrow *The linguists didn't eat a lot.*
 - b. The linguists didn't eat a lot. \Rightarrow *The linguists ate.*
- By contextual salience (adapted from Schlenker 2019) :
 - c. A: What did the linguists do – did they eat, did they eat a lot, or did they drink?
B: The linguists ate. \Rightarrow *The linguists didn't eat a lot.*

Amended definition of alternatives


(Schlenker, Lamberton & Lamberton 2023)

- a. S' is an alternative of S if S' can be derived from S by successive replacements of sub-constituents of S with elements of the substitution source for S in a context C , $SS(S,C)$.
 - b. $SS(X,C)$, the substitution source for X in context C , is the union of the following sets:
 - i. the lexicon
 - ii. the sub-constituents of X
 - iii. the set of salient constituents in C
 - iv. **iconic subparts of iconic elements of X**
-
- Katzir & Fox (2011)
- Schlenker et al.'s addition

Gestures/animations: Methods

- **Participants (AMT):** Gesture n=103; Animation n=99
- **Procedure:** Inferential judgment task (Tieu et al. 2017, 2018)
- All experimental materials and data available at: <https://osf.io/q9zyf>

Watch the following video:



The video player shows a central starburst animation on a grey background. The video title is "SI 1 Indirect StrongTarget F". The player controls show a play button, a volume icon, and a progress bar at 0:00 / 0:23. The YouTube logo and a full-screen icon are visible in the bottom right corner of the player.

To what degree do you infer the following?

This week, Jenny will not punch at all.

Implicatures from gestures

- **Context:** John is training to be a stunt driver. Yesterday, at the first mile marker, he was taught to TURN-WHEEL-COMpletely.
- **Target premise:** Today, at the next mile marker, he will TURN-WHEEL.
- **Target inference:** John will turn the wheel, but not completely.
- **Control premise:** Today, at the next mile marker, he will TURN-WHEEL-COMpletely.
- **Control inference:** John will turn the wheel completely.



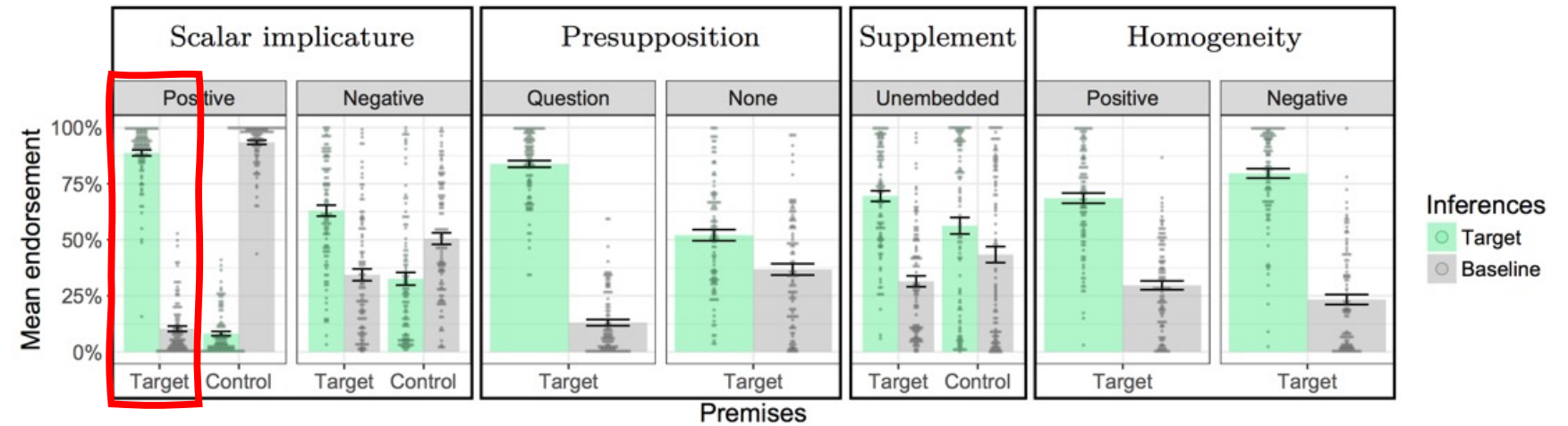
Implicatures from animations

- **Context:** John the Alien has been training on the punching bag at the gym. // At last week's workout, John had a lot of energy. He was able to. . . // FLASH-MANY.
- **Target premise:** This week, John will. . . // FLASH-ONEpop.
- **Target inference:** This week, John will punch, but not a lot.
- **Control premise:** This week, John will. . . // FLASH-MANY.
- **Baseline inference:** This week, John will punch a lot.

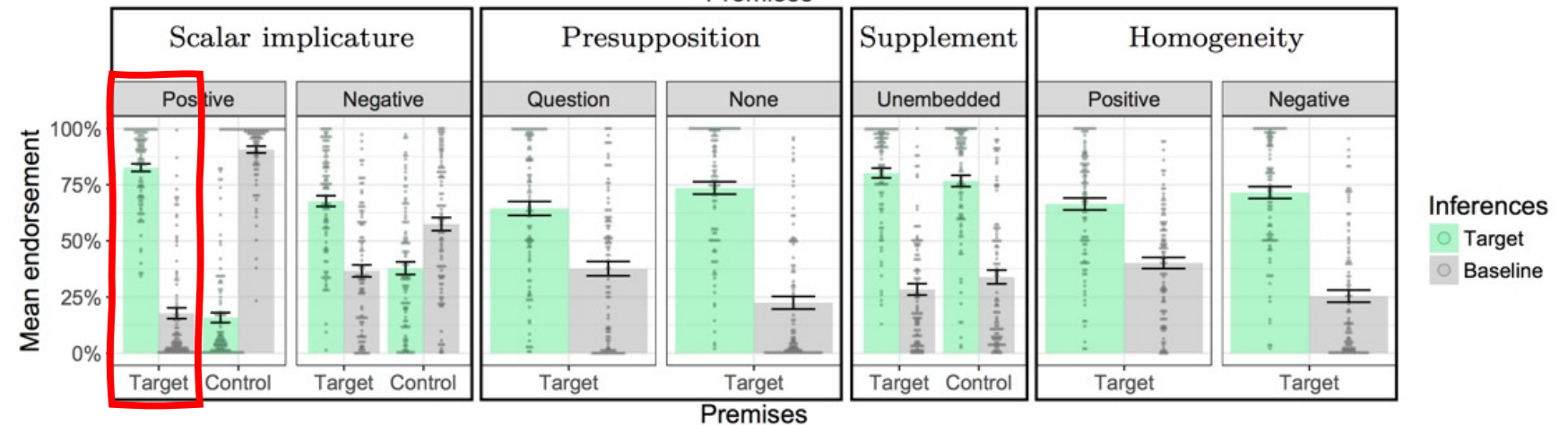
John the Alien has been training on the punching bag at the gym.

Results

Gesture
Experiment



Animation
Experiment



- Stronger endorsement of target (X-not-X+) inferences in response to target (X) premises compared to baseline inferences

Implicatures from emoji: Methods

- **Participants (Prolific):** 60 native speakers of English (30 'with alternatives', 30 'no alternatives')
- **Procedure:** Inferential judgment task
- Presented test items as Question-Answer pairs (in order to provide alternatives in context)
- Manipulated presence/absence of alternatives (between subjects)

Example

‘No alternatives’ condition

Target (X)

QUESTION:
What will Luke do?

ANSWER:
He will carve 🍂

Control (X+)

QUESTION:
What will Luke do?

ANSWER:
He will carve 🍂🍂🍂🍂🍂🍂

‘With alternatives’ condition

Target (X)

QUESTION:
What will Luke do? Will he carve 🍂, 🍂🍂🍂🍂🍂🍂, or 🥥?

ANSWER:
He will carve 🍂

Control (X+)

QUESTION:
What will Luke do? Will he carve 🍂, 🍂🍂🍂🍂🍂🍂, or 🥥?

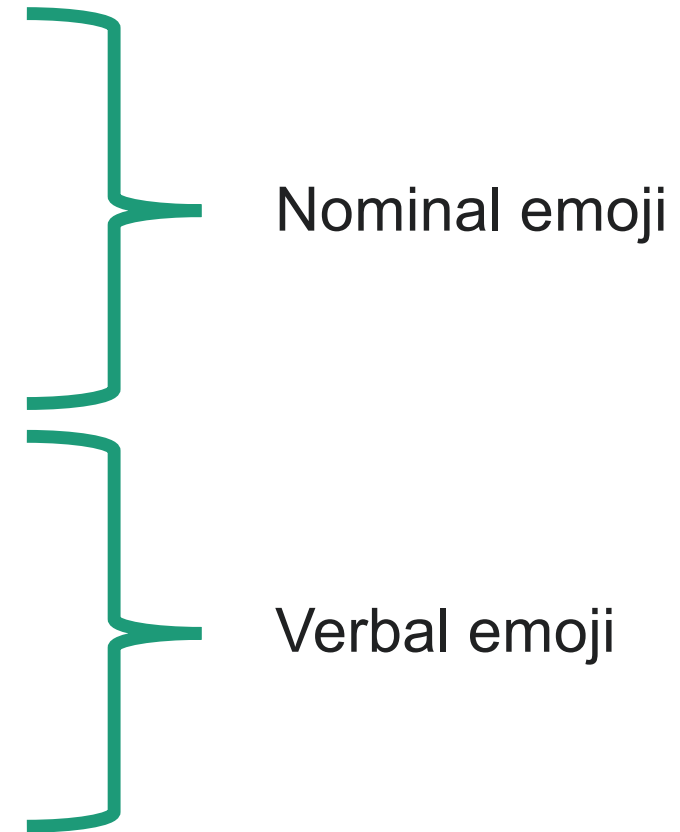
ANSWER:
He will carve 🍂🍂🍂🍂🍂🍂

X-not-X+ inference: *He will carve pumpkins, but not a lot of pumpkins.*

X+ inference: *He will carve a lot of pumpkins.*

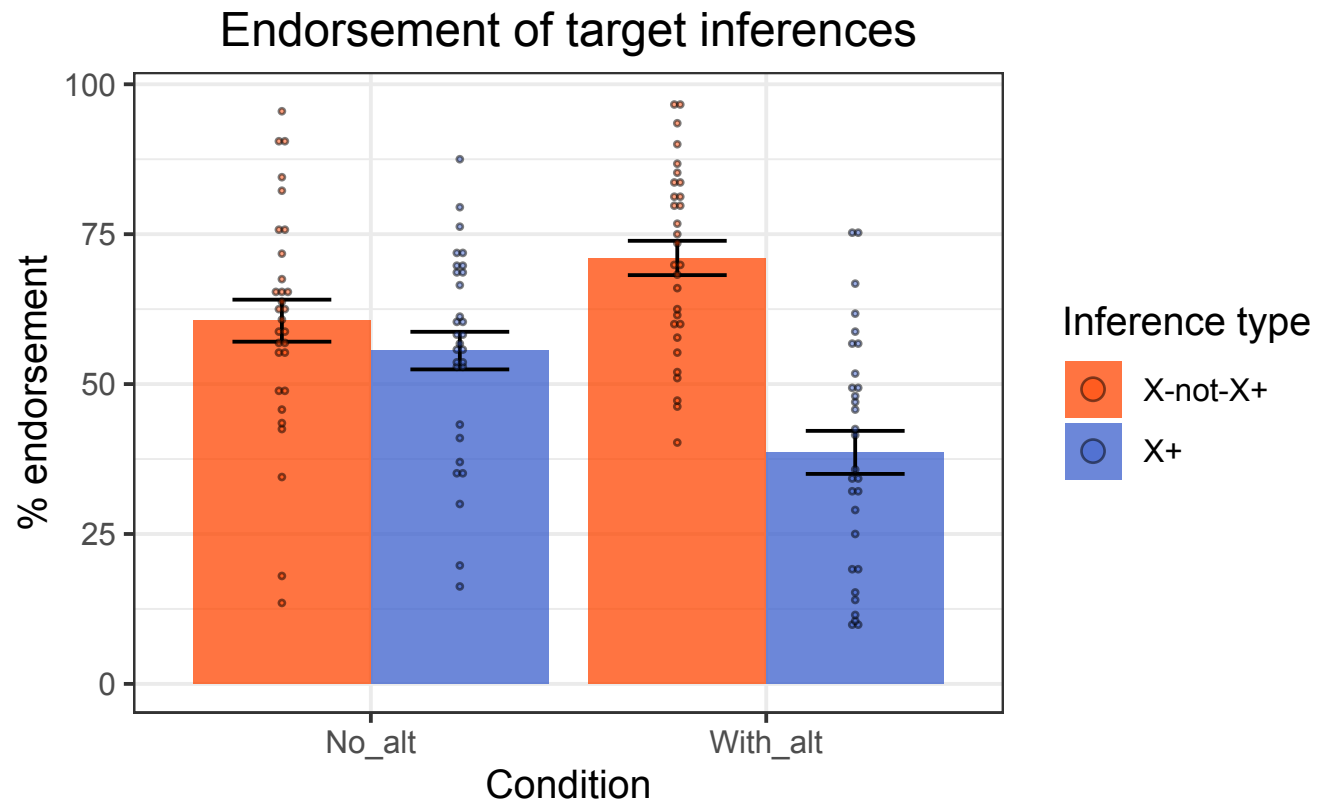
Emojis tested

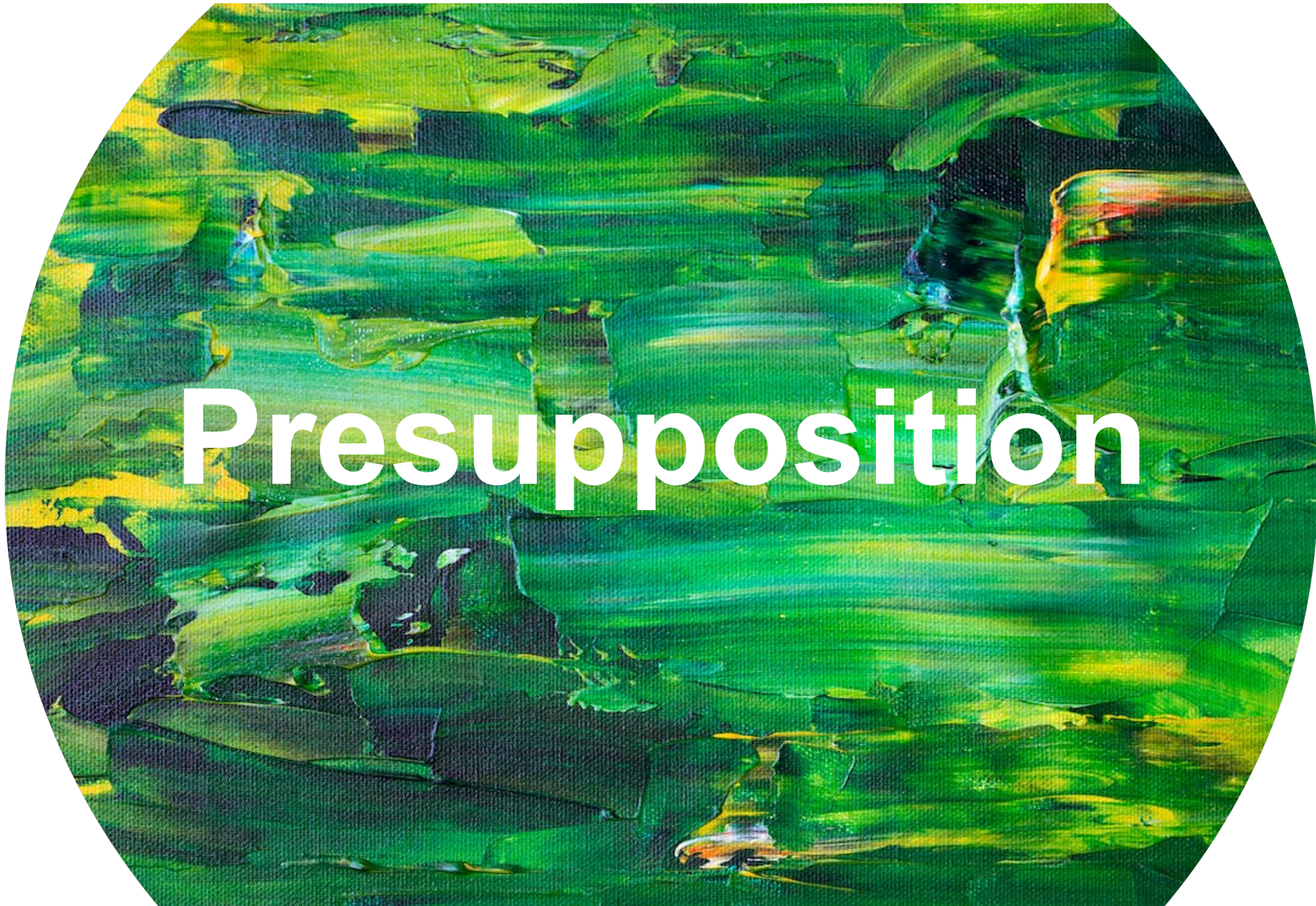
- She will adopt 🐶 / She will adopt 🐶🐶🐶🐶🐶🐶
- She will catch 🐟 / She will catch 🐟🐟🐟🐟🐟
- He will gather 🪵 / He will gather 🪵🪵🪵🪵🪵
- He will carve 🎃 / He will carve 🎃🎃🎃🎃🎃
- She will 😭 / She will 😭😭😭😭😭
- He will 🙌 / He will 🙌🙌🙌🙌🙌
- She will ✍️ / She will ✍️✍️✍️✍️✍️
- He will 🙏 / He will 🙏🙏🙏🙏🙏



Results

- Significant interaction between presence/absence of alternatives and inference type (target vs. control)
- Only in the presence of alternatives do people endorse target implicatures more than baseline inferences





Presupposition

Presuppositions

- Characterized by two properties: (i) normally taken for granted in the conversation; (ii) inherited by sentences across a variety of logical operators including negation
- a. Mary stopped smoking.
b. Mary did not stop smoking.
c. Did Mary stop smoking?
 → *Mary smoked before*
- d. None of my students stopped smoking.
 → *Each of my students smoked before*

Presuppositions

- Presuppositions are generally thought to be language-specific, and encoded in the meanings of words
- Compared to scalar implicatures, it would perhaps be more surprising to see presuppositions triggered by non-words
- Would require a general enough triggering algorithm (see Schlenker 2021)
- Experimental evidence of presuppositions triggered by: **gestures, visual animations, emojis**

Gestures/animations: Methods

- **Participants (AMT):** 104 native speakers of English (gesture n=103, animation n=99)
- **Procedure:** Inferential judgment task
- Tested 3 pro-speech gestures and 3 pro-text visual animations – each in a question and under the negative quantifier “none”
- Gestures and visual animations that could convey two kinds of information, one of which could intuitively be taken to be a precondition of the other
 - e.g., “x will REMOVE-GLASSES” presupposes that x is wearing glasses and asserts that x will remove them

Gesture in a question

- **Context:** During an experimental session, Valerie watches her graduate students use microscopes and says to the laboratory assistant standing next to her:
- **Target premise:** For the next phase of the experiment, will our visiting student REMOVE-GLASSES?
- **Target inference:** Valerie's visiting student currently has glasses on.
- **Baseline inference:** Valerie's visiting student does not currently have glasses on.



Animation in a question

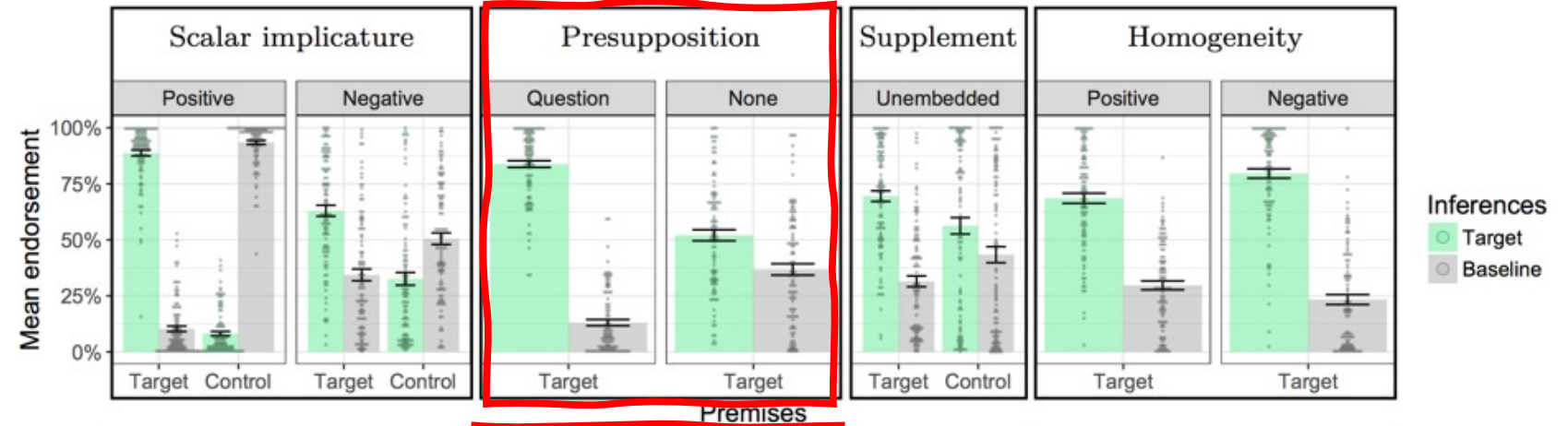
- **Context:** Aliens are green. But when they are in a meditative state, their antennae are blue. // There is a meditation session in progress on the first floor of a business firm. // Bill is watching the union representative and says: // “Will the union representative’s antenna...” // [animation] *bar is green at first, then slowly whole bar is blue*
- **Target inference:** The union representative is not currently in a meditative state.
- **Control inference:** The union representative is currently in a meditative state.

Aliens are green.

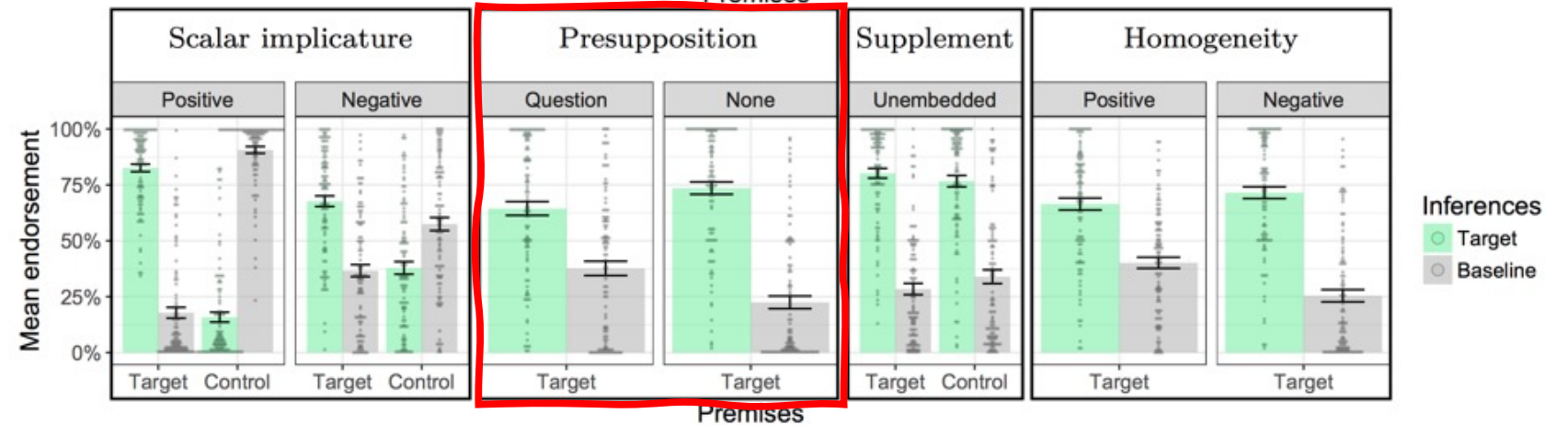
But when they are in a meditative state, their antennae are blue.

Results

Gesture
Experiment




Animation
Experiment



- Significant effect of inference type, with greater endorsement of target presuppositions than baseline inferences
- Consistent with participants deriving the target presuppositions

Emoji: Methods

- **Participants (Prolific):** 60 adult native speakers of English
- **Procedure:** Inferential judgment task
- **Materials:** 9 change-of-state emoji x 2 inferences (target vs. control) x 5 linguistic environments = 90 total sentences

Will the plane  ?

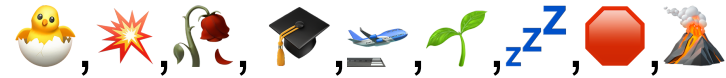
To what degree does the sentence suggest the following?

The plane has not taken off yet.

>>

Change-of-state presuppositions

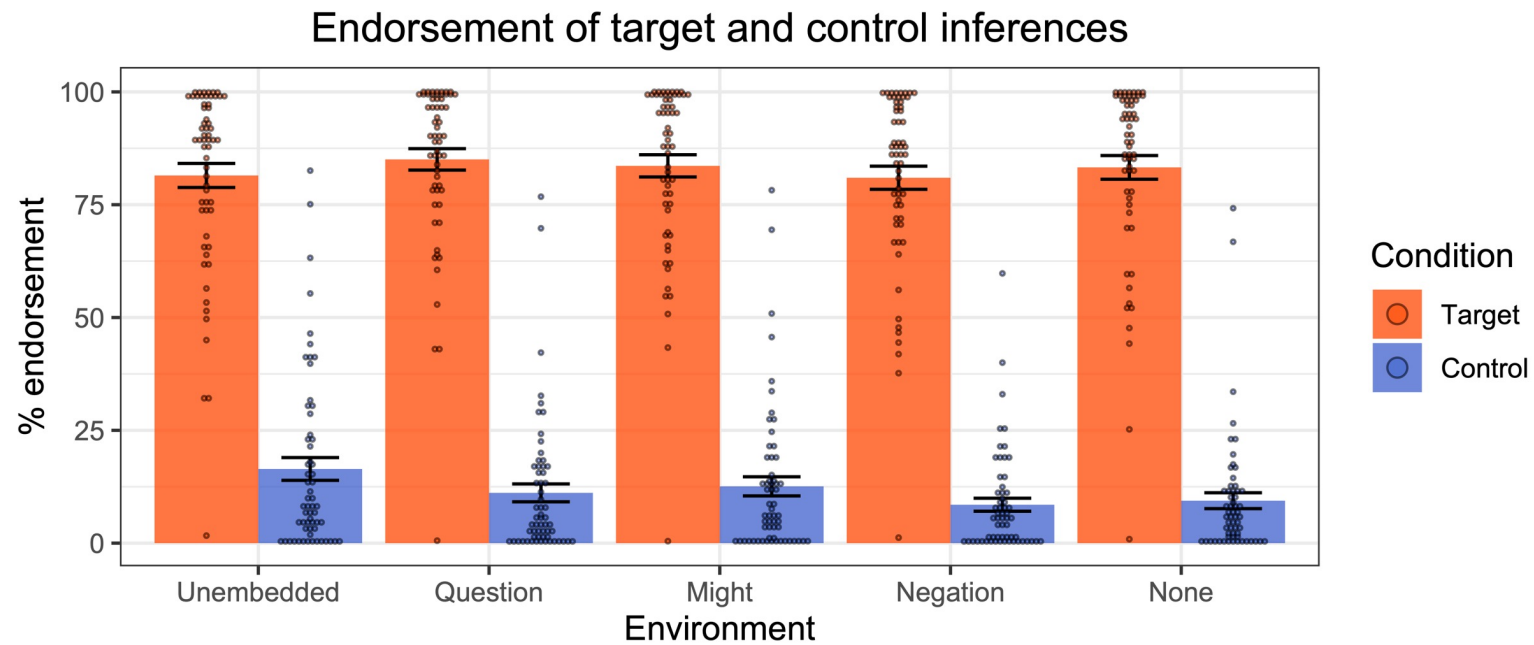
- We tested 9 emoji that could signify a change of state:

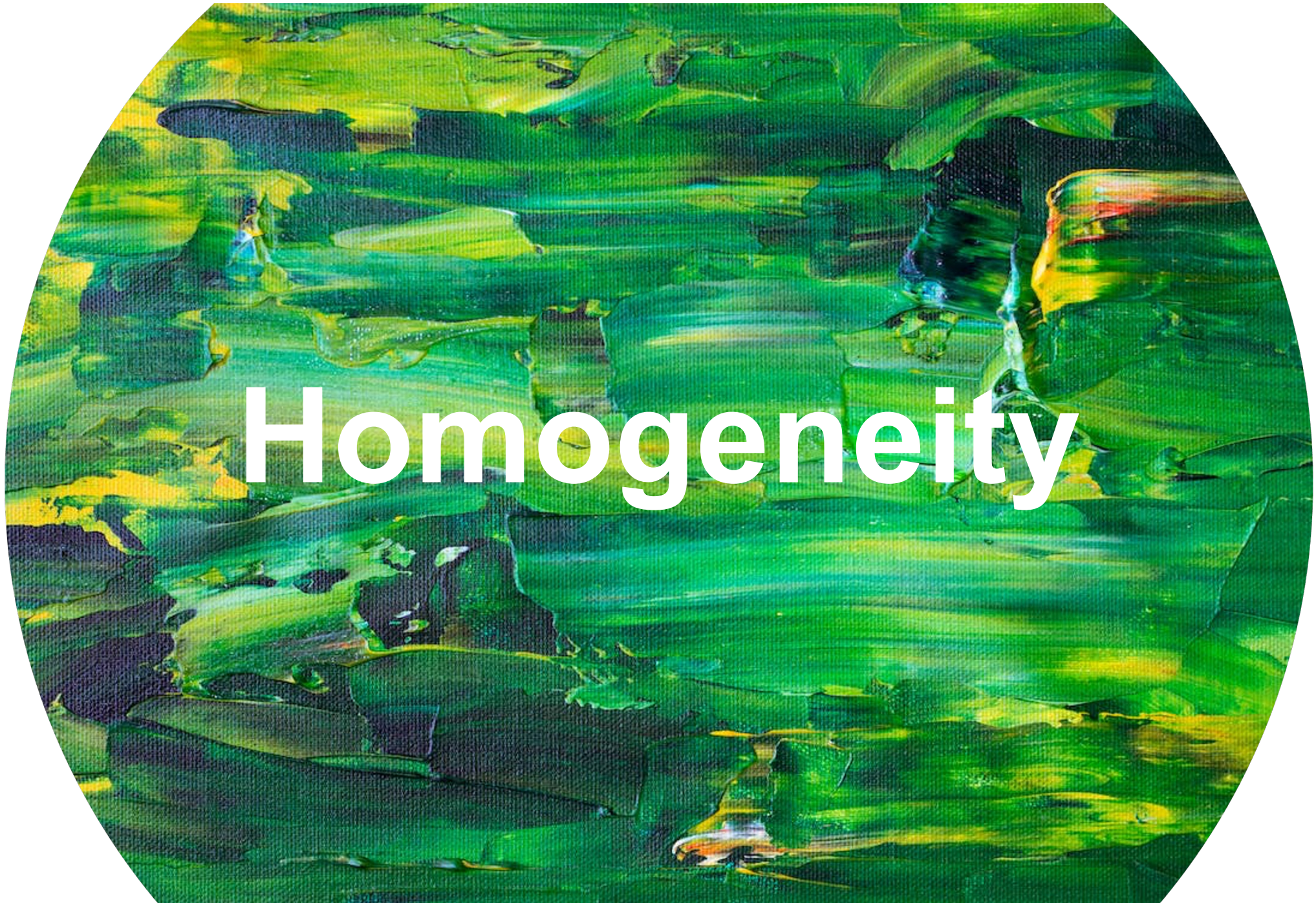


- Presupposition: the pre-change state currently holds
 - e.g., Will the egg 🐣? => *The egg has not yet hatched*
 - e.g., The plane will not ✈️ => *The plane is currently on the ground*
- Each emoji tested in 5 different linguistic environments: plain affirmative sentences, polar questions, scope of negation, ‘might’, and ‘none’

Results

- Stronger endorsement of target presuppositions than baseline control inferences
- Significant effect of condition across all environments
- Consistent with participants deriving the target presuppositions





Homogeneity

Homogeneity inferences

- Plural definite noun phrases trigger homogeneity inferences (Löbner 2000; Gajewski 2005; Spector 2013; Križ 2015; Križ & Spector 2021)
 - a. Mary will find her presents.
→ *Mary will find all of her presents*
 - b. Mary will not find her presents.
→ *Mary will find none of her presents*
- This characteristic inferential behavior is referred to as ‘homogeneous’, since all presents behave in the same way relative to the predicate



Gestures/animations: Methods

- **Gestural plurals:** Realized by iterating a gesture in different positions — a common means of plural formation in sign language (Pfau & Steinbach 2006)
- By introducing a gestural verb, e.g., TAKE-2-HANDED, which targets position in which repetition was effected, one can obtain a meaning akin to ‘take them’ — the gesture then implicitly contains a plural definite description
- **Animated plurals:** Presented groups of geometric shapes on the screen and a visual representation of a “laser” that could appear to roughly target the cluster of shapes
- Tested 2 examples of gestural plurals and 2 examples of animated plurals (positive and negative), crossed with two kinds of inferences (target/homogeneous and baseline/nonhomogeneous)

Homogeneity in gestures

- **Context:** Sam is participating in a treasure hunt in the forest, and she is looking for crosses and coins. Very quickly, Sam will find [CROSS-REP3]_left and [COIN-REP3]_right.

Positive target

Target premise: Sam will TAKE-2-HANDED-RIGHT

Target inference: Sam will take all of the coins.

Baseline inference: Sam will take some, but not all of the coins.



Negative target

Target premise: Sam will not TAKE-2-HANDED-RIGHT.

Target inference: Sam will not take any coins.

Baseline inference: Sam will take some, but not all of the coins.



Homogeneity in animations

- **Context:** In their favorite game, aliens flash lasers to destroy different kinds of objects. // At tonight's game, there will be... // Animation: three rows of three gray stars each appear on left of screen and disappear; three rows of three gray triangles each appear on right of screen and disappear. //
- **Positive target premise:** Lucas will... // **Negative target premise:** Terry will not... // Animation: blue spot appears on left (centered on where the group of stars was) and disappears.

In their favorite game, aliens flash lasers to destroy different kinds of objects.

In their favorite game, aliens flash lasers to destroy different kinds of objects.

Target inference: Lucas will laser all of the stars.

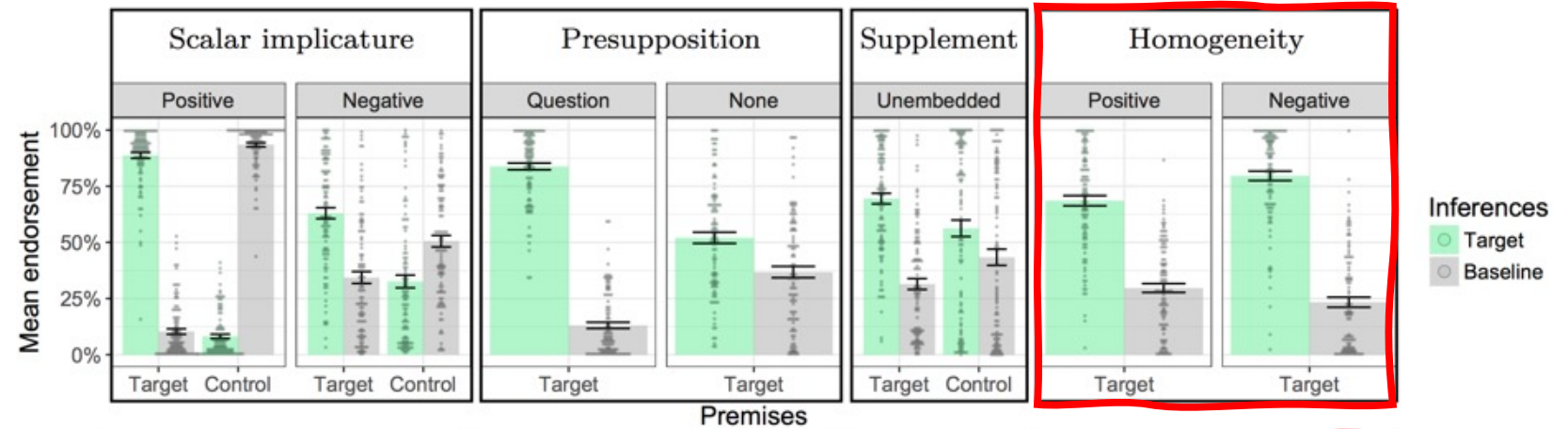
Target inference: Terry will not laser any of the stars.

Baseline inference: Lucas/Terry will laser some, but not all, of the stars.

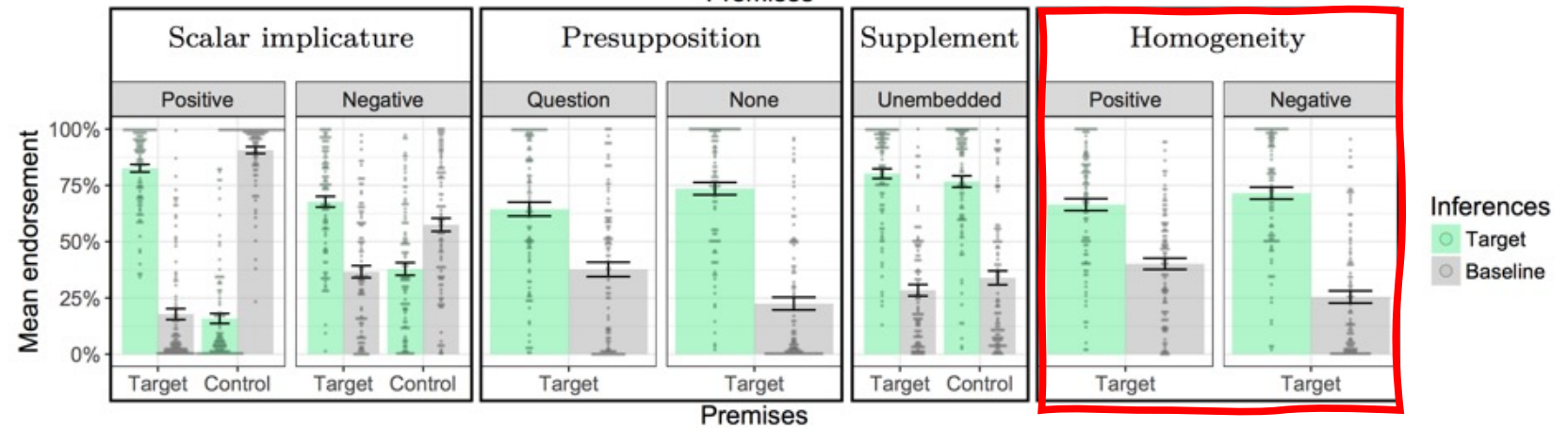
(Tieu, Schlenker & Chemla 2019, PNAS)

Results

Gesture
Experiment



Animation
Experiment



- Participants rated target inferences higher than baseline inferences for both positive and negative premises
- Consistent with presence of homogeneity inferences



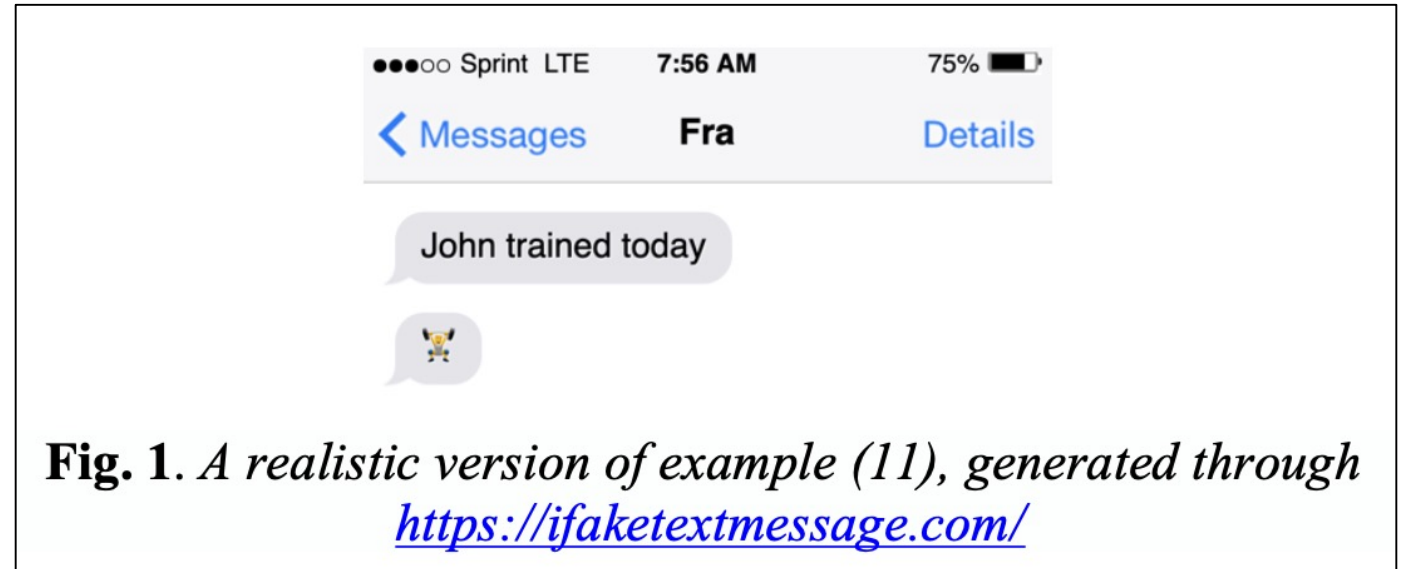
Supplements

Supplements

- Nonrestrictive relative clauses are believed to trigger a special type of inference, called a ‘supplement’, characterized by two main properties:
 - Unlike presuppositions, supplements are informative, i.e. not typically taken for granted in the conversation
 - Even when embedded under logical words, they trigger the same inferences as independent, unembedded sentences (as opposed to embedded conjunctions)

Post-text emoji

- Post-text emoji occur following the relevant text and contribute supplements (Pierini 2021):
 - a. John trained today... 🏋️‍♂️
 - b. John trained today - 🏋️‍♂️
↷ *John trained today, which involved weightlifting*



(Screen capture from Pierini 2021)

Prediction 1: Projection

- Supplements project from antecedents of conditionals
- If post-text emoji contribute supplements, these should project when the post-text emoji appears in the antecedent of a conditional (Pierini 2021)
 - a. If the professor is interrupted during her lecture...📞, she will end the lecture early.
↪ If the professor is interrupted during her lecture, it'll be because of a ringing phone
 - b. If the businesswoman travels to the board meeting...✈️, the company will reimburse her expenses.
↪ If the businesswoman travels to the board meeting, it'll be by plane

Prediction 2: Bad under negation

- Supplements are degraded in negative environments
- If post-text emoji trigger supplements, they should likewise be degraded in negative sentences (Pierini 2021)

a. John trained today... 🏆

↪ *John trained today, which involved weightlifting*

b. # John didn't train today... 🏆

↪ *# John didn't train today, which involved weightlifting*

Projection experiment: Methods

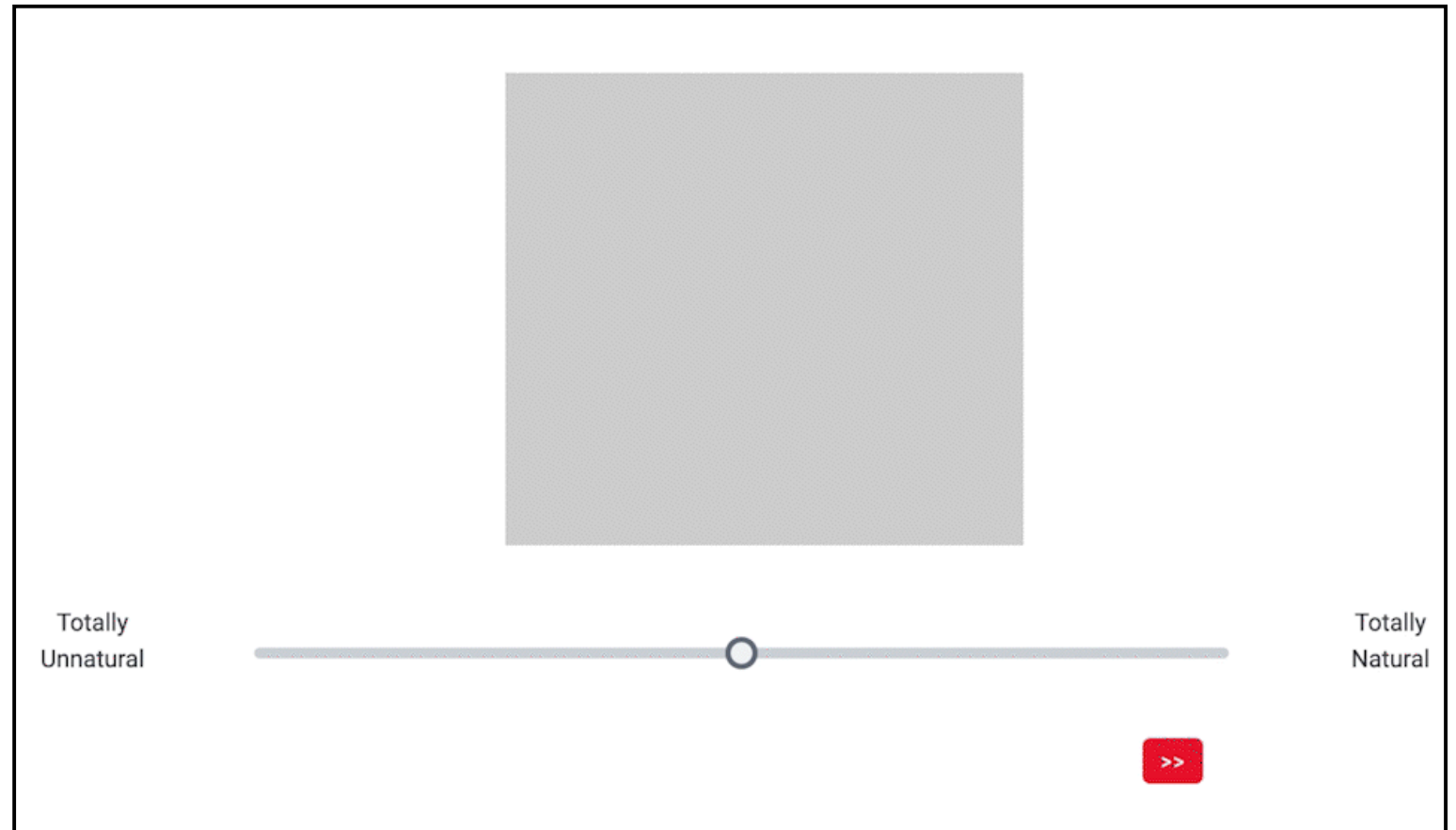
- **Participants (Prolific):** 60 native speakers of English
- **Procedure:** Inferential judgment task – read text message sequences and rate strength of given inferences
- **Materials:** Tested 5 post-text emoji in antecedent of conditional
 - 10 targets (each sentence paired with target supplemental inference and baseline control inference)
 - 10 filler items (5 pro-text emoji x 2 inferences)

Materials

- 5 emojis, presented in the antecedent of a conditional
 - a. If the employee steps out onto the balcony...🚬, he will miss a phone call.
 - b. If the party is cancelled tomorrow...🌂, the family will be very disappointed.
 - c. If the professor is interrupted during her lecture...📞, she will end the lecture early.
 - d. If the businesswoman travels to the board meeting...✈️, the company will reimburse her expenses.
 - e. If the student steps out of the classroom...🚽, the teacher will pause the class.

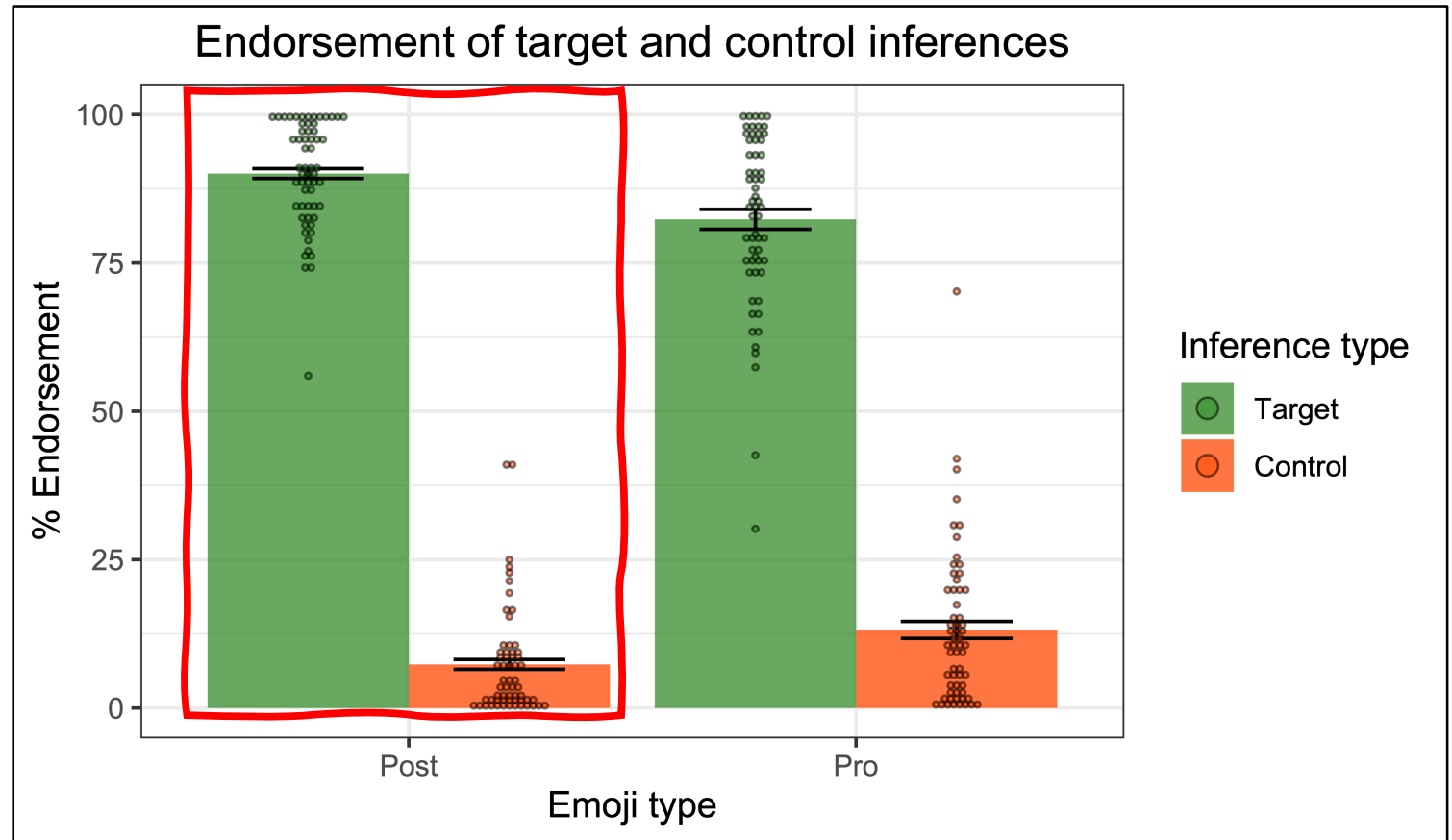
Dynamic text messaging

- Text messages popped up on the screen, mimicking the receipt of live texts






Results

- People endorse supplemental inferences of post-text emoji more than baseline/control inferences
- Projection of supplemental inferences from antecedents of conditionals



Acceptability experiment: Methods

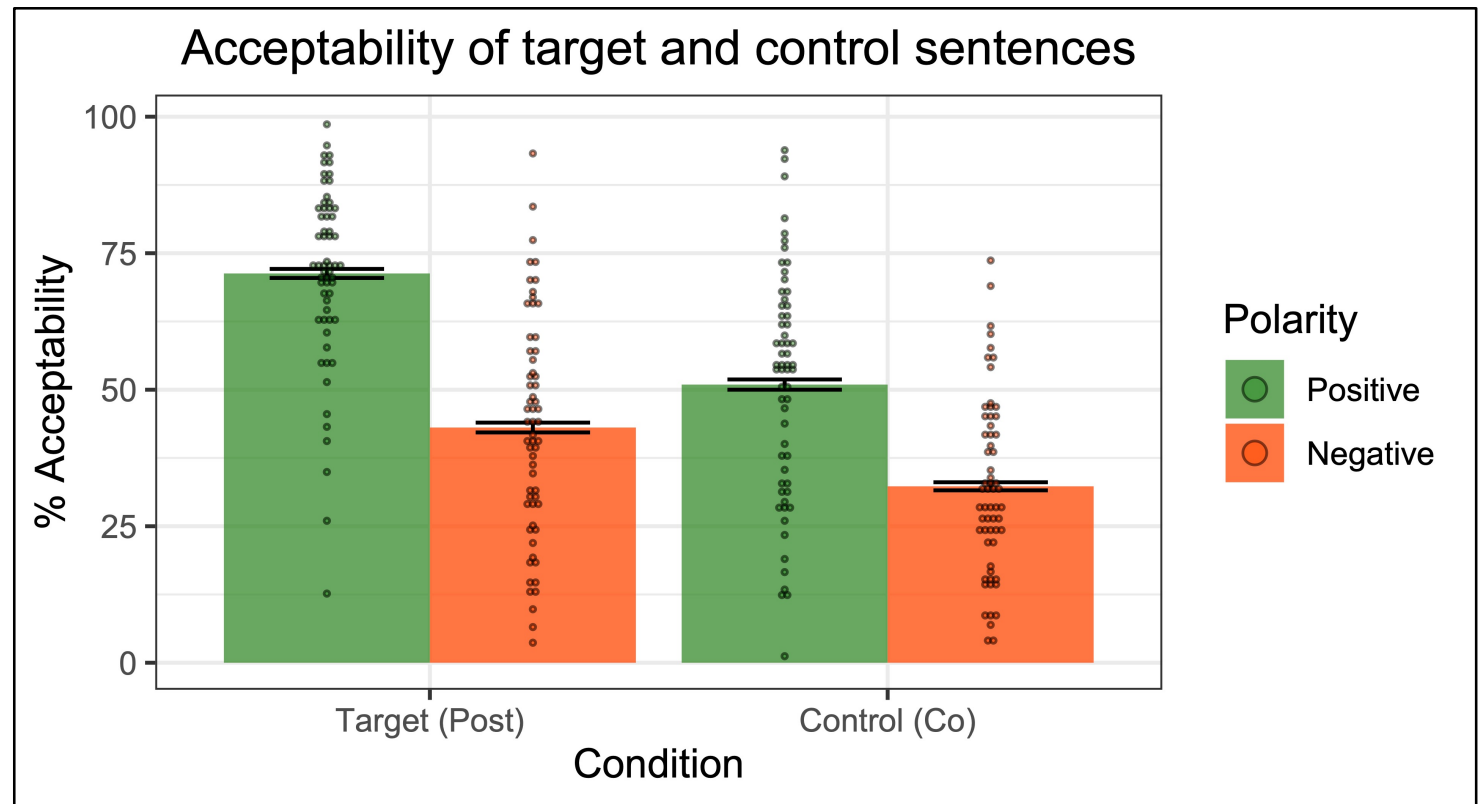
- **Participants (Prolific):** 61 native speakers of English
- **Procedure:** Acceptability judgment task (with dynamic text messaging), rating acceptability of post-text emoji in positive vs. negative sentences
- Tested 5 emoji in 3 linguistic environments x 2 polarities, e.g.,:
 - a. The employee will/will not step out onto the balcony... 
 - b. Each/None of these three parties will be cancelled tomorrow... 
 - c. The professor is likely/unlikely to be interrupted during her lecture 

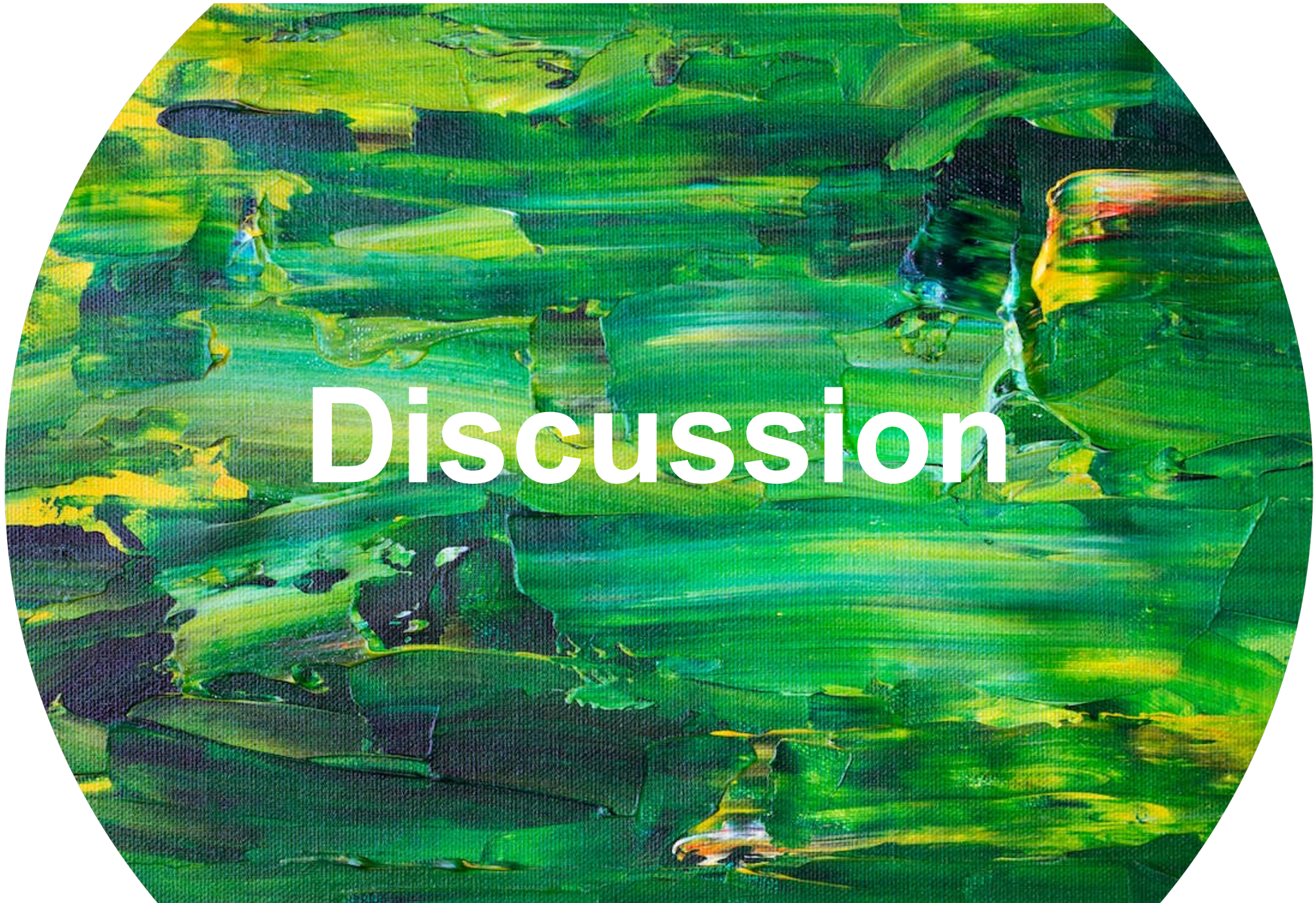
Co-text emoji controls

- An effect of polarity could be due to generally lower endorsement of negative sentences
- Compare with positive and negative co-text emoji, where we do not expect the same degradation effect
 - a. The party will be cancelled tomorrow... 🌧️
#The party will **not** be cancelled tomorrow... 🌧️
 - b. The party will 🌧️ be cancelled tomorrow 🌧️
The party will **not** 🌧️ be cancelled tomorrow 🌧️

Results

- Post-text emoji are indeed more acceptable in positive sentences than negative sentences
- Difference in polarities more pronounced than for post-text emoji than for co-text controls (significant interaction between emoji type and polarity)





Discussion

Summary

- We collected semantic judgments about composite utterances containing regular words mixed with iconic gestures/animations/emoji
- Participants are able to analyze iconic content they have not previously encountered in a linguistic context, in the same way that they analyze words — productively dividing it among well-established components of the inferential typology
- Suggests that inference types usually thought to be language-specific and in some cases lexically encoded may instead result from productive, domain-general cognitive algorithms

What we observe

	Gestures	Visual animations	Emoji
Scalar implicatures	✓	✓	✓
Presuppositions	✓	✓	✓
Homogeneity	✓	✓	(Not yet tested)
Supplements	✓	✓	✓

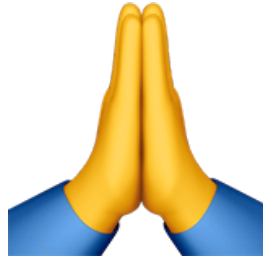
What should we expect?

- Table from Schlenker, Lamberton & Lamberton (2023) (with minor modifications):

	Lexical?
Scalar implicatures	No except possibly for the existence of lexical scales (Horn 1972)
Presuppositions	Yes (Heim 1983)
Homogeneity	Not clear
Supplements	Yes, through comma intonation (Potts 2005)

Wrapping up

- **Part 1:** Experiments can tease apart competing theories by testing predictions of theories of specific inference types
- **Part 2:** Much of the inferential typology can be replicated with gestures, visual animations, and emoji
- **Ongoing work:** what is the generalizability of the inferential typology? Can we replicate inferential phenomena without linguistic embedding?



- **Collaborators:** Cory Bill, Emmanuel Chemla, Nadia Faehndrich, Robert Pasternak, Vaishnavy Puvipalan, Jimmy Qiu, Jacopo Romoli, Philippe Schlenker
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References

- Aloni, Maria. 2007. Free choice, modals, and imperatives. *Natural Language Semantics* 15(1). 65–94. <http://dx.doi.org/10.1007/s11050-007-9010-2>.
- Aloni, Maria. 2022. Logic and conversation: the case of free choice. *Semantics & Pragmatics* 15. <http://dx.doi.org/doi.org/10.3765/sp.15.5>.
- Alonso Ovalle, Luis. 2006. *Disjunction in Alternative Semantics*. University of Massachusetts at Amherst dissertation.
- Bar-Lev, Moshe. 2018. *Free choice, homogeneity and innocent inclusion*, The Hebrew University of Jerusalem dissertation.
- Bar-Lev, Moshe & Danny Fox. 2020. Free choice, simplification, and Innocent Inclusion. *Natural Language Semantics* 28. 175–223. <http://dx.doi.org/10.1007/s11050-020-09162-y>.
- Barnes, Kathryn & Cornelia Ebert. 2023. The information status of iconic enrichments: modelling gradient at-issueness. *Theoretical Linguistics* 49(3-4), doi: 10.1515/tl-2023-2009
- Bill, Cory, Jacopo Romoli & Florian Schwarz. 2018. Processing presuppositions and implicatures: Similarities and differences. *Frontiers in Communication* 3(44), doi: 10.3389/fcomm.2018.00044
- Bill, Cory, Jacopo Romoli, Florian Schwarz & Stephen Crain. 2016. Scalar implicatures vs. presuppositions: The view from acquisition. *TOPOI special issue: Presuppositions: Philosophy, Linguistics and Psychology*, 57-71. <https://doi.org/10.1007/s11245-014-9276-1>
- Chemla, Emmanuel. 2010. Similarity: towards a unified account of scalar implicatures, free choice permission and presupposition projection. Ms., Ecole Normale Supérieure.
- Chemla, Emmanuel & Lewis Bott. 2014. Processing inferences at the semantics/pragmatics frontier: disjunctions and free choice. *Cognition* 130(3). 380–396.
- Chierchia, Gennaro. 2013. *Logic in grammar: Polarity, free choice, and intervention*. Oxford University Press.
- Chierchia, Gennaro, Danny Fox & Benjamin Spector. 2012. The grammatical view of scalar implicatures and the relationship between semantics and pragmatics. In Claudia Maienborn, Klaus von Stechow & Paul Portner (eds.), *Semantics: An international handbook of natural language meaning* volume 3, Berlin: Mouton de Gruyter.
- Clark, H.H. 2016. Depicting as a method of communication. *Psychol Rev* 123: 324–347.
- Cremers, Alexandre, Frances Kane, Lyn Tieu, Lynda Kennedy, Yasutada Sudo, Raffaella Folli & Jacopo Romoli. 2018. Testing theories of temporal inferences: Evidence from child language. *Glossa: A journal of general linguistics* 3(1), 139. doi:10.5334/gjgl.604

References

- Del Pinal, Guillermo, Itai Bassi & Uli Sauerland. 2022. Free choice and presuppositional exhaustification. Unpublished manuscript, UMass and ZAS.
- Ebert, Cornelia & Christian Ebert. 2014. Gestures, demonstratives, and the attributive/referential distinction. Slides from a talk given at Semantics and Philosophy in Europe (SPE 7).
- Fox, Danny. 2007. Free choice and the theory of scalar implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presupposition and Implicature in Compositional Semantics*, 71–120. Palgrave.
- Franke, Michael. 2011. Quantity implicatures, exhaustive interpretation, and rational conversation. *Semantics and Pragmatics* 4(1). 1–82. <http://dx.doi.org/10.3765/sp.4.1>.
- Fusco, Melissa. 2015. Deontic modality and the semantics of choice. *Philosophers' Imprint* 15.
- Gajewski, Jon. 2005. *Neg-raising: polarity and presupposition* (PhD thesis), Cambridge, MA: MIT.
- Goldstein, Simon. 2019. Free choice and homogeneity. *Semantics and Pragmatics* 12(23). 1–47. <http://dx.doi.org/10.3765/sp>.
- Grice, P. 1975. *Logic and conversation. The Logic of Grammar*, eds Davidson D, Harman GH (Dickenson Publishing Company, Encino, CA), pp 64–75; reprinted in Grice HP (ed) (1989) *Studies in the Way of Words* (Harvard Univ Press, Cambridge, MA), pp 22–40.
- Heim, Irene. 1983. On the projection problem for presuppositions. In Daniel P. Flickinger (ed.), *Proceedings of the 2nd West Coast Conference on Formal Linguistics*, 114–125. Stanford University, Stanford, CA: CSLI Publications.
- Horn, Laurence R. 1972. *On the semantic properties of the logical Operators in English*. Ph.D. thesis, University of California at Los Angeles.
- Kamp, Hans. 1974. Free choice permission. *Proceedings of the Aristotelian Society* 74. 57–74.
- Katsos, Napoleon & Dorothy VM Bishop. 2011. Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. *Cognition* 120(1). 67–81.
- Katzir, Roni. 2007. Structurally-defined alternatives. *Linguistics & Philosophy* 30:669–690.
- Katzir, Roni & Danny Fox. 2011. On the characterization of alternatives. *Natural Language Semantics*, 19(1), 87–107.
- Klinedinst, Nathan. 2007. *Plurality and possibility*, UCLA dissertation.
- Kratzer, Angelika & Junko Shimoyama. 2002. Indeterminate pronouns: The view from Japanese. In Yukio Otsu (ed.), *Proceedings of the Tokyo conference on psycholinguistics*, vol. 3, 1–25. Tokyo: Hituzi Syobo.
- Križ, Manuel. 2015. *Aspects of homogeneity in the semantics of natural language*, University of Vienna dissertation.

References

- Križ, Manuel & Benjamin Spector. 2021. Interpreting plural predication: homogeneity and non-maximality. *Linguistics and Philosophy* 44, 1131–1178. doi: 10.1007/s10988-020-09311-w
- Löbner, S. (2000). Polarity in natural language: predication, quantification and negation in particular and characterizing sentences. *Linguistics & Philosophy* 23, 213–308. doi: 10.1023/A:1005571202592
- Montague, Richard. 1970. English as a formal language. *Linguaggi nella Società e nella Tecnica*, ed Visentini B (Edizioni di Comunità, Milan), pp 189–224; reprinted in Thomason RH, ed (1974) *Formal Philosophy. Selected Papers of Richard Montague* (Yale Univ Press, New Haven), pp 188–221.
- Pasternak, Robert & Lyn Tieu. 2022. Co-linguistic content inferences: From gestures to sound effects and emoji. *Quarterly Journal of Experimental Psychology* 75(10). doi: 10.1177/17470218221080645
- Pierini, Francesco. 2021. Emojis and gestures: a new typology. In Patrick Grosz, Luisa Martí, Hazel Pearson, Yasutada Sudo & Sarah Zobel, eds., *Proceedings of Sinn und Bedeutung* 25, 720–732.
- Potts, Christopher. 2005. *The Logic of Conventional Implicatures*. Oxford University Press.
- Renans, Agata, Jacopo Romoli, Maria-Margarita Makri, Lyn Tieu, Hanna de Vries, Raffaella Folli & George Tsoulas. 2018. The abundance inference of pluralised mass nouns is an implicature: Evidence from Greek. *Glossa: A journal of general linguistics* 3(1), 103. doi:10.5334/gjgl.531
- Rothschild, Daniel & Stephen Yablo. 2018. Permissive updates. Ms., UCL and MIT.
- Russell, B. 1905. On denoting. *Mind* 14:479–493.
- Santorio, Paolo & Jacopo Romoli. 2017. Probability and implicatures: A unified account of the scalar effects of disjunction under modals. *Semantics & Pragmatics* 10(13).
- Schlenker, Philippe. 2019. Gestural semantics: Replicating the typology of linguistic inferences with pro- and post-speech gestures. *Natural Language & Linguistic Theory*, 37(2), 735-784.
- Schlenker, Philippe. 2018. Iconic pragmatics. *Natural Language & Linguistic Theory* 36:877–936.
- Schlenker, Philippe. 2018. Gesture projection and cosuppositions. *Linguistics & Philosophy* 41:295–365.
- Schlenker, Philippe. 2021. Triggering presuppositions. *Glossa: a journal of general linguistics* 6(1):35. 1–28. doi: 10.5334/gjgl.1352

References

- Schlenker, Philippe. 2023. On the typology of iconic contributions. *Theoretical Linguistics* 49(3-4), doi: 10.1515/tl-2023-2014
- Schlenker, Philippe, Jason Lamberton & Jonathan Lamberton. 2023. The inferential typology of language: Insights from sign language (ASL). Ms., Institut Jean-Nicod, lingbuzz/007646
- Spector, Benjamin. 2013. Homogeneity and plurals: From the strongest meaning hypothesis to supervaluations. Available at https://ehutb.ehu.eus/uploads/material/Video/3289/Sinn18_01.pdf. Accessed August 30, 2018.
- Starr, Will. 2016. Expressing permission. In *Proceedings of SALT 26*, 325–349.
- Tarski, A. 1943. The semantic conception of truth and the foundation of semantics. *Philos Phenomenol Res* 4:341–376.
- Tieu, Lyn, Jacopo Romoli, Peng Zhou & Stephen Crain. 2016. Children’s knowledge of free choice inferences and scalar implicatures. *Journal of Semantics* 33(2). 269–298.
- Tieu, Lyn, Robert Pasternak, Philippe Schlenker & Emmanuel Chemla. 2017. Co-speech gesture projection: Evidence from truth-value judgment and picture selection tasks. *Glossa: a journal of general linguistics* 2:102.
- Tieu, Lyn, Robert Pasternak, Philippe Schlenker & Emmanuel Chemla. 2018. Inferences of co-speech gestures: Evidence from inferential judgments. *Glossa: a journal of general linguistics* 3:109.
- Tieu, Lyn, Manuel Kriz & Emmanuel Chemla. 2019. Children’s acquisition of homogeneity in plural definite descriptions. *Frontiers in Psychology* vol. 10. doi:10.3389/fpsyg.2019.02329.
- Tieu, Lyn, Philippe Schlenker & Emmanuel Chemla. 2019. Linguistic inferences without words. *Proceedings of the National Academy of Sciences (PNAS)* 116(20), 9796-9801. doi:10.1073/pnas.1821018116
- Tieu, Lyn, Cory Bill, Jacopo Romoli & Stephen Crain. 2020. Testing theories of plural meanings. *Cognition* vol. 205. doi: 10.1016/j.cognition.2020.104307
- Tieu, Lyn, Jimmy L. Qiu, Vaishnavy Puvipalan & Robert Pasternak. 2023. Experimental evidence for a semantic typology of emoji: Inferences of co-, pro-, and post-text emoji. Ms., University of Toronto.
- Tieu, Lyn, Cory Bill & Jacopo Romoli. 2023. An experimental investigation of implicature and homogeneity approaches to free choice. Ms., University of Toronto.
- Willer, Malte. 2017. Widening free choice. In *Proceedings of the 21st Amsterdam Colloquium*, 511–520.
- von Wright, G. H. 1969. An Essay on Deontic Logic and the Theory of Action. Chapter I, Section 7.