From the Structure of Experience to Concepts of Structure

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Many object categories (i.e., most artifacts) criticially rely on causal properties – one reason they include members with different surface features. Here we ask:

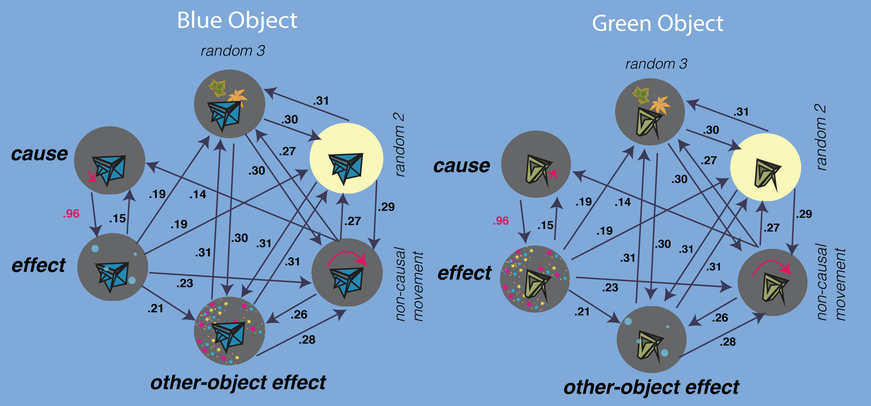
1. What aspect of experience do causal properties of objects come from? Can they be extracted from predictive information presented in naturalistic event streams?

2. How spontaneously and automatically do we form generalizable causal categories?

Experiment 1: How do we assign causal properties to objects in naturalistic event streams?

Task: determine what each object causes.

Stimuli: sequence of 250 animated visual events order governed by markov chain.



Each object appeared with all ambient events, but only one of those events also depended on its movements.

Sentence Acceptability Measure

1. Causality: Effect Event

"The green object seemed to cause the multi-colored stars to appear"

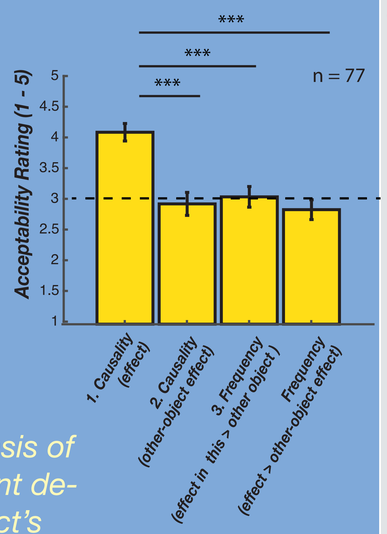
2. Causality: Other-Object Effect Event

"The green object seemed to cause the bubbles to appear"

3. Frequency: Effect vs. Other-Object Effect Event

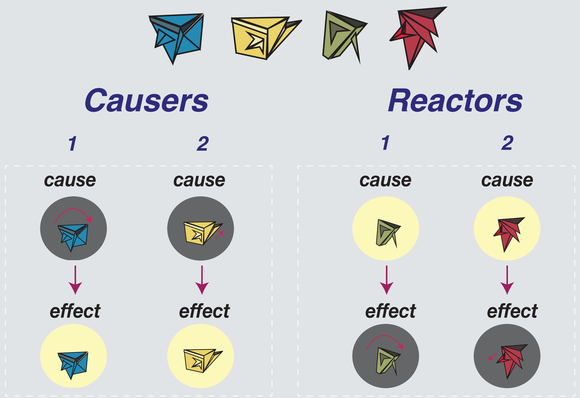
"When the green object was present, multi-colored stars appearing happened more often than when the blue object was present"

1 definitely false — ***2*** — ***3*** unsure — ***4*** — ***5*** definitely true



Causality can be assigned on the basis of higher-order event structure: an event dependency that depends on the object's presence.

Experiment 2: Do learners spontaneously form generalized causal categories?

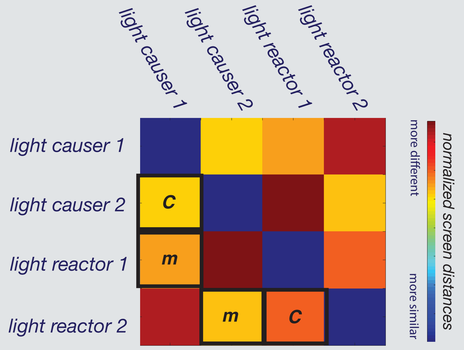


Shape to condition assignments and effect events counterbalanced

Task: learn as much as possible about the object and press a button when anything unexpected happens.

similarity judgments

using a spatial sorting task



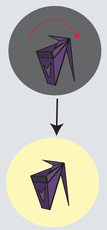
Casual model
t(17) = 2.42, p < .05
Motion model
t(17) = 2.39, p <.05
Mixture model
t(17) = 3.53, p < .01

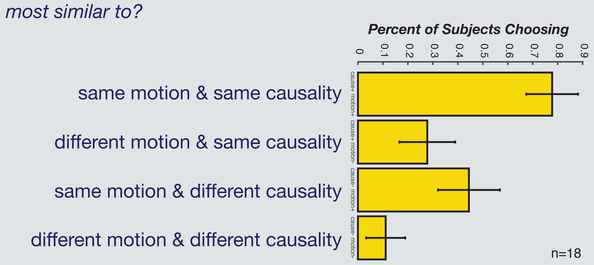
Linear regression with motion model : c cells = 0 , others = ; causal model : m cells = 0 , others = 1, fit on individual data, betas subjected to t-test.

Linear regression with a single factor: mixture model: c cells = .5 and m cells = .5, others = 1

generalization test

which objects is this most similar to?





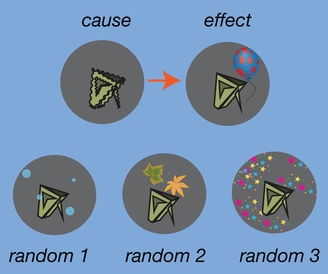
Motion match F(1,17) = 15.36, p < .001
Causal match F(1,17) = 5.52, p < .05

Participants used a combination of motion and causality/predictive structure to group objects.

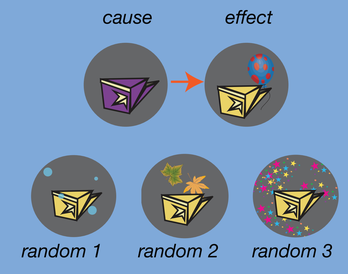
Experiment 3: Is causal generalization automatic?

Task: hit a key whenever an event repeats

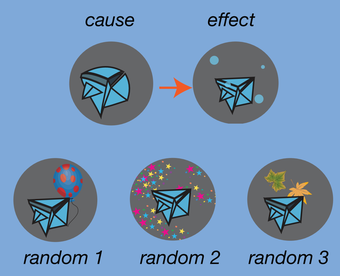
same effect object 1



same effect object 2



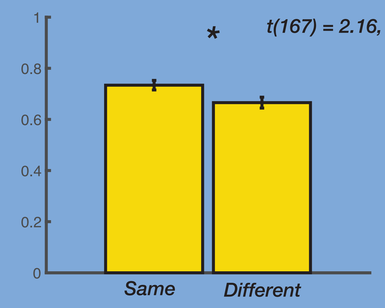
different effect object



Event assignments counterbalanced

familiarity forced choice test

example



When the same event was predictable (v.s., radom), learning was automatically facilitated, indicating automatic generalization.

Why is this important?

Predictive structure is a pervasive part of experience that can be extracted using straightforward learning mechanisms. But it can also be leveraged to gain abstraction, as predictive relations can be generalized across participating events and sensory features. Together, this could account for bottom-up abstraction of sensory experience and the formation of novel kinds generalizing across sensory features.

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