The Effect of Valence Framing on Inferring Cause Normalities

Bachelor's Thesis

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Tübingen, 29.10.2025

Place and date

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Signature

Abstract

This study examines how event normality, causal structure, and valence framing of outcome influence people's causal explanations and inferences. Building on previous work on causal reasoning, it tests whether framing an outcome positively or negatively affects how people select and interpret causes.

Participants completed an online experiment with two parts: a Speaker task, where they chose which event best explained an outcome, and a Listener task, where they judged the normality of events based on an explanation.

The results only partially replicated previous findings. Participants preferred normal causes in disjunctive structures, but this pattern was weaker in conjunctive structures. Valence framing had a modest influence on both explanatory choices and inferences.

These findings suggest that causal explanation is shaped not only by causal structure and event normality, but also by the valence framing of outcomes. [1]

[1] All experimental materials, data, and analysis code are available at `https://github.com/aidayg24/causal_selection`.

Contents

1. Introduction

Understanding how people explain why things happen has been an important topic in philosophy, psychology, and linguistics. When several causes contribute to an outcome, people usually mention only one or a few of them in their explanations. This suggests that causal explanation follows systematic patterns rather than being random. (Kirfel et al., 2021)

Previous research has shown that people's judgments about causes depend mainly on two factors: the causal structure and the normality of those events (Icard et al., 2017; Kirfel et al., 2021). In a conjunctive structure, where both causes are required, people tend to prefer abnormal causes. In contrast, in a disjunctive structure, where either cause alone is sufficient, normal causes are more often selected. These findings suggest that causal explanation depends on both how events are connected and how typical or expected they are.

However, less is known about how explanations are affected by the way outcomes are described, in other words, their *valence framing*. In everyday communication, outcomes are often presented either positively or negatively, such as "I won because..." or "I lost because...". Work in moral cognition has shown that such framing can influence how people assign responsibility or blame (Knobe, 2003), but it is still unclear whether it also affects ordinary causal explanation.

The goal of this study is to test whether the valence framing of an outcome influences how people select and interpret causes. It builds on the framework of Kirfel et al. (2021), which views explanation as a communicative process between speakers and listeners.

To investigate this, the experiment included two parts. In the *Speaker task*, participants chose which of two causes best explained a given outcome. In the *Listener task*, they inferred how normal each event was after reading an explanation. Together, these tasks make it possible to test how causal structure, event normality, and valence framing interact in both explaining and interpreting outcomes.

By adding outcome valence to these factors, this study aims to extend previous research on causal explanation and show how differences in framing can influence how people communicate and reason about causes.

2. Theoretical Background

Over the past decades, researchers from philosophy, psychology, and linguistics have sought to understand how people infer and explain causes (Halpern and Pearl, 2005; Hitchcock, 2024; Gerstenberg, 2022).. As Kirfel et al. (2021) points out, an important question is how causal explanations enable people to learn so much from a seemingly simple statement such as "E because C." When multiple causes contribute to an outcome, people usually mention only one or a few in their explanations rather than listing all of them (Hitchcock and Knobe, 2009; Icard et al., 2017; Kirfel et al., 2021). Importantly, this causal selection follows systematic patterns rather than being random. Previous work suggests that two factors play a central role in such judgments: causal structure and event normality. (Icard et al., 2017; Kirfel et al., 2021; Quillien and Lucas, 2023)

Structural Causal Models (SCMs; Pearl 2000; Halpern and Pearl 2005) provide a formal framework for representing how events depend on one another. In these models, causal relations are expressed as structural equations that link variables, making it possible to predict how changes in one variable affect another. However, SCMs by themselves cannot account for which causes people find most explanatory. That is, which causes they actually choose to mention when explaining why something happened.

Empirical studies have shown that causal judgment depends not only on structural dependence but also on the normality of events. The normality of an event reflects how typical, expected, or norm-conforming it seems (Icard et al., 2017; Kominsky et al., 2015; Kirfel et al., 2021). It was assumed that people often treat abnormal events as more causally relevant precisely because they deviate from what is expected. Importantly, this notion of normality extends beyond mere statistical frequency to include prescriptive, moral, and social expectations. (Gerstenberg, 2022; Icard et al., 2017; Kominsky et al., 2015; Kirfel et al., 2021)

A crucial determinant of explanatory choice is also the causal structure linking potential causes to outcomes. Kirfel et al. (2021) demonstrated that people's explanations vary systematically depending on whether causes combine conjunctively (both required) or disjunctively (either sufficient). Together with related findings (Icard et al., 2017), this suggests that explanatory choices depend jointly on causal structure and event normality: in conjunctive structures, abnormal causes are preferred, while in disjunctive structures, normal causes are favored. These results support the idea that explanation involves a pragmatic inference about informativeness; Speakers highlight the cause that best distinguishes why the outcome occurred.

To the best of current knowledge, prior studies have not yet explored how valence framing affects explanatory judgments and causal selection. Valence framing refers to whether an outcome is dein a positive or negative manner. For instance, "I won the game because..." versus "I lost the game because...". Research in moral cognition has shown that people's causal attributions differ between harmful and beneficial outcomes (Knobe, 2003). This raises the possibility that evaluative framing could influence which causes are considered explanatory, particularly when outcomes are desirable or undesirable.

Recent work has further proposed that explanation should be understood as a communicative act, in which speakers select information that guides a listener's inference (Kirfel et al., 2021). Within this view, explanatory choices can be modeled as rational pragmatic decisions: speakers highlight the causes that maximize informativeness for a cooperative listener, and listeners interpret explanations to infer both causal and normative structure.

Building on this framework, the present study investigates whether valence framing (positive vs. negative outcomes) alters how speakers and listeners reason about causal normality and structure. Existing research has established that causal judgments are sensitive to both event normality and causal structure, yet the influence of outcome valence on these effects remains underexplored. The current study addresses this gap by testing whether positive and negative framings modulate how people select and interpret explanations in conjunctive and disjunctive structures. By combining production (speaker) and interpretation (listener) tasks, it further examines how communicative perspective shapes causal reasoning.

3. Experimental Design and Procedure

Overview

This experiment investigates how event normality, causal structure, and valence framing influence people's causal judgments. It builds on prior findings that people's explanatory choices depend on perceived normality and causal structure (Quillien and Lucas, 2023; Kirfel et al., 2021; Icard et al., 2017). The present study extends this line of research by testing whether these effects remain stable across changes in outcome valence.

3.1 Hypotheses

Hypothesis 1 (Replication): People's selection of causal explanations is influenced by event normality and causal structure (Kirfel et al., 2021).

Previous studies have shown that both the normality of causes and the causal structure affect causal judgments. Accordingly, the first hypothesis aims to replicate these effects. Specifically, when a normal and an abnormal cause bring about an outcome E, participants are expected to select the abnormal cause as the explanation in a *conjunctive* causal structure (where both causes are required), and to select the normal cause in a *disjunctive* structure (where either cause is sufficient). Participants' judgments are measured through written vignettes presented in a gamified format.

Hypothesis 2 (Replication): People infer an event's normality from an explanation when given information about the causal structure (Kirfel et al., 2021).

According to Kirfel et al. (2021), when people are provided with both a causal explanation and knowledge of the underlying causal structure, they can reliably infer the relative normality of the mentioned cause. In line with this work, the present study tests whether participants make similar inferences in a comparable setting, using written, game-like vignettes to elicit their judgments.

Hypothesis 3 (Valence Framing): Valence framing may influence people's causal selections or judgments of event normality.

Previous studies have not directly investigated whether the valence framing of an outcome affects how people select or interpret causes. While causal structure and event normality are assumed to be the main determinants of causal judgment, it remains possible that the emotional tone of an outcome subtly shapes explanatory choices. Therefore, this hypothesis explores whether people's causal selections and normality inferences differ between positively framed explanations (e.g., "Alice won because...") and negatively framed ones (e.g., "Alice lost because..."), without a strong prediction regarding the direction of the effect.

3.2 Participants and Implementation Details

Participants and Design

A total of 55 participants were recruited via Prolific. Of these, 26 took part in the *disjunctive* condition ($M_{age} = 42.2$), and 29 in the *conjunctive* condition ($M_{age} = 44.7$). All participants received monetary compensation for their time.

The experiment followed a $2 \times 2 \times 2$ mixed design with the following factors:

- **Causal Structure:** conjunctive vs. disjunctive (between participants),
- **Cause Normality:** normal vs. abnormal (within participants),
- **Valence Framing:** positive vs. negative (within participants).

The order of vignettes was randomized individually for each participant. All participants first completed the Speaker task, followed by the Listener task.

Procedure

Before starting the main tasks, participants read a short introduction explaining the rules of the game and their roles in both parts of the experiment. They then completed a few comprehension-check questions to ensure understanding. After each question, feedback and a short explanation were shown. Because feedback was available and the total sample size was relatively small, no participants were excluded from the analysis.

Participants were told that the experiment involved a simple card game between two players, Alice and Bob. In each round, they saw the outcome of one game and were asked to make a judgment based on their own interpretation. They were explicitly informed that there were no correct or incorrect answers.

The experiment always began with the *Speaker Task*, where participants imagined themselves as Alice and chose the best explanation for why she won or lost each round. This was followed by the *Listener Task*, where they read new outcomes and explanations produced by Alice and judged how normal each possible event seemed. Further details and screenshots are provided in Appendix A and in the next section.

3.3 Design Details

The experiment consisted of two consecutive parts, designed to examine how valence framing influences people's inferences about causal normality and structure.

In *Part 1*, participants took the role of a *speaker*, represented as one of the game characters, Alice, who had to choose which event best explained a given outcome. This part primarily tested **Hypothesis 1**, focusing on how causal structure and event normality influence explanatory choices, and also examined **Hypothesis 3** to explore whether valence framing affects these choices.

In *Part 2*, the same participants acted as *listeners*, reading new scenarios in which Alice provided an explanation for an outcome. Their task was to infer which of two possible events was more normal based on the explanation they received and the causal structure. This part tested **Hypothesis 2**, concerning people's ability to infer event normality from an explanation and causal structure, and again included **Hypothesis 3** to investigate whether valence framing influences these inferences.

This two-part design adapts and extends the framework of Kirfel et al. (2021), testing whether communicative role (speaker vs. listener) modulates how people integrate causal structure, event normality, and outcome valence when explaining or interpreting events.

3.3.1 Variables

The experiment included several independent and dependent variables, which differed slightly between the two parts of the study. The goal was to examine how event normality, causal structure, and valence framing shape people's explanatory choices and inferences about cause normality.

In the *Speaker* part, the independent variables were:

- **Causal structure** (between participants): Scenarios were either *conjunctive*, where both causes were required for the outcome, or *disjunctive*, where either cause alone was sufficient. Each participant saw only one of these two types.

- **Cause normality** (within participants): Each scenario included one *normal* and one *abnormal* cause. Normal events represented more typical or expected actions, while abnormal ones represented unusual or unexpected ones.

- **Valence framing** (within participants): The outcome of each scenario was described either positively (e.g., "Alice won because. . . ") or negatively (e.g., "Alice lost because. . . "), allowing examination of whether valence framing affected explanatory judgments.

The dependent variable in this part was participants' **causal selection**, which of the two causes they chose as the best explanation for why the outcome occurred. This design allowed testing how causal structure and event normality influence causal selection, and whether these effects are stable across positive and negative framings.

In the *Listener* part, participants were shown new scenarios where an explanation was already provided by Alice, one of the players. Here, the independent variables were:

- **Causal structure** (between participants): the same as in the Speaker part, either conjunctive or disjunctive.

- **Valence framing** (within participants): outcomes were again described as either positive or negative.

The dependent variable in this part was participants' **judgment of cause normality**. After reading the explanation, they estimated how normal each event seemed, based on the given causal structure, the explanation, and the valence of the outcome. This part tested whether listeners could infer event normality from explanations based on causal structure and whether outcome valence influenced this inference.

In each vignette, the two possible causes were performed by different agents (Alice and Bob). However, the experiment was not designed to systematically test the effect of agent identity, so this factor was not included in the main analyses. Possible ways to extend the design to explore this question are discussed in Chapter 5.

3.3.2 Part 1: Speaker Task

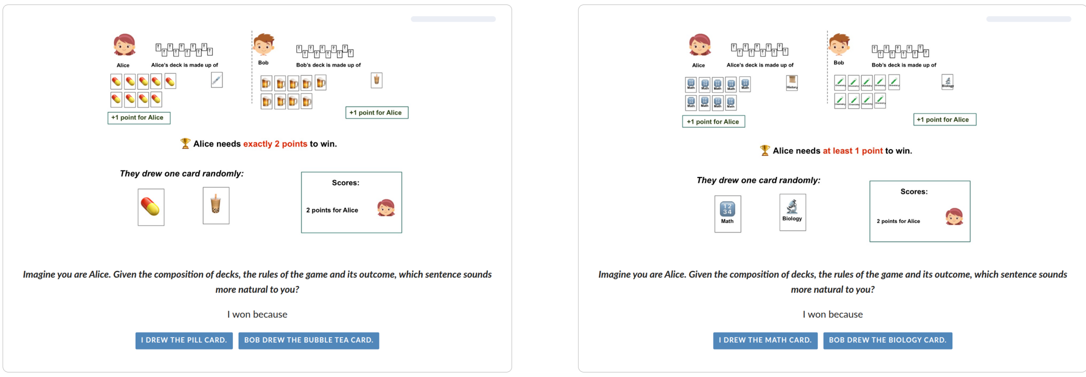
In the first part of the experiment, participants took on the role of a *speaker*, represented by one of the game characters, Alice. Their task was to choose which of two possible causes best explained a given outcome. Each trial presented a short vignette describing a round of the card game, in which two potential causes could jointly or separately bring about the same outcome E.

The underlying causal structure of each vignette was either *conjunctive*, meaning that both causes were required for the outcome (e.g., "Alice needs exactly two points to win"), or *disjunctive*, meaning that either cause alone was sufficient (e.g., "Alice needs at least one point to win"). Event normality was represented through the frequency of cards; participants were told how common or rare each type of card was, which established what counted as a *normal* or *abnormal* cause.

Each scenario was presented in either a positive or a negative valence frame. In positive framings, the outcome was desirable (e.g., "I won the game because…"), while in negative framings the outcome was described as undesirable (e.g., "I lost the game because…"). The underlying causal structure remained identical across all the experiment parts, allowing comparison of whether framing influenced participants' causal selections.

On each trial, participants read the vignette and selected which of the two causes they considered to be the best explanation for why the outcome occurred. They indicated their choice by clicking on one of two response options. Each participant completed all trials, which were presented in random order.

An example trial from the Speaker task is shown in Figure 3.1. The full set of eight vignettes (four conjunctive and four disjunctive) and the experimental interface are provided in Appendix A.



(a) Conjunctive Structure

(b) Disjunctive Structure

Figure 3.1: Examples from the Speaker task.

3.3.3 Part 2: Listener Task

In the second part of the experiment, the same participants took the role of a *listener*. This part examined how people infer event normality from a given explanation while taking the causal structure into account. Each trial presented a short vignette describing an outcome and an explanatory statement produced by a hypothetical speaker, Alice. Participants' task was to judge how normal each causal event seemed based on this explanation.

The materials were structurally parallel to those used in the Speaker task. Each scenario again involved two potential causes (performed by distinct agents, e.g., Alice and Bob) that could bring about a common outcome E. The causal structure matched that of the first part (either conjunctive or disjunctive), and each outcome was framed as either *positive* or *negative*. The explanation shown to participants corresponded to one of the two causes, allowing for a direct comparison between production and interpretation.

On each trial, participants read the vignette and the explanation (e.g., "I won because I drew a salad card") and then rated how normal each event seemed. Event normality was represented by the number of corresponding cards out of ten, and participants selected one of three options: fewer than five (abnormal), five, or more than five (normal). These ratings served as the main dependent measure for the Listener task. The order of trials was randomized independently of the Speaker part. An example trial from the Listener task is shown in Figure 3.2, and the complete set of materials is provided in Appendix A.

(a) Conjunctive structure

(b) Disjunctive structure

Figure 3.2: Examples of the Listener task.

4. Results

4.1 Speaker Task

A total of 55 participants participated in the speaker task, divided between the two conditions of causal structure: 26 in the disjunctive condition ($M_{age} = 42.2$, $SD_{age} = 14.4$) and 29 in the conjunctive condition ($M_{age} = 44.7$, $SD_{age} = 13.3$). The causal selections of the participants were analyzed as a function of the causal structure (disjunctive vs. conjunctive) and the valence framing (positive vs. negative). Participants' binary responses (choosing the normal cause or abnormal cause) were analyzed using Bayesian logistic regression models with random effects for participants, allowing estimation of both overall and individual-level effects of valence framing.

Overview of Causal Selections

Table 4.1 and Table 4.2 summarize participants' causal selections by valence framing and normality for each causal structure. These descriptive results provide a general overview of how often participants chose the *normal* versus *abnormal* cause across conditions, before turning to comparisons with prior work and model-based analyses.

Table 4.1: Distribution of speaker responses by valence and normality (disjunctive structure).

Valence	**Normality**	**# of responses**	**Percentage**
Negative	Abnormal	20	38.5%
Negative	Normal	32	61.5%
Positive	Abnormal	7	13.5%
Positive	Normal	45	86.5%

Table 4.2: Distribution of speaker responses by valence and normality (conjunctive structure).

Valence	**Normality**	**# of responses**	**Percentage**
Negative	Abnormal	37	63.8%
Negative	Normal	21	36.2%
Positive	Abnormal	23	39.7%
Positive	Normal	35	60.3%

As shown in Table 4.1, in the disjunctive condition, participants tended to choose the *normal* cause in both framings (86.5% under positive; 61.5% under negative). In contrast, the conjunctive condition (Table 4.2) shows a clearer sensitivity to valence: normal-cause selections were above chance under positive framing (60.3%) but shifted toward *abnormal* causes under negative framing (63.8%). Thus, the classic structure effect (disjunctive → normal; conjunctive → abnormal) appears only partially in these descriptives and depends on outcome valence, with the strongest shift occurring in the conjunctive condition.

Figure 4.1 illustrates the stylized expectation based on prior literature(Kirfel et al. (2021)), according to which participants are typically more likely to select the *normal* cause in disjunctive structures and the *abnormal* cause in conjunctive structures, independent of outcome valence.

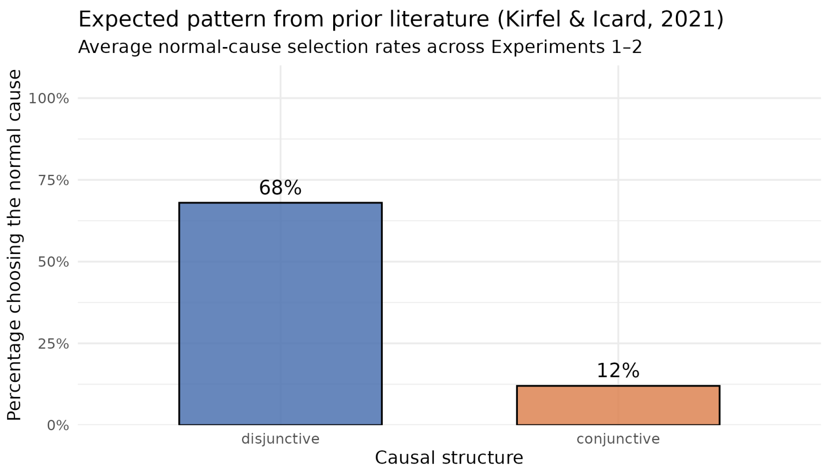


Figure 4.1: Stylized expectation from Kirfel et al. (2021): predicted proportion of normal-cause selections by causal structure.

Figure 4.2 shows the aggregated results from the current experiment, collapsed across valence framing. The pattern follows the general direction reported in previous studies, with participants choosing the normal cause more often in disjunctive than in conjunctive structures (74% vs. 48%). However, the difference is smaller than what has been observed in earlier work, mainly because participants selected the normal cause more frequently in conjunctive cases.

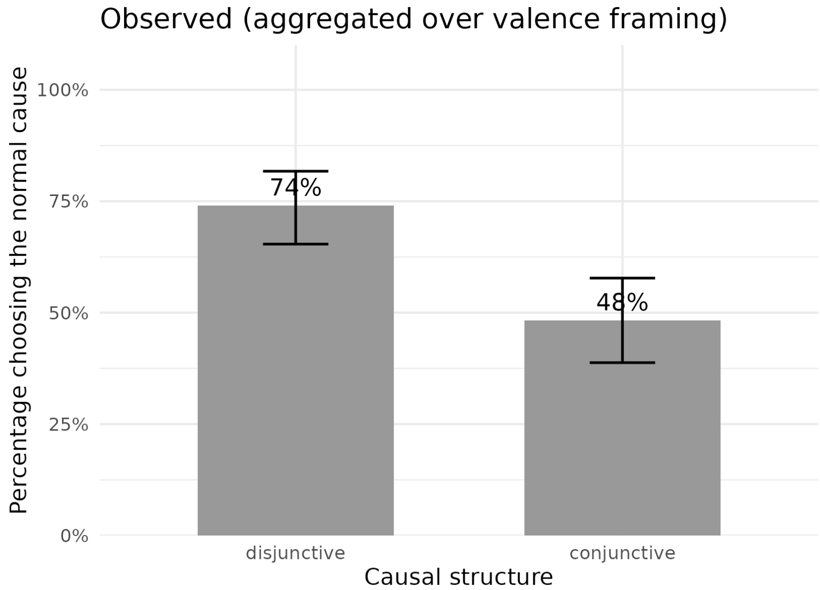


Figure 4.2: Observed data aggregated over valence framing: percentage of normal-cause selections by causal structure (disjunctive: 74%; conjunctive: 48%).

When valence framing is considered separately, a systematic shift becomes apparent. Under positive framing (Figure 4.3), participants predominantly selected the normal cause in both structures (87% in disjunctive, 60% in conjunctive). Under negative framing (Figure 4.4), this preference was reduced, particularly in the conjunctive condition (62% in disjunctive vs. 36% in conjunctive). Together, these results indicate that outcome valence modulated participants' explanatory choices, weakening the preference for normal causes when outcomes were negatively framed.

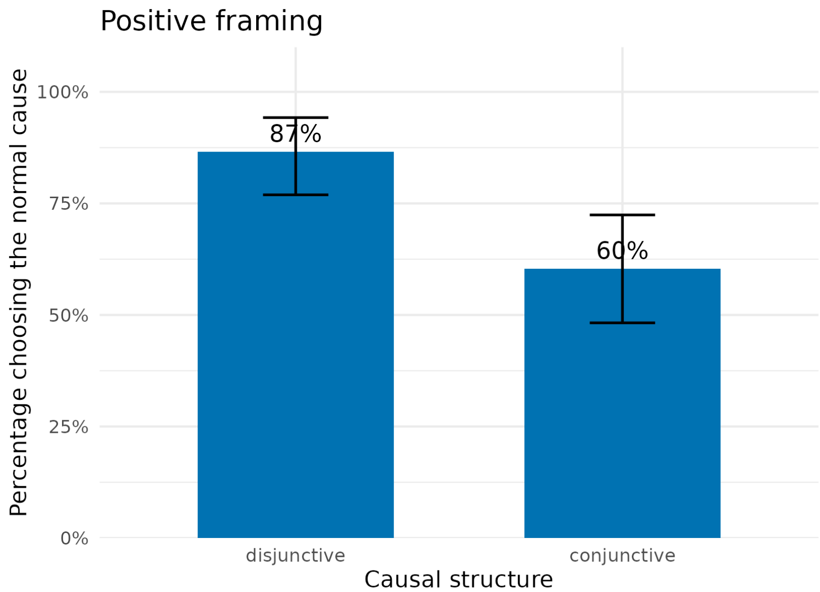


Figure 4.3: Proportion of normal-cause selections under positive framing.

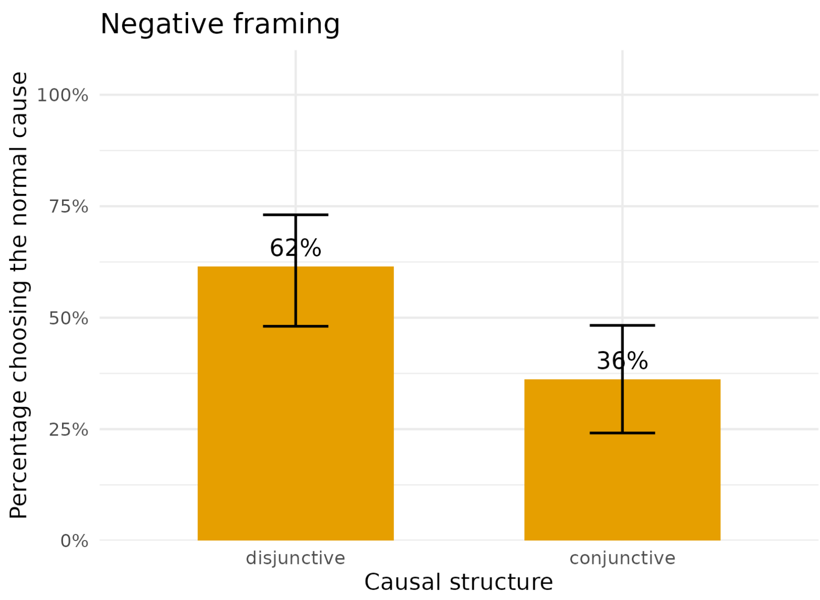


Figure 4.4: Proportion of normal-cause selections under negative framing.

Figure 4.5 summarizes the full interaction between valence framing and causal structure. In the positive framing, both structures show a clear preference for normal causes, though the disjunctive advantage remains visible. In contrast, under negative framing, this preference is substantially weaker and partially reversed in the conjunctive structure, suggesting that negative outcomes may highlight abnormal or blameworthy causes.

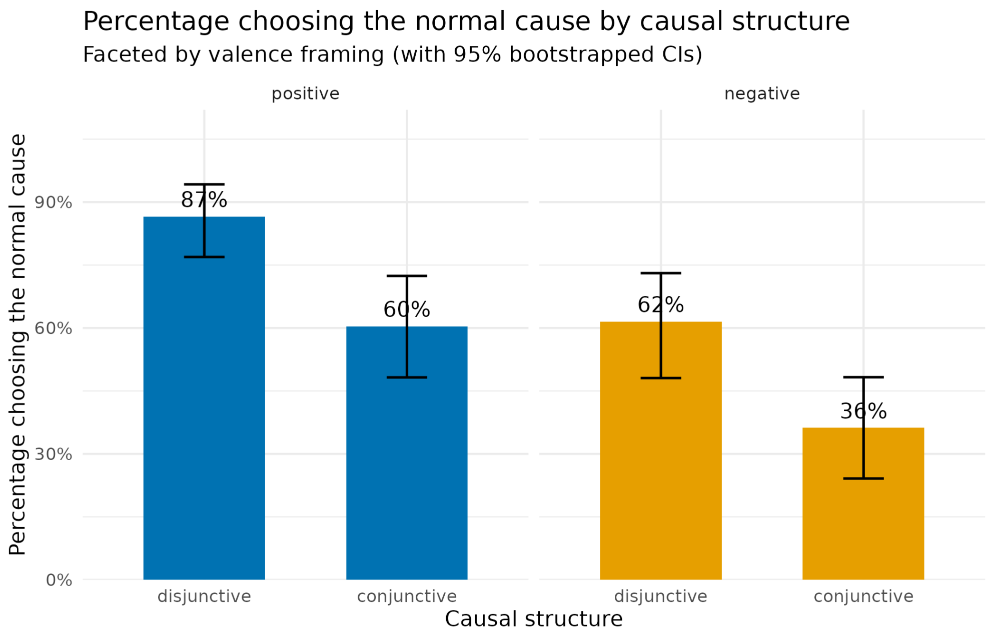


Figure 4.5: Percentage choosing the normal cause by causal structure, faceted by valence framing.

Bayesian Logistic Regression

To test whether valence framing influenced participants' causal selections, hierarchical Bayesian logistic regressions were fitted separately for the disjunctive and conjunctive structures, using a Bernoulli likelihood and logit link:

$$\texttt{normal\_choice} \sim \texttt{valence} + (1 + \texttt{valence} \,||\, \texttt{submission\_id})$$

The dependent variable (`normal_choice`) was coded as 1 when the participant selected the *normal* cause and 0 otherwise. The model included a fixed effect of valence (positive framing as baseline) and by-participant random intercepts and slopes for valence.

Posterior estimates for the disjunctive structure indicated a strong overall bias toward selecting the normal cause ($\beta_{\text{Intercept}} = 3.13$, 95% CrI [1.53, 5.57]), corresponding to a predicted probability of approximately 0.96 under positive framing. The estimated effect of negative framing ($\beta_{\text{valence-negative}} = -2.07$, 95% CrI [-4.65, 0.30]) suggested fewer normal-cause selections under negative framing, although the credible interval included zero, implying that the evidence is *inconclusive* for this condition.

The directional posterior probability that negative framing decreased normal-cause selections was 0.962.

For the conjunctive structure, posterior estimates revealed a weaker overall preference for normal causes ($\beta_{\text{Intercept}} = 0.88$, 95% CrI [-0.53, 2.51]) and a stronger negative valence effect ($\beta_{\text{valence-negative}} = -2.40$, 95% CrI [-4.71, -0.76]).

The credible interval excluded zero, providing clear evidence that negative framing reduced the likelihood of choosing the normal cause in conjunctive scenarios. The directional posterior probability for this contrast was 0.999, indicating strong support for the hypothesis that negative framing decreases normal-cause selections.

Table 4.3: Posterior probabilities for directional hypotheses on valence framing by causal structure (speaker task).

Causal structure	**Hypothesis**	**Posterior probability**
Disjunctive	negative < positive	0.962
Conjunctive	negative < positive	0.998

Overall, the results only partly reflect the expected pattern. Participants still preferred the normal cause in disjunctive structures, but in conjunctive cases this tendency did not reverse as strongly as reported in previous studies. In fact, under positive framing, normal causes were chosen more than half of the time, suggesting a weaker or less consistent structure effect. However, this pattern changes when the outcome is negative. Negative framing reduced this tendency somewhat, but the difference remained smaller than expected.

Full posterior summaries and diagnostic checks for all models are reported in Appendix B.

4.2 Listener Task

The listener task employed the same two causal structures (disjunctive vs. conjunctive) and valence framings (positive vs. negative) as in the speaker task. Participants judged the perceived normality of the cause on three ordered categories (*abnormal* < *equal* < *normal*). The analysis examined how inferred cause normality varied across structure and valence, using ordinal regression models with by-participant random effects.

Overview of Inferences

Figure 4.6 illustrates the expected pattern derived from prior literature (Kirfel et al., 2021), according to which listeners should more often infer a *normal* cause in disjunctive structures than in conjunctive ones. Figure 4.7 shows the aggregated outcomes from the present study, averaged across valence framing. Although the overall direction is consistent with this expectation, the effect appears considerably weaker than in previous findings.

When valence framing is considered, a clearer picture emerges. Under positive framing (Figure 4.8), participants inferred a *normal* cause more often in disjunctive than in conjunctive structures (46% vs. 29%), consistent with the expected structural asymmetry. Under negative framing (Figure 4.9), this difference nearly disappears (35% vs. 33%), suggesting that negative valence reduces or masks the structural effect. The combined overview in Figure 4.10 summarizes this interaction, showing that while the disjunctive advantage remains visible under positive framing, it becomes negligible under negative framing.

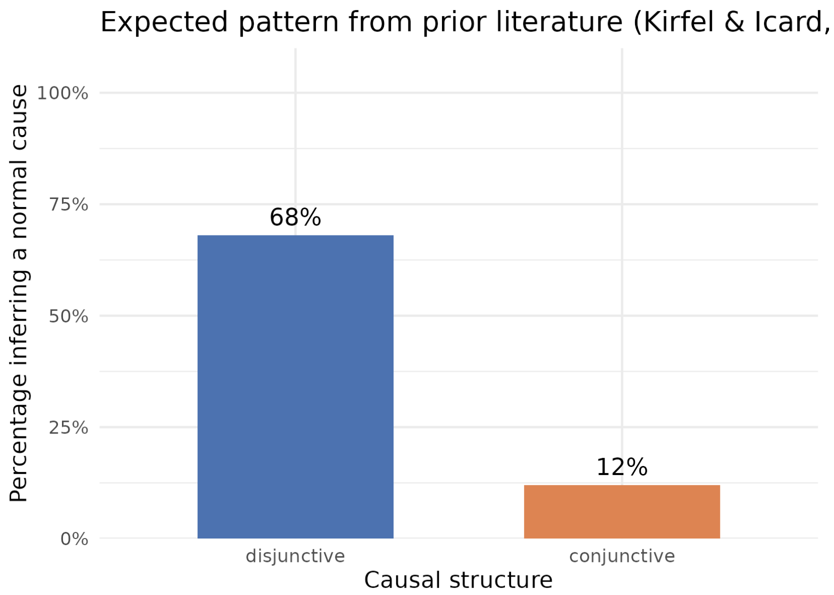


Figure 4.6: Listener: stylized expectation from prior literature; bar heights reflect normal-cause rates reported by Kirfel et al. (2021).

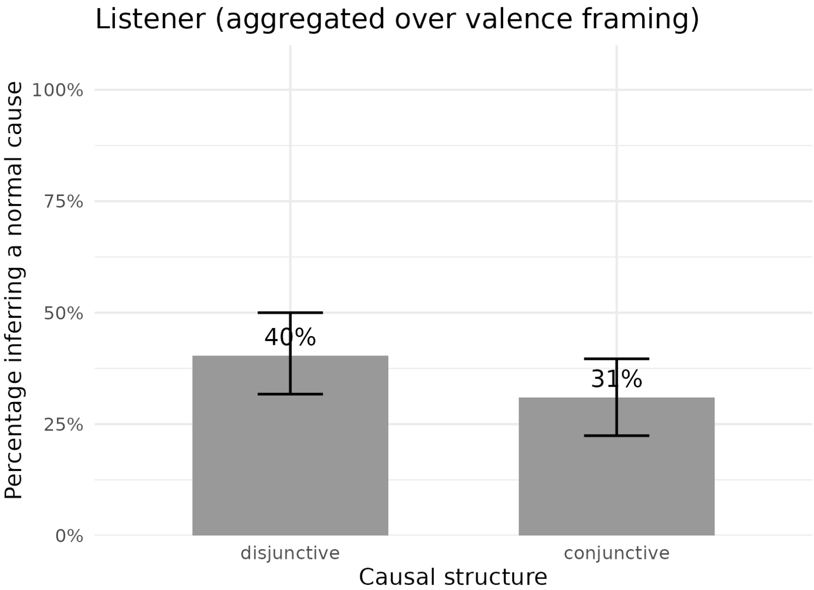


Figure 4.7: Listener: observed proportion of *normal* inferences by structure, aggregated over valence.

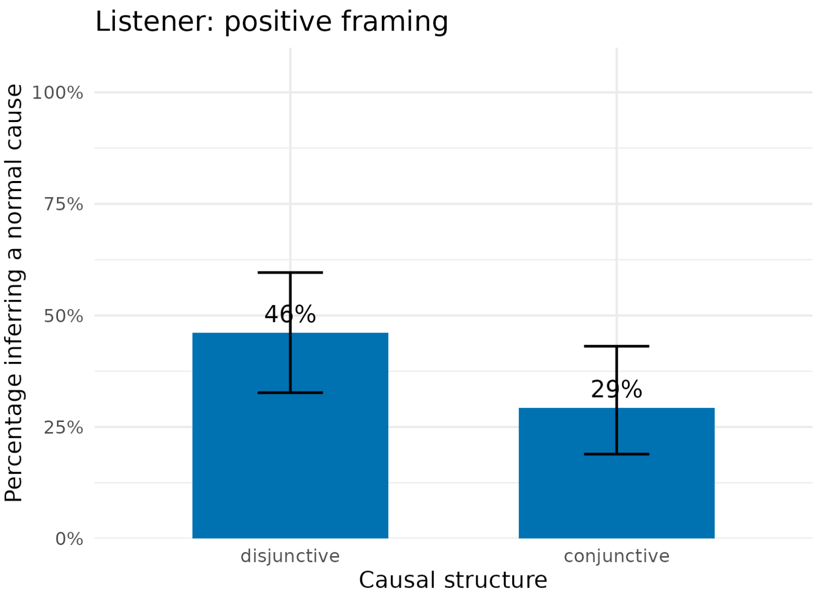


Figure 4.8: Listener: proportion of *normal* inferences under positive framing.

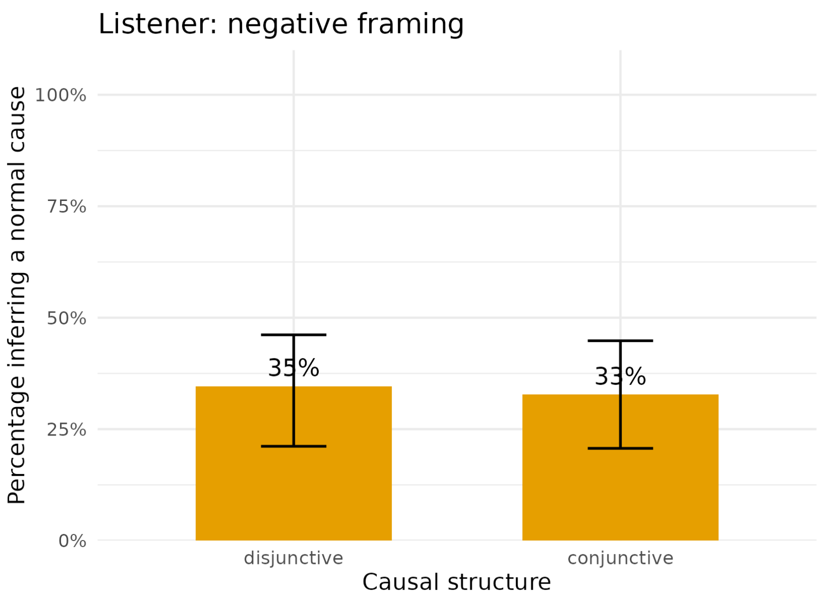


Figure 4.9: Listener: proportion of *normal* inferences under negative framing.

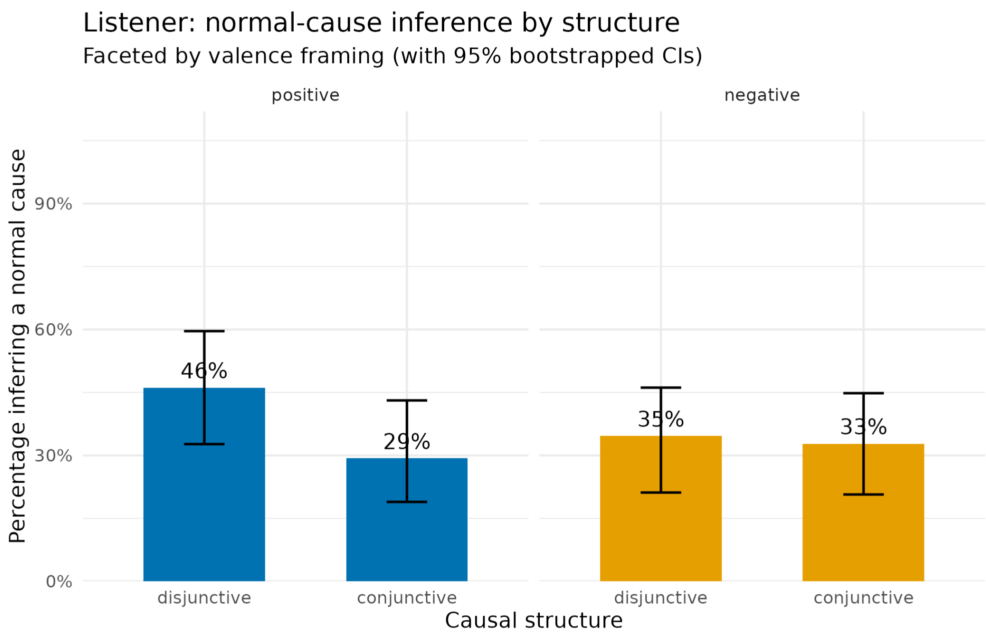


Figure 4.10: Listener: percentage inferring a *normal* cause by structure, faceted by valence framing.

Bayesian Ordinal Regression

Listener judgments were analyzed using hierarchical Bayesian *ordinal* regressions (cumulative logit), fitted separately for the disjunctive and conjunctive structures:

$$\texttt{cause\_inferred} \sim \texttt{valence} + (1 + \texttt{valence} \,||\, \texttt{submission\_id})$$

The dependent variable (`cause_inferred`) was treated as an ordered factor with three levels (*abnormal* < *equal* < *normal*). Each model included a fixed effect of valence and random intercepts and slopes for participants. Posterior predictive checks indicated satisfactory model fit (see Appendix B).

In the disjunctive structure, the estimated effect of negative framing was slightly negative ($\beta_{\text{valence-negative}} = -0.48$, 95% CrI $[-1.23, 0.28]$), suggesting that participants under negative framing were marginally less likely to infer the cause as *normal*. However, the credible interval included zero, indicating substantial uncertainty about this trend. Posterior category probabilities (Table 4.4) show that *normal* inferences were somewhat more frequent under positive framing (0.45 [0.29, 0.60]) than under negative framing (0.34 [0.19, 0.50]). The directional posterior probability that negative framing reduced normal inferences was $p = 0.89$ (Table 4.6), which constitutes weak-to-moderate evidence for a valence effect.

Table 4.4: Posterior estimated probabilities for each inference category by valence (listener task, disjunctive condition).

Valence	**Category**	**Mean**	**95% CrI**
Positive	Abnormal	0.31	[0.18, 0.46]
Positive	Equal	0.42	[0.26, 0.59]
Positive	Normal	0.45	[0.29, 0.60]
Negative	Abnormal	0.25	[0.16, 0.35]
Negative	Equal	0.45	[0.29, 0.60]
Negative	Normal	0.34	[0.19, 0.50]

In the conjunctive structure, the estimated valence effect was near zero ($\beta_{\text{valence-negative}} = 0.23$, 95% CrI $[-0.43, 0.89]$), with a wide credible interval spanning both positive and negative values. The probability of inferring a *normal* cause was similar across framings—0.36 [0.27, 0.46] under positive and 0.32 [0.21, 0.45] under negative framing, yielding a weak directional probability ($p = 0.25$) that negative < positive (Table 4.5). Thus, there was no reliable evidence that outcome valence systematically affected listeners' inferences in this condition.

Table 4.5: Posterior estimated probabilities for each inference category by valence (listener task, conjunctive condition).

Valence	**Category**	**Mean**	**95% CrI**
Positive	Abnormal	0.36	[0.24, 0.49]
Positive	Equal	0.31	[0.20, 0.44]
Positive	Normal	0.36	[0.27, 0.46]
Negative	Abnormal	0.36	[0.27, 0.46]
Negative	Equal	0.28	[0.17, 0.39]
Negative	Normal	0.32	[0.21, 0.45]

Table 4.6 summarizes the posterior directional probabilities across both struc-

tures. While both models favor the direction of negative < positive, only the disjunctive structure shows mild evidence for such an effect.

Table 4.6: Directional posterior probabilities for the *normal* category, p(negative < positive) (listener task).

Causal structure	**Hypothesis**	**Posterior probability**
Disjunctive	negative < positive	0.89
Conjunctive	negative < positive	0.25

Overall, listeners inferred a *normal* cause more often in disjunctive than in conjunctive structures, consistent with the expected structural asymmetry. However, the influence of outcome valence was weak and uncertain across both structures. Negative framing showed a small tendency to reduce normal inferences in the disjunctive condition but virtually no effect in the conjunctive one. In general, the listener data parallel the pattern observed in the speaker task but with attenuated magnitudes, suggesting that valence exerts only a subtle influence on causal inference.

5. Discussion

The results only partially replicated the previous findings described in Hypotheses 1 and 2. While participants tended to prefer normal causes in the disjunctive structure, as predicted by Hypothesis 1, the pattern was less consistent in the conjunctive structure, where normal causes were also chosen in nearly half of the trials on average (see Figure 4.2). This suggests that the effect of causal structure may be weaker or more context-dependent than previously observed. It is possible that in this gamified setup, participants focused more on surface-level cues, such as what appeared reasonable or typical to explain the outcome, rather than fully reasoning through the logical structure of the game. As shown in Figure 4.5, valence framing also appeared to influence causal selection, providing some support for Hypothesis 3. This means that how an outcome is framed, whether as success(positive) or failure(negative), can subtly shift people's explanatory preferences even when the causal structures remain identical.

The results from the Listener task only partially support Hypothesis 2. In both negative and positive framings, fewer than half of the participants inferred the normal cause in disjunctive cases, suggesting a general tendency to interpret the abnormal event as the cause. This pattern indicates that listeners may not automatically use structural knowledge to reconstruct normality from an explanation, or that the cues available in the explanations were not strong enough to trigger this inference. The framing manipulation also showed only a weak influence on participants' inferences of normality, suggesting that valence framing may shape explanatory production more strongly than interpretation. In other words, speakers seem more sensitive to the evaluative tone of the outcome than listeners, who must rely on sparse linguistic and structural information to infer what counts as normal.

These mixed results highlight the complexity of the relationship between causal structure, normality, and valence framing. While the theoretical framework based on Kirfel et al. (2021) and related work (Icard et al., 2017; Gerstenberg, 2022) predicts systematic dependencies between these factors, the present findings suggest that such effects may not be robust across different task formats and communicative perspectives. Even small changes in the context, such as who is speaking or how the outcome is framed, may alter how people interpret causal relevance. This variability supports the idea that causal explanation is not merely a mechanical reflection of structural relations, but a flexible communicative act shaped by pragmatic and affective considerations.

The small sample size and the subtle nature of the valence manipulation limit the strength of these effects. The gamified vignettes also simplified the causal contexts, and the potential influence of agent identity could not be tested due to design constraints. It is possible that the agent performing the cause (e.g., Alice or Bob) interacts with valence framing in shaping causal judgments. Future studies could address this possibility by using richer narratives and more detailed vignettes to test whether agent identity influences explanatory choice and causal inference. It would also be valuable to test whether stronger or more emotionally engaging framings, such as high-stakes outcomes or real-world scenarios, amplify the observed framing effects.

Overall, the findings highlight that even minimal changes in valence framing can influence how people communicate and interpret causal information. This suggests that causal explanation is a context-sensitive process, shaped not only by causal structure and event normality but also by the valence framing of outcomes. From a broader perspective, these results point toward a more dynamic understanding of explanation, one that integrates formal causal reasoning with pragmatic and affective dimensions of human communication.

6. Conclusion

The present study investigated how causal structure, event normality, and outcome valence framing influence causal selection and inferences about normality. Building on the communicative framework of causal explanation proposed by Kirfel et al. (2021), the experiment examined whether people's causal judgments remain stable when the outcome of an event is framed positively or negatively. Participants completed two complementary tasks: in the *Speaker* task, they selected which cause best explained a given outcome, and in the *Listener* task, they inferred which event was more normal based on an explanation provided by a hypothetical speaker.

The results only partially replicated previous findings. While participants preferred normal causes in the disjunctive condition, consistent with earlier work, this pattern was less clear in the conjunctive condition, where normal and abnormal causes were chosen with similar frequency. In the Listener task, participants inferred abnormal causes as more likely overall, suggesting that inferring normality from explanations is more difficult or context-sensitive than previously assumed. Across both tasks, valence framing showed a modest effect on causal selection, indicating that even subtle evaluative cues can shape explanatory preferences.

These findings contribute to ongoing discussions about the cognitive and communicative basis of causal explanation. They suggest that people's causal judgments are not determined only by structural relations and norms but are also shaped by pragmatic and affective factors.

The study's limitations include the relatively small sample size and the use of simplified, game-based vignettes. Additionally, potential effects of agent identity could not be examined due to design constraints. Future research could extend these findings by testing larger samples, using richer and more realistic scenarios, and systematically varying the valence of the outcomes. Such studies could clarify whether stronger framing manipulations or interpersonal factors amplify the effects observed here.

In conclusion, the present work provides initial evidence that valence framing can modulate how people explain and interpret causal events. Understanding this interaction between causal reasoning and framing can help refine existing models of causal explanation and shed light on how people communicate about causes in everyday life.

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References

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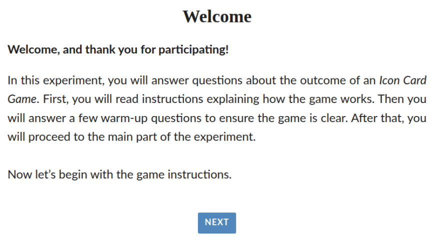
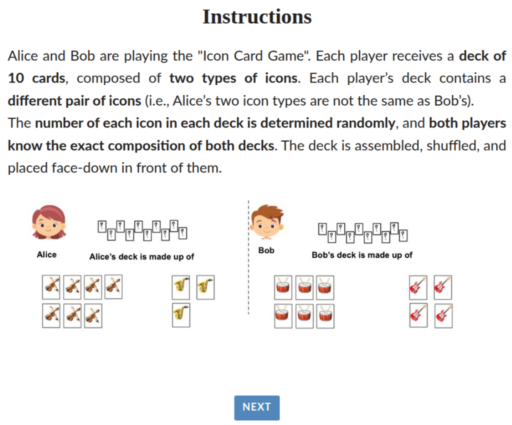
A. Appendix A: Experimental Materials

This appendix provides the full set of screenshots from the online experiment. Participants first read instructions and practiced with warm-up trials (with feedback), then completed the Speaker and Listener tasks.[1]

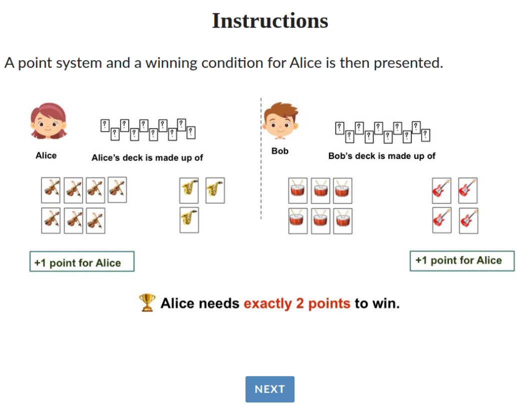
A.1 Instructions and Comprehension Screens



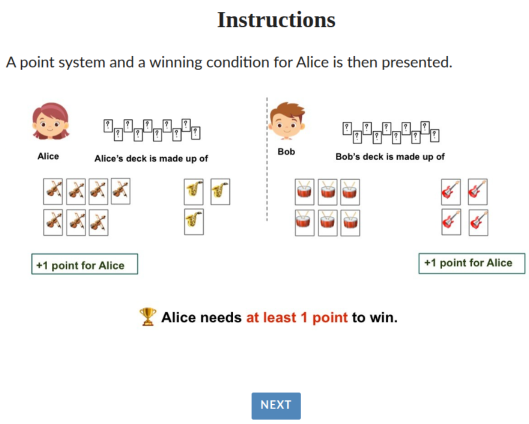
(a) Instruction 1: introduction to the game



(b) Instruction 2: task overview and rules

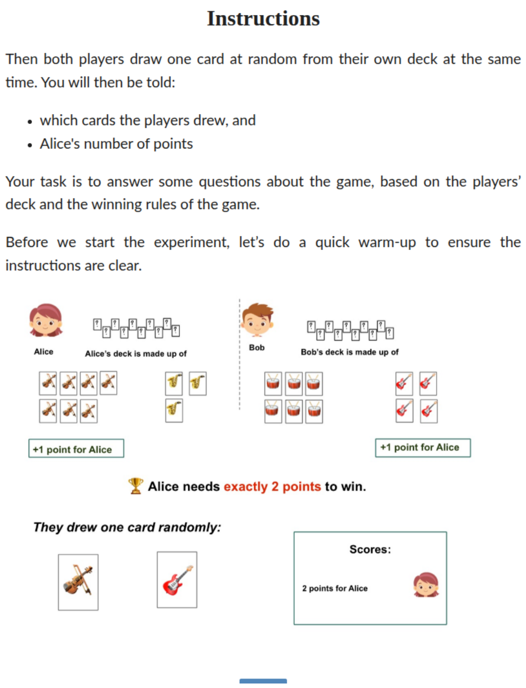


(a) Conjunctive structure example

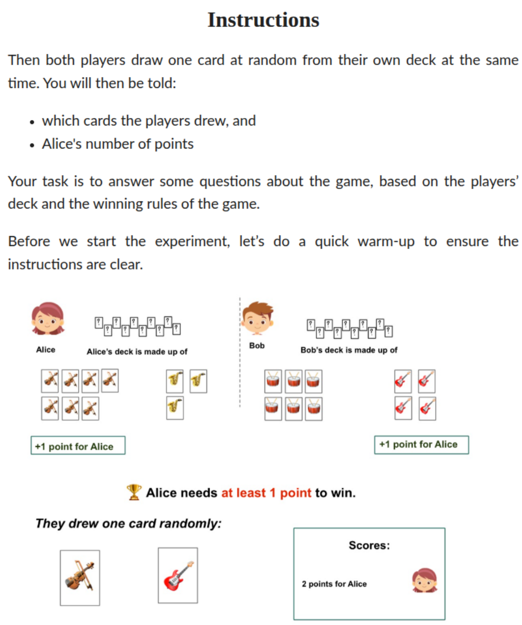


(b) Disjunctive structure example

[1]The full interactive version of the experiment can be accessed at https://aidayg24.github.io/causal_selection/.



(a) Goal and scoring (conjunctive)



(b) Goal and scoring (disjunctive)

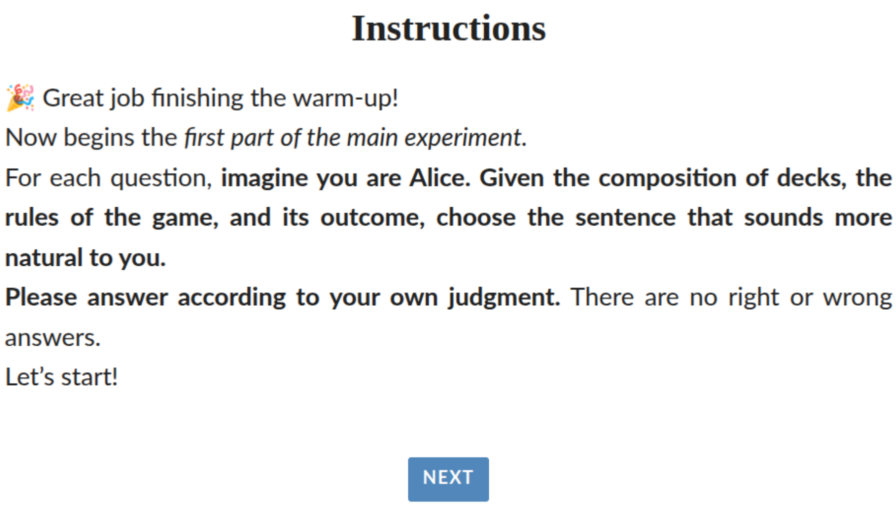
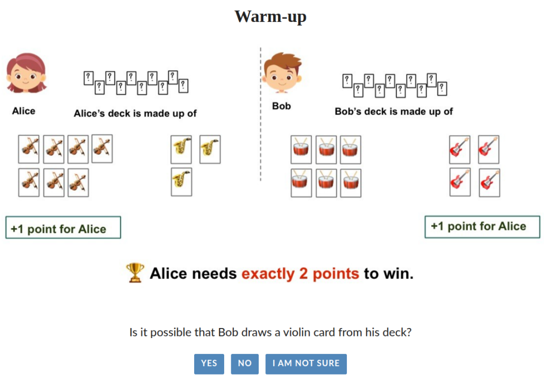
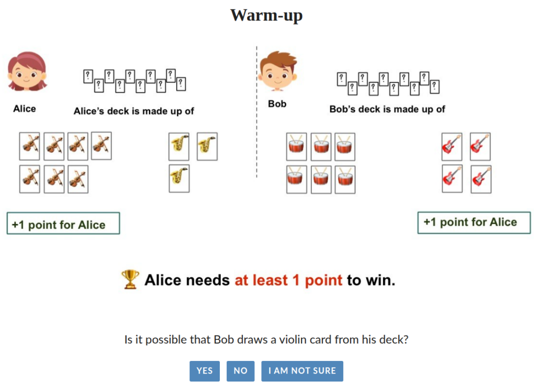


Figure A.4: End of warm-up before the speaker task

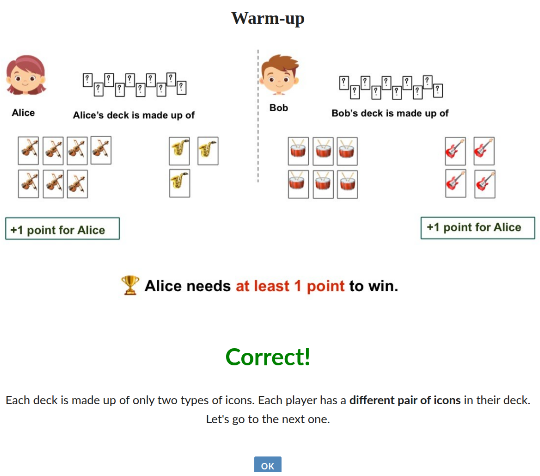
A.2 Warm-Up Trials (with Feedback)



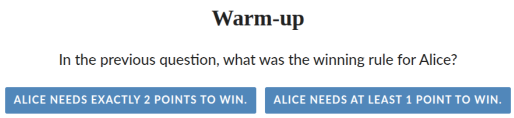
(a) Warm-up 1 (conjunctive)



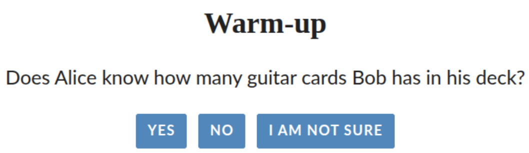
(b) Warm-up 1 (disjunctive)



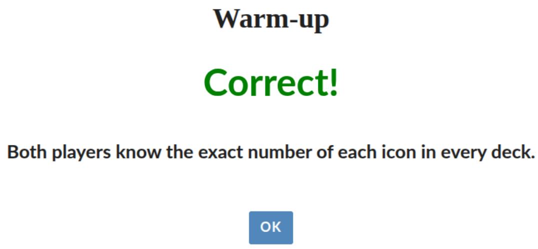
(a) Warm-up 1 feedback (disjunctive)



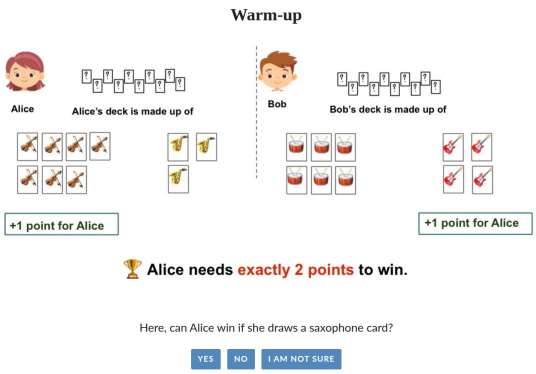
(b) Warm-up 2 (disjunctive)



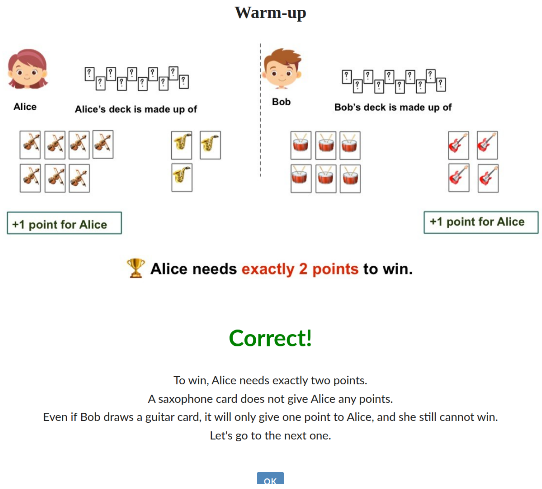
(a) Warm-up 3



(b) Warm-up 3 feedback (disjunctive)

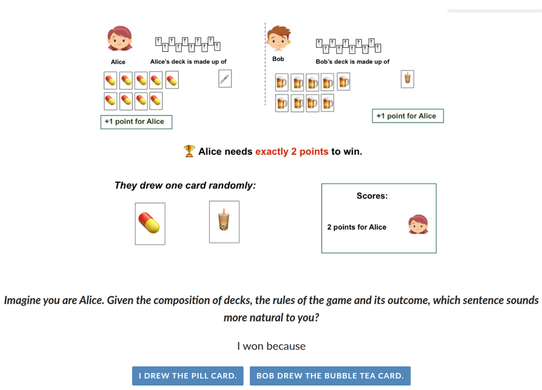


(a) warm-up only in conjunctive

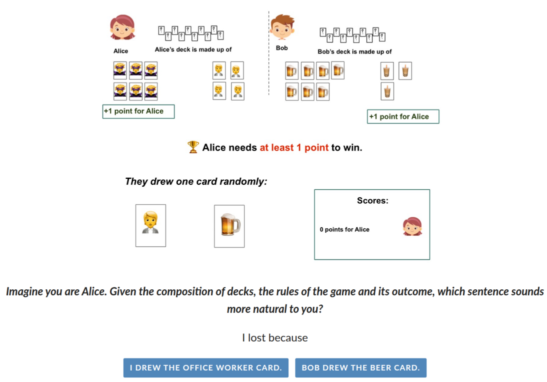


(b) warm-up only in conjunctive feedback

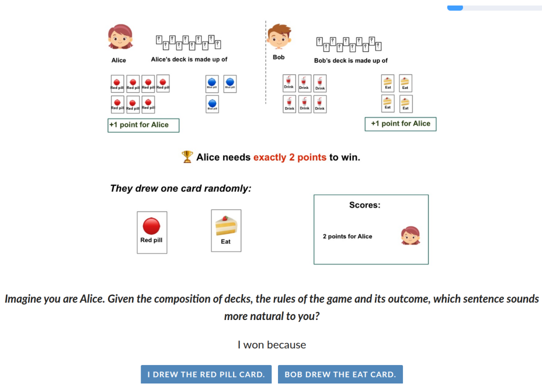
A.3 Speaker Task (Conjunctive and Disjunctive Examples)



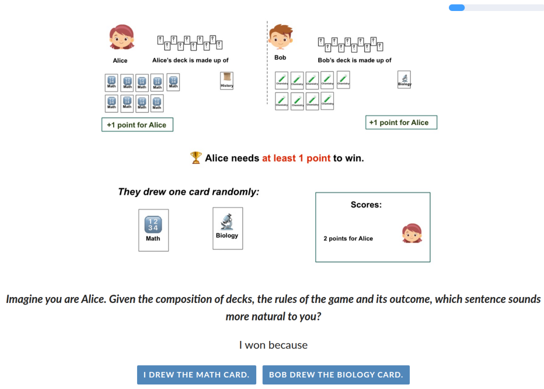
(a) Speaker trial (conjunctive) 1



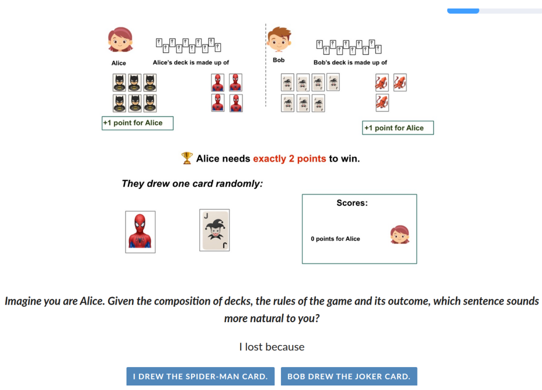
(b) Speaker trial (disjunctive) 1



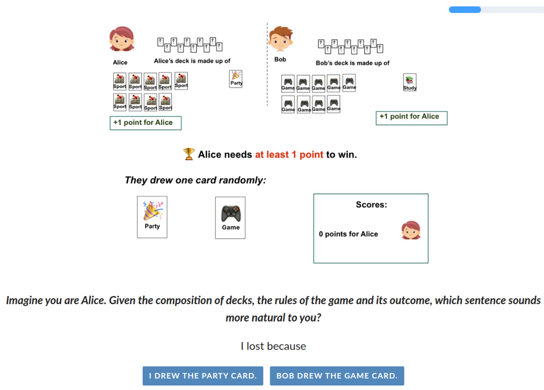
(a) Speaker trial (conjunctive) 2



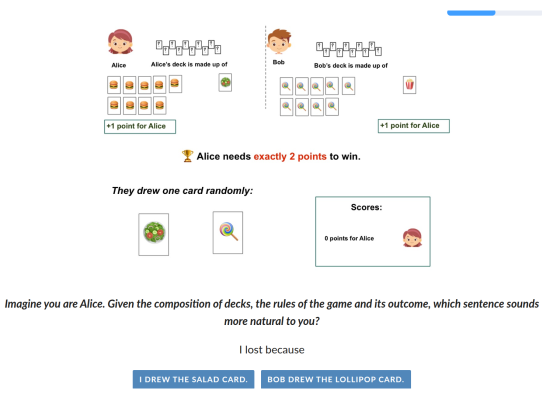
(b) Speaker trial (disjunctive) 2



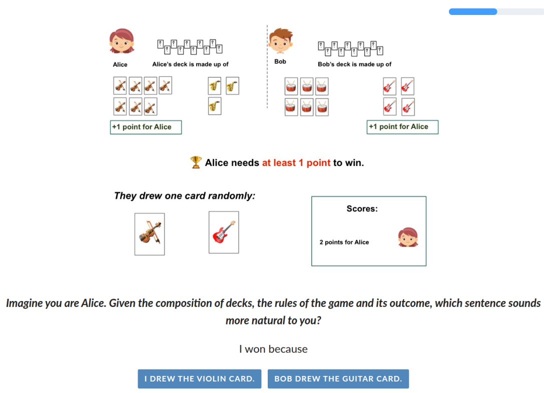
(a) Speaker trial (conjunctive) 3



(b) Speaker trial (disjunctive) 3



(a) Speaker trial (conjunctive) 4



(b) Speaker trial (disjunctive) 4

A.4 Listener Task (Instructions and Examples)

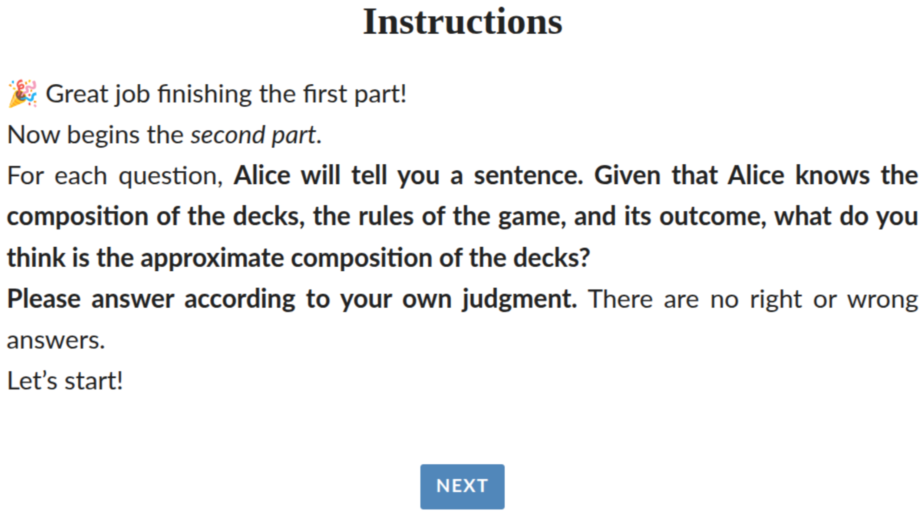
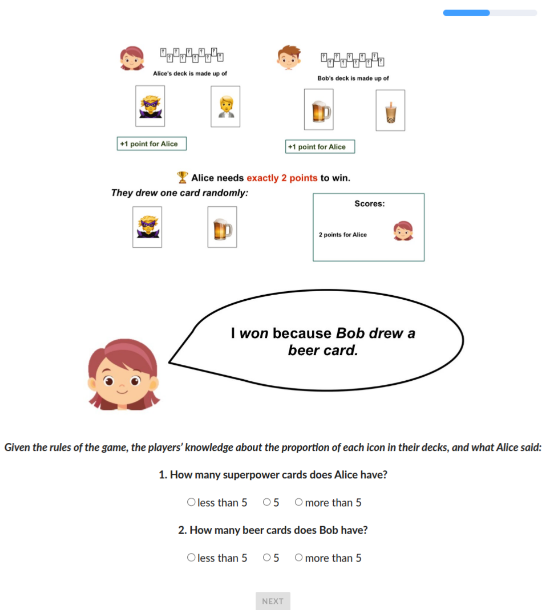
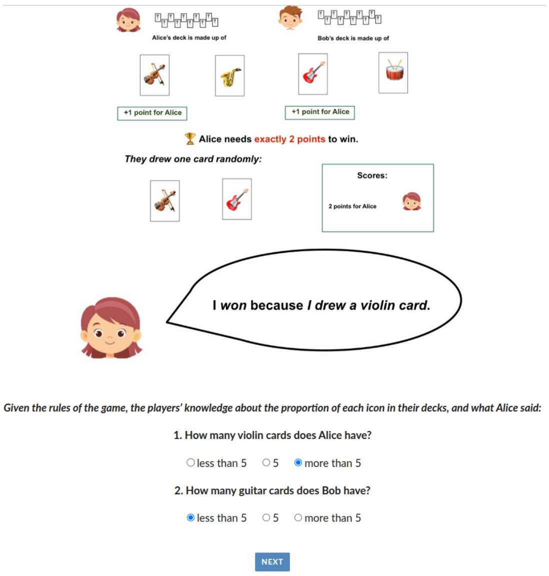


Figure A.13: Listener task: start screen

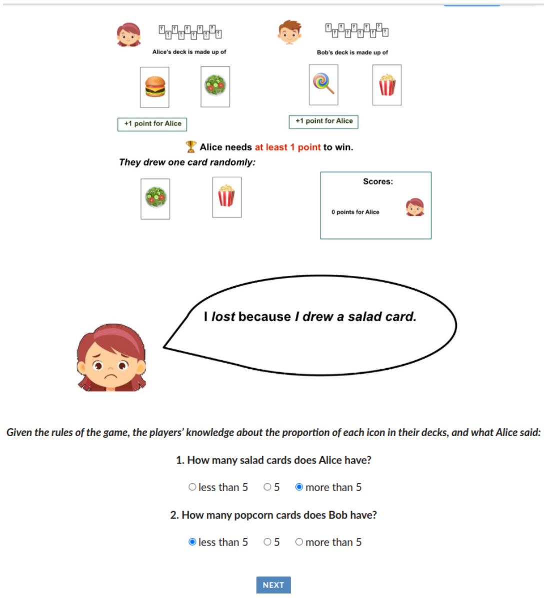


(a) Listener trial (conjunctive) 1

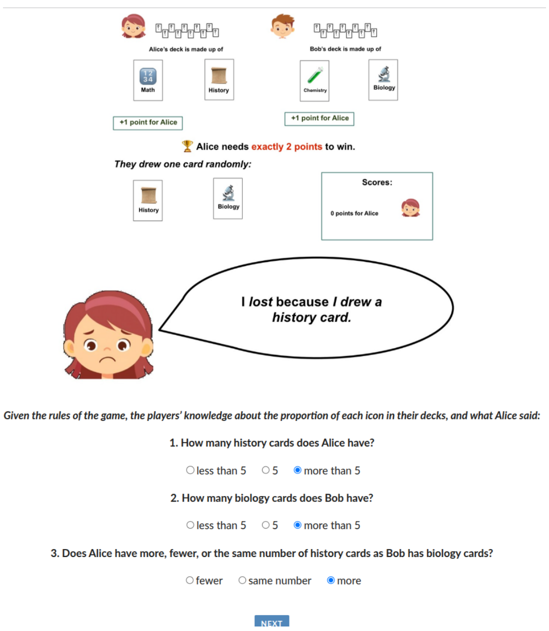
(b) Listener trial (disjunctive) 1



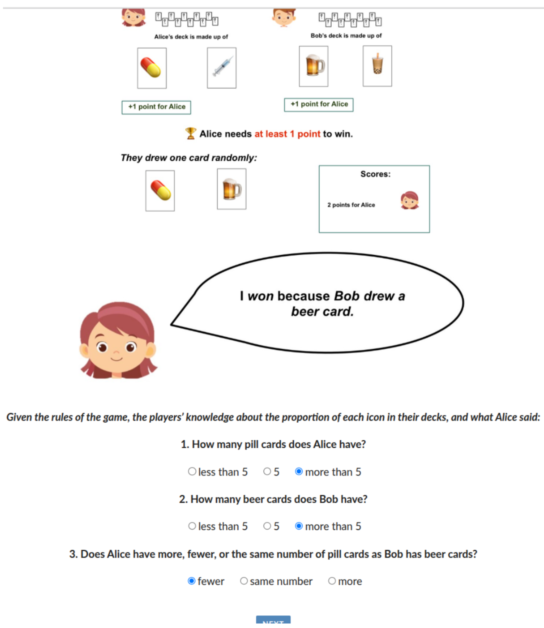
(a) Listener trial (conjunctive) 2



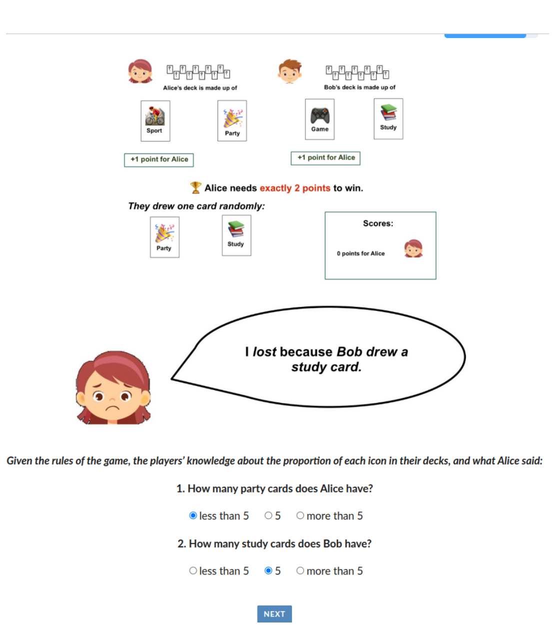
(b) Listener trial (disjunctive) 2



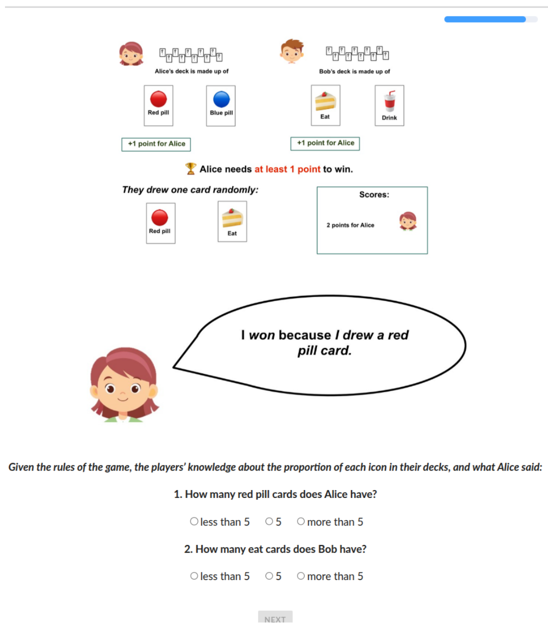
(a) Listener trial (conjunctive) 3



(b) Listener trial (disjunctive) 3

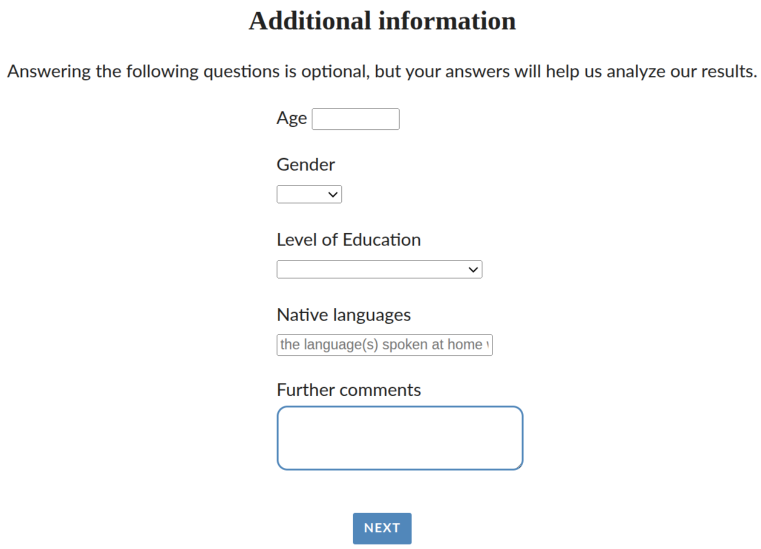


(a) Listener trial (conjunctive) 4



(b) Listener trial (disjunctive) 4

A.5 Completion Screen



Final submission / thank-you screen.

B. Appendix B: Bayesian Regression Models

B.1 Bayesian Regression Model Fitting Code for Speaker Task

Model specification:

```
m_bayes <- brm(
  formula = normal_choice ~ valence + (1 + valence || submission_id),
  data    = speaker_dat,
  family  = bernoulli(link = "logit"),
  prior = c(
    prior(normal(0, 1.5), class = "Intercept"),
    prior(normal(0, 1),   class = "b"),
    prior(exponential(1), class = "sd")
  ),
  chains  = 4, iter = 4000, warmup = 1000,
  seed    = 1702,
  cores   = parallel::detectCores() - 1
)
```

—

B.2 Bayesian Regression Model Outputs for Speaker Task

B.2.1 Disjunctive Structure

Model:
`normal_choice ∼ valence + (1 + valence ‖ submission_id)`
Family: Bernoulli (logit link)
Chains: 4, **Iterations:** 4000 (1000 warmup)
Observations: 104, **Participants:** 26

```
Multilevel Hyperparameters:
~submission_id (Number of levels: 26)
                    Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
sd(Intercept)           2.36      1.05     0.58     4.78 1.00     3281     3052
sd(valencenegative)     3.08      1.66     0.39     6.92 1.00     3186     2894

Regression Coefficients:
                Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
Intercept           3.13      1.04     1.53     5.57 1.00     5537     5676
valencenegative    -2.07      1.23    -4.65     0.30 1.00     6585     6893
```

All diagnostics were satisfactory ($\hat{R} = 1.00$ for all parameters; high effective sample sizes).

—

B.2.2 Conjunctive Structure

Model:
`normal_choice` $\sim$ `valence + (1 + valence` $\|$ `submission_id)`
Family: Bernoulli (logit link)
Chains: 4, **Iterations:** 4000 (1000 warmup)
Observations: 116, **Participants:** 29

```
Multilevel Hyperparameters:
~submission_id (Number of levels: 29)
                    Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
sd(Intercept)           3.15      1.02     1.60     5.59 1.00     3461     5196
sd(valencenegative)     2.28      1.41     0.14     5.62 1.00     2055     3396

Regression Coefficients:
                Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
Intercept           0.88      0.76    -0.53     2.51 1.00     5604     6959
valencenegative    -2.40      0.99    -4.71    -0.76 1.00     5238     4096
```

Diagnostics confirmed convergence ($\hat{R} = 1.00$; no divergences). Posterior predictive checks suggested an adequate fit.

B.3 Bayesian Regression Model Fitting Code for Listener Task

Model specification:

```
m_listener_ord <- brm(
  cause_inferred ~ valence + (1 + valence || submission_id),
  data   = listener_ord,
  family = cumulative(link = "logit"),
  prior  = c(
    prior(normal(0, 1.5), class = "Intercept"),   # thresholds
    prior(normal(0, 1.0), class = "b"),
    prior(exponential(1), class = "sd")
  ),
  chains = 4, iter = 4000, warmup = 1000, seed = 1702
)
```

—

B.4 Bayesian Regression Model Outputs for Listener Task

B.4.1 Disjunctive Structure

Model:
`cause _ inferred` $\sim$ `valence + (1 + valence` $\|$ `submission_id)`
Family: Cumulative (logit link)
Chains: 4, **Iterations:** 4000 (1000 warmup)
Observations: 104, **Participants:** 26

```
Multilevel Hyperparameters:
~submission_id (Number of levels: 26)
                     Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
sd(Intercept)            0.84      0.43     0.07     1.72 1.00     2767     4240
sd(valencenegative)      0.54      0.43     0.02     1.60 1.00     3896     5442

Regression Coefficients:
                 Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
Intercept[1]        -0.82      0.34    -1.51    -0.17 1.00     8973     8168
Intercept[2]         0.23      0.33    -0.42     0.90 1.00    11651     8052
valencenegative     -0.48      0.39    -1.23     0.28 1.00    13275     8255
```

Diagnostics confirmed excellent convergence ($\hat{R} = 1.00$ for all parameters, no divergences, high effective sample sizes). The valence effect ($\beta_{\text{valence-negative}} = -0.48$) was small and uncertain, with a wide credible interval including zero.

—T

B.4.2 Conjunctive Structure

Model:
`cause _ inferred` $\sim$ `valence + (1 + valence` $\|$ `submission_id)`
Family: Cumulative (logit link)
Chains: 4, **Iterations:** 4000 (1000 warmup)
Observations: 116, **Participants:** 29

```
Multilevel Hyperparameters:
~submission_id (Number of levels: 29)
                     Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
sd(Intercept)            0.49      0.32     0.02     1.17 1.00     2887     5204
sd(valencenegative)      0.30      0.25     0.01     0.92 1.00     5748     5161

Regression Coefficients:
                 Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
Intercept[1]        -0.57      0.28    -1.15    -0.03 1.00     9540     8697
Intercept[2]         0.98      0.29     0.43     1.58 1.00    12480     8490
valencenegative      0.23      0.34    -0.43     0.89 1.00    13794     8230
```

Diagnostics confirmed convergence ($\hat{R} = 1.00$ for all parameters, no divergences). Posterior predictive checks indicated a good model fit. The valence effect ($\beta_{\text{valence-negative}} = 0.23$) was close to zero, again with wide uncertainty.

Note: Parts of the phrasing and code formatting were refined with the help of OpenAI's ChatGPT (GPT-5). All analyses, interpretations, and final decisions were made independently by the author.

Acknowledgements

This thesis exists thanks to the time, patience, and generosity of many people. I am grateful to Prof. Dr. Michael Franke for his guidance and support, and to my friends for their encouragement. My deepest thanks go to my brother, whose belief in me made this journey possible.