Redundancy across Connectives*

Alexandros Kalomoiros
Heinrich Heine Universität Düsseldorf

Matthew Mandelkern
New York University

Paul Marty
Universidade de Lisboa

Jacopo Romoli
Heinrich Heine Universität Düsseldorf

Florian Schwarz
University of Pennsylvania

Abstract. We present an experimental investigation of redundancy effects across connectives, focusing on Hurford disjunctions, Hurford conditionals, and the corresponding conjunctions. We address whether clause order, polarity (negation), and the specific connective type affects redundancy strength. Our results show that all three factors modulate redundancy. Finally, we discuss options for how existing theoretical approaches to redundancy can be extended to accommodate our findings.

Keywords: Hurford disjunction, Hurford conditional, local contexts, triviality, simplification, (super-)redundancy, communicative principles

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1 Introduction

1.1 Redundancy Effects: Basic Data and Theoretical Approaches

Informativity is a core communicative principle: when asserting a sentence, a speaker is expected to convey information that is not already part of the interlocutors' common ground (Stalnaker 1974), as illustrated by the following contrast:

(1) CONTEXT: *we know that John lives in France.*
John lives in France.

(2) CONTEXT: *we have no idea where John lives.*
John lives in France.

In standard approaches that model contexts as a set of possible worlds and assertion as a proposal to intersect the context C with the proposition expressed by a sentence S (Stalnaker 1978), the informativity constraint can be expressed as follows:

(3) **Global informativity:**
A sentence S is infelicitous in a context C if $C \cap [\![S]\!] = C$.

The constraint in (3) is global, in that it applies to sentences as a whole and does not take into account their potentially complex internal structure. But as is well known, global informativity alone cannot explain all redundancy effects, e.g., the contrast below:

(4) CONTEXT: *we have no idea where John lives.*
a. John lives in Paris.
b. #John lives in Paris and he lives in France.

These sentences, taken as a whole, are contextually equivalent in expressing the proposition that John lives in Paris. Global Informativity thus treats them on par. Intuitively, however, (4b) is infelicitous, because the second conjunct is *locally* uninformative: living in Paris contextually entails living in France.

Local violations of informativity also are in play in so-called 'Hurford disjunctions' (Hurford 1974; see Marty & Romoli 2022 for an overview):

(5) CONTEXT: *we have no idea where John lives.*
a. John lives in France.
b. #Either John lives in France or he lives in Paris.

Here too, (5b) conveys the same information as (5a) and does therefore not violate Global Informativity. Nevertheless, the second disjunct intuitively is locally uninformative.

Two main approaches have been proposed to account for these redundancy effects: the Simplification approach (e.g., Katzir & Singh 2013) and the Local Context approach (e.g., Schlenker 2009).

Simplification attributes redundancy effects to a sentence being equivalent to one of its proper parts. More precisely, a sentence S displays a redundancy effect whenever it contains a constituent D whose removal yields a sentence S' contextually equivalent to S. That is, D is a *redundant constituent* of S. For example, a conjunction of the form $p^+ \wedge p$, where p^+ entails p, suffers from redundancy because it is equivalent to p^+ (hence p is redundant). Similarly, a disjunction of the form $p \vee p^+$ gives rise to redundancy because it is equivalent to p (hence p^+ is redundant).

According to the Local Context approach, a sentence is odd when one of its parts is either entailed by or inconsistent with its local context. While different formal implementations exist, all agree that the local context for q in $p \wedge q$ is $C \cap p$, and that for q in $p \vee q$ is $C \cap \neg p$. Thus, $p^+ \wedge p$ gives rise to redundancy because p is entailed by its local context, and $p \vee p^+$ gives rise to redundancy because p^+ is inconsistent with its local context.

1.2 Questions for Experimental Investigation

We experimentally test three questions, which are motivated (at least partially) by controversial intuitions from the literature.

First, while there is widespread agreement that $p^+ \wedge p$ is infelicitous, opinions diverge on the status of $p \wedge p^+$ (see Mayr & Romoli 2016, Katzir & Singh 2013 among others). By contrast, both orders of Hurford disjunctions are generally judged infelicitous. In light of the potential role of order for at least some connectives, we thus ask:

Q1 (Effect of order): Can clause order affect redundancy effects?

The basic setup of the Simplification and Local Contexts approaches is compatible with either outcome for this question: they both can be fleshed out in asymmetric and symmetric variants, which respectively do or do not yield a role for order. The version of Simplification informally presented above is symmetric, but to obtain an asymmetric variant, one can replace the notion of contextual equivalence above with a notion of contextual equivalence holding fixed *just what is to the left of the deleted constituent* (Mayr & Romoli 2016). However, importantly, the choice point is a global one, not tied to particular expressions. An important consequence of this is that order effects are predicted to be *uniform across different connectives*: either connectives should be symmetric across the board, or asymmetric across the board.

The issue of order is more complex for the local-context approach. Significantly, however, recent local-context accounts, in particular Schlenker 2009 and Rothschild 2011, make the same predictions as the simplification approach discussed above.[1] These approaches can be formulated in an asymmetric version of the local-context approach, which takes into account only preceding material, or in a symmetric version, which takes into account both preceding and following material in a complex sentence. In either case, the prediction is that order effects should be uniform across connectives.

By comparing several connectives, we will test this prediction of uniform order sensitivity or insensitivity.

Another dimension of complexity with controversial intuitions reported in the literature is whether the presence of negation impacts redundancy effects. In particular, Kalomoiros (2023a) claims that (6b) suffers from redundancy to a lesser extent than (6a), even though in both cases, the second disjunct entails the first.

(6) a. #Either John lives in France or he lives in Paris.
b. #[?] Either John doesn't live in Paris or he doesn't live in France.

Similar issues arise for another case of redundancy effects, namely so-called *Hurford conditionals* (Mandelkern & Romoli 2018). These can be constructed from Hurford disjunctions by applying what we'll refer to as the *or-to-if* inference pattern, whereby (7b) follows from (7a):[2]

(7) a. #Either John lives in Paris or he lives in France.
b. #If John doesn't live in Paris, he lives in France.

Parallel to the above claim for disjunction, Mandelkern & Romoli (2018) argue that (8b), the conditional derived from the negated Hurford disjunction, suffers from redundancy to a lesser extent than (7b) (and may even display no redundancy effect at all):

(8) a. #[?] Either John doesn't live in France or he doesn't live in Paris.
b. If John lives in France, he doesn't live in Paris.

1 Traditional local-context approaches, going back to Heim 1983, can encode order effects directly in the meaning of connectives and therefore do not necessarily make the same uniform predictions. Such approaches have been criticized, however, for not being explanatory enough, so we set them aside here; see Schlenker 2009 for discussion. Schlenker 2009 and Rothschild (2011) are the only two local-context accounts we know of that address the explanatory challenge raised in that literature. We return to this issue in section 8.

2 Without any commitment at this point to what type of semantics underlies the 'or-to-if' inference (see Stalnaker 1975 among many others). We revisit the complex issue of conditional semantics in section 8.

Modulation of redundancy effects by negation is unexpected on both Simplification and Local Context, since both are based on entailment relations. By contrast, the proposal in Kalomoiros (2023a) introduces a notion of 'super-redundancy' which predicts polarity effects. We save more details for the general discussion, but for now we can just think of super-redundancy as a stricter notion of redundancy: something is super-redundant if it's redundant in an 'irredeemable way', in a sense to be specified below. Building on these theoretical differences, our second empirical question, focused on disjunctions and conditionals, then is :

Q2 (Effect of negation): Does negation impact redundancy effects (despite fixed entailment relations)?

Finally, we will also ask whether redundancy effects vary across connectives. Such differences could show up as general differences in strength, or as differences in the role of the various potential factors modulating redundancy effects. As highlighted above, the two main approaches in their standard form inherently provide no room for differences between connectives. But Kalomoiros's (2023a) super-redundancy hypothesis does predict such an effect of connective type. Our third questions thus also speaks to the need for a notion like super-redundancy.

Q3 (Effect of connective):

a. Does the strength of redundancy-based oddness vary across connectives?

b. Do the roles of order and polarity vary across connectives?

In sum, our three questions relate to various theoretical predictions: Q1 tests the uniformity prediction of the two standard approaches w.r.t. order-(in)sensitivity. Q2 and Q3 speak to the need for a notion of super-redundancy, which predicts polarity and connective effects.

To preview, our main findings and related theoretical considerations are as follows:

- **Non-uniform order effects**: We find effects of order, but these vary across connectives: Hurford disjunctions are degraded in both orders, conjunctions only in one order, while order in exhibits a complex interaction with polarity. This challenges the prediction, shared by the two approaches discussed above, that sensitivity to order should be uniform across connectives.

  These results also mirror recent findings of parallel non-uniform order effects in the presupposition literature (Mandelkern et al. 2020, Kalomoiros & Schwarz 2024) in interesting ways. This points to the need for a common

account of the two phenomena. As we discuss in 8.2, this unification appears easier to pursue within the Local Contexts tradition.

- **Polarity and connective-type effects**: Redundancy judgments in disjunctions and conditionals are polarity-sensitive. More generally, the effect of redundancy is connective-sensitive. This supports the integration of a notion like super-redundancy.

1.3 Overall Experimental Approach

In the theoretical literature, redundancy effects have been assumed to give rise to infelicity. Our experiments use an acceptability judgment task in order to detect this infelicity, asking participants to evaluate the naturalness of sentences presented in contexts. However, it is well known that redundant sentences can be rescued in various ways, at least to some extent. Speakers are capable of accommodating, enriching, or pragmatically reinterpreting apparently redundant material, and in many cases such material gives rise to additional inferences rather than straightforward infelicity.[3] But these complexities notwithstanding, to the extent that we find measurable decreases in acceptability based on manipulating whether or not a sentence contains redundant parts, we can take this as indicative of redundancy. And this logic, of course, extends to potential factors modulating redundancy effects, such as order, polarity and connective type.

To properly use acceptability to diagnose redundancy experimentally, it is necessary to ensure that other potential factors impacting acceptability are controlled for. We therefore look at relative differences in acceptability, contrasting critical redundant items with baselines that keep everything constant except redundancy. Correspondingly, we will not make much of absolute levels of acceptability (which also may be affected by the rescue strategies mentioned above). Potential modulating roles of order, polarity, and connective type will then be tested by looking at interactions, i.e., whether the difference between redundant items and non-redundant controls varies across different levels of the order, polarity and connective factors. The presence of such interactions would establish that the impact of the redundancy indeed gets modulated by these additional factors.

We report four experiments investigating redundancy and the potentially modulating roles of order, polarity, and connective type. The first two experiments examine disjunctions (section 2) and conditionals (section 3), respectively manipulating both

3 The mechanisms by which redundant information is made to "work" in discourse are themselves of independent theoretical interest, but not our focus here. For related work on informational redundancy and pragmatic enrichment, see Kravtchenko & Demberg (2022), Degen et al. (2020), Crone (2017), Rubio-Fernández (2016), among others.

order and polarity. Results for these two connectives are compared in section 4. The third experiment focuses on conjunction (section 5) and a possible modulating role of order. Section 6 compares conjunction to the other connectives. To obtain a within-subject comparison across connectives, a last experiment replicates key aspects of the prior studies in an accordingly adjusted design, in section 7. Sections 8 discusses implications of our findings for theoretical approaches to redundancy.

2 Experiment 1: Disjunction

The aim of this first experiment was to experimentally measure the impact of redundancy on disjunction, and furthermore to assess the potential modulating roles of negation and order. Concretely, we tested (i) whether the presence of an entailment relation between the two disjuncts decreases the naturalness ratings of these sentences in context; (ii) whether the order of the disjuncts influences any observed effects; and (iii) whether the presence of negation modulates this effect. Our analyses also take into account potential interactions of these factors.

2.1 Design

2.1.1 Measuring Redundancy

The critical conditions for the first experiment consisted of Hurford Disjunctions, where one disjunct asymmetrically entails the other, which generally is taken to lead to redundancy effects. To motivate the use of disjunction in the first place, disjunctive target sentences were presented with a context that ensured the disjuncts were plausible, salient alternatives. Participants' task was to indicate how natural the sentence was in the provided context. (9) illustrates a case where the first disjunct is redundant:

(9) CONTEXT: John and his family want to visit Asia. They have various destinations in mind, but the most prominent ones are cities in Japan, especially Tokyo. Recently, John and his family returned from their Asia trip, so I thought:
Either John's family visited Tokyo or they visited Japan. (HD-FIRST)

As noted in the overview of our experimental approach, our measure of redundancy effects is based on comparison with a baseline that is maximally similar, but crucially does not involve any redundancy. Our Simple Disjunction (SD) control condition is illustrated in (10), where the entailment relationship between the disjuncts has been removed (here by replacing 'Japan' with 'China', with corresponding adjustments in the context).

(10) CONTEXT: John and his family have been wanting to visit Asia for a long time. They considered various options, but in the end had to choose between going to Tokyo in the spring, or visiting some place in China for vacation in the summer. I have no idea what they ended up choosing, but given that the summer has ended now, I know that:
Either John's family visited Tokyo or they visited China. (SD-FIRST)

This 'Simple' (SD) vs. 'Hurford' (HD) manipulation constituted our first and basic experimental factor, REDUNDANCY.[4] A significant decrease in acceptability for HD relative to SD experimentally confirms a basic redundancy effect.

2.1.2 Potential Factors Modulating Redundancy

Turning to factors that might modulate redundancy effects, we also created variants with reversed clause order for both HD and SD, where the redundant disjunct in HD appeared SECOND:

(11) a. Either John's family visited Japan or they visited Tokyo. (HD-SECOND)
b. Either John's family visited China or they visited Tokyo. (SD-SECOND)

Having baseline conditions in both orders crucially controls for potential order-based effects on the acceptability of disjunctions that arise independently of redundancy: e.g., a general order effect present in SD might carry over to HD without indicating a modulation of redundancy by order. Only if the impact of order in HD were different from a potential order effect in SD would we have evidence for such a modulation. Statistically, this would correspond to an interaction of ORDER and REDUNDANCY.

As we also are interested in potential modulating effects of POLARITY as a factor, we included variations of all conditions with negated disjuncts NEGHD (Negative Hurford Disjunction) in addition to the HD (Positive Hurford Disjunctions) above. The contexts for disjunctions containing negation made sure to motivate the use of negated disjuncts, which may otherwise be marked and less acceptable.

(12) *Negative Hurford Disjunction* (NEGHD)
CONTEXT: John and his family want to visit Asia. They have various destinations in mind like some cities in Japan (especially Tokyo), as well as some cities in China. However, I have no idea if they could afford to go to all of these places. Recently, John and his family returned from their Asia trip. I noticed that they made no mention of Tokyo or Japan, so I thought:

4 Note that throughout this paper, we use the labels 'Hurford' and 'Redundant' interchangeably when we talk about our stimuli; similarly for the 'Simple' and 'Non-redundant' labels.

a. Either John's family didn't visit Japan or they didn't visit Tokyo. (FIRST)
b. Either John's family didn't visit Tokyo or they didn't visit Japan. (SECOND)

(13) *Negative Simple Disjunction* (NEGSD)
CONTEXT: John and his family have been wanting to visit Asia for a long time. They considered various options and initially thought about going both to Tokyo and to some places in China this summer. I have no idea if they had time to do either the Tokyo or the China option. However, I'm sure that they couldn't afford to go to both. So, even though I don't know where they traveled, I know that:
a. Either John's family didn't visit China or they didn't visit Tokyo. (FIRST)
b. Either John's family didn't visit Tokyo or they didn't visit China. (SECOND)

As for the order manipulation, having negated SD controls is crucial: it's plausible that negation incurs a general acceptability penalty that would apply in both SD and HD. A modulating effect of POLARITY on REDUNDANCY specifically would then, again, be reflected in an interaction, with variation in impact of REDUNDANCY across the levels of the POLARITY factor.

Altogether, the three factors above yielded a $2\times2\times2$ factorial design. REDUNDANCY was manipulated between subjects, whereas ORDER and POLARITY were manipulated within subjects. For ease of reference, we summarise schematically the use of the labels for all conditions in Table 1. The stimuli outlined above represent our experimental conditions. In total, 24 items were created.[5]

2.1.3 Fillers

In addition to the experimental items, we included 24 fillers, which came in two kinds (and were also presented in contexts, omitted here for space). The first kind was conjunctions, specfically 6 GOOD and 6 BAD conjunctions: the former were normal conjunctions, while latter having a redundant second conjunct.

(14) Conjunctions

5 'Item' here denotes a collection of contexts and test sentences that form a coherent whole. For example, the sentences above involving John and his family visiting (or not visiting) Japan are instantiations of one item, which might be thought of as the *John's family (not) visiting Japan* story/item. In total 24 such stories/items were created and were used to create instantiations of each condition within that story/item.

Polarity	Redundancy	Order: First	Order: Second
Pos	Hurford Disj	$T \vee J$ (HDFirst)	$J \vee T$ (HDSecond)
	Simple Disj	$T \vee C$ (SDFirst)	$C \vee T$ (SDSecond)
Neg	Hurford Disj	$\neg J \vee \neg T$ (NegHDFirst)	$\neg T \vee \neg J$ (NegHDSecond)
	Simple Disj	$\neg C \vee \neg T$ (NegSDFirst)	$\neg T \vee \neg C$ (NegSDSecond)

Table 1 Experiment 1 conditions: T, stands for *Tokyo*, J for *Japan*, and C for *China*.

a. Mary is pregnant and that's why she's excited. GoodConj
b. Sam is a widow and she's a woman. BadConj

The second kind of fillers were conditionals:

(15) Conditionals
a. If Tom only visited Paris, he didn't visit Germany. GoodCond
b. If Mary is in Paris, she's not in France. BadCond

Again, we included 6 Good and 6 Bad conditionals. In the Good ones, the consequent followed uncontroversially from the antecedent, while in the Bad ones the consequent contradicted the antecedent. In addition to providing distraction from the critical sentences, these filler provided a check on how participants made use of the scale (see the discussion in section 2.7). The full list of stimuli is available in the supplemental materials (see data availabilty section below).

2.2 Procedure

The redundancy factor was implemented as a between-subjects manipulation (see section 7 for a partial replication within-subjects). The order and polarity factors were manipulated within-subjects. As a result, the items were divided into two main lists. List 1 included the four baseline conditions corresponding to the SD and NegSD items presented in both orders. List 2 included the four target conditions corresponding to the HD and NegHD items in both orders. For each list, there were counterbalanced variants that included 6 critical items per condition (representing

the 4 combinations of the 2 factor levels of ORDER and POLARITY), yielding 24 critical items, and 24 fillers, hence 48 items in total.[6]

After providing informed consent, participants completed three training trials to familiarize themselves with the task. Each training trial presented a context followed by a sentence. The sentences included: (1) a simple conjunction with no redundancy violation and no negation, (2) a conjunction where the first conjunct entailed the second (i.e., a redundancy violation), and (3) a simple conjunction with no redundancy violation but with negated conjuncts. Participants rated the naturalness of each sentence in context on a 7-point scale (1 = least natural, 7 = most natural) and received feedback on their training trial responses. The experiment then began, with items presented in a randomized order. In each trial, the context was presented first, and participants had to press the space bar to proceed to the sentence, which was only possible after two seconds. This was intended to ensure that they would read the context before turning to the sentence.

2.3 Participants

We recruited 199 participants from a subject pool at the university of one of the authors; participants received class credit for their participation. All participants were undergraduate students who were native English speakers.

2.4 Data availability

All stimuli, together with the files and scripts required for the statistical analysis reported below, can be found on the *OSF* page for this paper, linked here.

2.5 Data analysis

Our main objective was to measure effects of redundancy, that is, to test whether Hurford Disjunctions (HDs) receive lower acceptability ratings than their corresponding Simple Disjunctions (SD) baseline counterparts. We also wanted to test whether polarity and order modulate redundancy effects. To allow for potential interactions of these factors, we thus started from a 3-way interaction analysis and then proceeded to planned comparisons in line with our main questions.

6 We aimed for a large participant sample (≈100 per between-subjects group) to ensure sufficient statistical power to detect the hypothesized interaction effects. Given the Latin Square counterbalancing, each participant provided 6 observations per condition, resulting in approximately 600 observations per cell in the final dataset.

All of our data was analysed by fitting ordinal mixed-effects regressions, using the *ordinal* package in R. The predictors in the models were sum-coded, and both participants and items were included for random effects.[7] In addition to intercepts, we included random slopes, adopting the following modeling approach to avoid overfitting. We always began by finding the maximal model (in terms of including random slopes) that converged, and then employed model comparison with simpler models to reach a final model. For each random slope in the initial model, we computed a model without it, and then compared the resulting model to the initial maximal model using the *anova* method. A random slope was kept in the final model if it significantly improved model fit (based on the result of the *anova* comparison), and including it led neither to convergence issues (such as non-convergence or singularity) nor to high correlations (close to 1 or -1) with other random effects. Note that by-participant random slopes for Redundancy were in general not justified by the design, given its implementation as a between-subjects factor. Where relevant, we use the *emmeans* package to test specific contrasts with Tukey-adjusted p-values. The details of all statistical analyses reported in this paper can be found in the relevant R files on the *OSF* page for this paper, linked here.

2.6 Results

Figure 1 shows the distribution of the responses for the HD and SD conditions, aggregated across order levels and grouped by polarity. Overall, we see an effect of Redundancy: responses for the HD conditions had lower means than their SD baselines. Moreover, note that the mean acceptability for positive cases (SD) was high, with responses clustered predominantly around 6-7, whereas it was lower for the negative cases (NegSD), with more evenly distributed responses across the scale, showing greater variability in judgments. This suggests a general impact of negation on acceptability, independent of redundancy.

We fit an ordinal mixed-effects model (using a *logit* link function) to predict responses based on Redundancy, Polarity, Order and their interactions. Our final model included random intercepts for both participants and items, a by-participant random slope for polarity and by-item random slopes for redundancy and polarity and their interaction. The model revealed significant effects of polarity ($\beta = -0.23$, $SE = 0.06$, $z = -4$, $p < .001$) and redundancy ($\beta = -0.97$, $SE = 0.11$, $z = 8.6$, $p < .001$), as well as a significant Polarity:Redundancy interaction ($\beta = 0.37$, $SE = 0.04$, $z = -9$, $p < .001$). No significant effects involv-

7 'Item' here refers to story-types, where each such type is instantiated by a combination of 'context + test sentence' (see footnote 5).

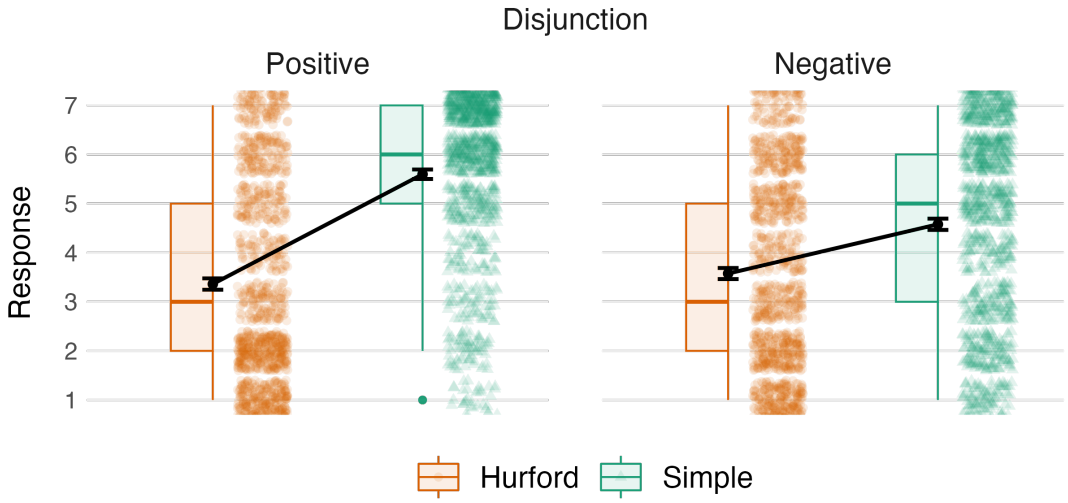

Figure 1 Responses (1-7 scale) for Hurford (HD) and Simple (SD) disjunctions (collapsed across Order levels) by Polarity. The right half of each panel shows individual responses as jittered points, while the left half shows a half-boxplot summarizing the overall distribution. Black lines connect mean values within each panel, and black points with error bars show the mean ±95% confidence interval. HDs were generally less accepted than their non-redundant SD baselines, with a stronger contrast in positive than negative forms.

ing order were found, i.e., including for POLARITY:ORDER, ORDER:REDUNDANCY or ORDER:POLARITY:REDUNDANCY interactions.

We used the *emmeans* package to conduct planned comparisons with Tukey-adjusted p-values. This analysis revealed significant REDUNDANCY effect (with HD less acceptable than SD) at all levels of combinations of POLARITY and ORDER (positive, first: $\beta = 2.56$, $SE = 0.26$, $z = 9.79$, $p < .0001$; negative, first: $\beta = 1.17$, $SE = 0.24$, $z = 4.91$, $p < .0001$; positive, second: $\beta = 2.82$, $SE = 0.26$, $z = 10.74$, $p < .0001$; negative, second: $\beta = 1.25$, $SE = 0.23$, $z = 5.22$, $p < .0001$). But the REDUNDANCY ORDER interaction shows this to be stronger for positive sentences. This suggests a first part towards an answer to our question **Q2**: polarity can indeed have a modulating effect on redundancy.

REDUNDANCY and ORDER Turning to question **Q1**, i.e. whether the effect of redundancy is modulated by the order of the disjuncts, it is clear that the absence

of a ORDER:REDUNDANCY interaction ($\beta = -0.04$, $SE = 0.02$, $z = -1.53$, $p = 0.12$) means there is no support for a positive answer in the data. Given that we found that redundancy is modulated by polarity, one could speculate that any potential modulating effect of order on redundancy would be stronger for the level of the POLARITY factor where redundancy is stronger. This possibility predicts an ORDER:REDUNDANCY interaction for POSITIVE but not NEGATIVE polarities, and consequently should give rise to a three-way POLARITY:ORDER:REDUNDANCY interaction. But the relevant three-way interaction in our model is also not significant ($\beta = 0.02$, $SE = 0.02$, $z = 0.85$, $p = 0.39$).

We thus have no evidence for an effect of order on redundancy in disjunction. Of course, this is still only a null result, not evidence for the absence of order effects. We'll return to further discussion of this point when comparing different connectives in terms of order effects.

2.7 Discussion

Our results show that disjunctions with redundant disjuncts are indeed less acceptable than their simple controls: Hurford disjunctions, whether positive or negative, were rated significantly lower than their SD baselines. While this aligns with the standard judgment reported in the literature, it provides the first experimental measure confirming this effect that we are aware of.

Importantly, while redundancy effects are present across variants with positive and negated disjuncts, they are modulated by polarity. We interpret the lower ratings of the negative baseline (NEGSD relative to the positive baseline SD as reflecting a general felicity cost associated with negation. This could be due to increased processing complexity, stronger contextual requirements, or related factors discussed in the literature (see Tian & Breheny 2019 for an overview). As such, it's reasonable to assume that this cost applies uniformly to negative sentences, affecting both negative baselines (NEGSD and negative targets NEGHD. The comparable acceptability of positive (HD) and negative NEGHD then has to be considered in light of this: the parallel, general negation effect appears to be offset by a smaller redundancy effect for the negative disjunction - i.e., polarity modulates redundancy.

Other explanations of this aspect of the results pattern are, of course, in principle possible, but we take them to be considerably less plausible. One possibility is that the redundancy effect is constant, while the effect of negation differs between negative targets and negative baselines. However, this would require a theory of negation that is sensitive to changes in one of the disjuncts in a highly specific

way. We do not see how such a dependency could be motivated independently, rather than in an ad hoc manner tailored to fit the present data.

A perhaps more promising alternative is that ratings for infelicitous sentences 'bottom out' at a certain value on the scale, perhaps at a floor of around 3 in our data. Combined with a general effect of negation, this could also explain the observed interaction. However, our fillers (designed among other considerations to provide an independent perspective on how participants use the scale) suggest otherwise. Looking at the means for the BadCond cases, we find that they are at 1.3 and 1.39 in the Hurford and Simple between-subjects groups respectively. This shows that participants were indeed willing to make use of the lower end of the scale, and thus makes a general floor effect explanation less likely.[8]

In sum, we take the most plausible interpretation of the polarity×redundancy interaction to be one that combines a uniform negation cost with a modulating effect of polarity on redundancy. This provides experimental support for the the claim in Kalomoiros 2023a that negation impacts oddness judgments for disjunction. Thus, our data poses problems for standard approaches to redundancy which fail to predict any modulating role of polarity. Finally, we currently do not have evidence for a modulating role of order. We'll explore this further in comparison to other connectives, in sections 4 and 6.

3 Experiment 2: Conditionals

Adapting the paradigm and design from Experiment 1, Experiment 2 investigated redundancy in conditionals, as well as potential effects of order and polarity.

3.1 Design

We again employed a 2×2×2 factorial design, manipulating whether (a) the conditional was redundant (redundancy), (b) the order of antecedent and consequent (order), and (c) whether the antecedent contained negation (polarity). The first factor was manipulated between subjects, whereas the latter two were manipulated within subjects.

Our critical conditions consisted of of Hurford conditionals, derived from the disjunctions in Experiment 1 via the *or-to-if* correspondence between disjunctions and conditionals. (16) illustrates those with a negation in the antecedent, which are

8 For completeness, here are the means for all the filler conditions. In the Hurford group: BadCond: 1.3, GoodCond: 4.98, BadConj: 4.82 GoodConj: 5.92. In the Simple group: BadCond: 1.39, GoodCond: 4.32, BadConj: 4, GoodConj: 5.66.

based on the positive Hurford Disjunctions. For uniformity with the disjunction discussion, they are encoded as positive Hurford Conditionals (HC). The potential redundancy in play here again relates to the entailment relation between the negation of the consquent and the antecedent. The controls in (17) provide the baseline for comparison to get a difference-based measure of redundancy effects, as before.

(16) *Positive Hurford Cond* (HC)
CONTEXT: John and his family want to visit Asia. They have various destinations in mind, but the most prominent ones are cities in Japan, especially Tokyo. Recently, John and his family returned from their Asia trip, so I thought:
a. If John's family didn't visit Tokyo, they visited Japan. (ANTFIRST)
b. John's family visited Japan, if they didn't visit Tokyo. (ANTSECOND)

(17) *Positive Simple Cond* (SC)
CONTEXT: John and his family have been wanting to visit Asia for a long time. They considered various options, but in the end had to choose between going to Tokyo in the spring, or visiting some place in China for vacation in the summer. I have no idea what they ended up choosing, but given that the summer has ended now, I know that:
a. If John's family didn't visit Tokyo, they visited China. (ANTFIRST)
b. John's family visited China, if they didn't visit Tokyo. (ANTSECOND)

As in Experiment 1, we manipulated ORDER, here by switching the order of antecedent and consequent, yielding what we label ANTFIRST and ANTSECOND Hurford conditionals in (a) and (b) above. Parallel to the case of disjunction, the FIRST versus SECOND labels also encode whether the potential redundancy is introduced in the linearly first or second clause.

The polarity manipulation was introduced by including conditional variants derived from cases with negated disjuncts, which lead to a positive antecedent and a negation in the consequent. Again maintaining uniformity with the disjunction discussion, we label these as negative Hurford Conditionals (NEGHC). The baseline controls, with versions for both order variants, were labeled Negative Simple Condtionals (NEGSC).

(18) *Negative Hurford Cond* (NEGHC)
CONTEXT: John and his family want to visit Asia. They have various destinations in mind like some cities in Japan (especially Tokyo), as well as some cities in China. However, I have no idea if they could afford to go to

all of these places. Recently, John and his family returned from their Asia trip. I noticed that they made no mention of Tokyo, so I thought:
a. If John's family visited Japan, they didn't visit Tokyo. (AntFirst)
b. John's family didn't visit Tokyo, if they visited Japan. (AntSecond)

(19) *Negative Simple Cond* (NegSC)
Context: John and his family have been wanting to visit Asia for a long time. They considered various options and initially thought about going both to Tokyo and to some places in China this summer. I have no idea if they had time to do either the Tokyo or the China option. However, I'm sure that they couldn't afford to go to both. So, even though I don't know where they traveled, I know that:
a. If John's family visited China, they didn't visit Tokyo. (AntFirst)
b. John's family didn't visit Tokyo, if they visited China. (AntSecond)

The remainder of the design was identical to Experiment 1 in all relevant respects. A full list of the 24 critical items and 24 fillers used in this experiment is provided in the supplemental materials (see data availability section). For ease of reference, we summarise schematically the use of the labels for each conditions in Table 2.

		Order	
Polarity	**Redundancy**	**Antecendent First**	**Antecedent Second**
Neg	Hurford Cond	if J, $\neg T$ (NegHCAntFirst)	$\neg T$, if J (NegHCAntSecond)
	Simple Cond	if C, $\neg T$ (NegSCAntFirst)	$\neg T$, if C (NegSCAntSecond)
Pos	Hurford Cond	if $\neg T$, J (HCAntFirst)	J, if $\neg J$ (HCAntSecond)
	Simple Cond	if $\neg T$, C (SCAntFirst)	C, if $\neg T$ (SCAntSecond)

Table 2 Experiment 2 conditions: T, stands for *Tokyo*, J for *Japan*, and C for *China*.

3.2 Procedure

The procedure was the same as in the previous experiment. The training phase was identical to the one used in Experiment 1 (See Section 2.2 for details).

3.3 Participants

We recruited 195 new participants from Prolific. Participants were screened so that they would only be able to participate in the study if their first language was English; they received monetary compensation labeled 'Good' for their participation.

3.4 Data availability

All stimuli, together with the files and scripts required for the statistical analysis reported below, can be found on the *OSF* page for this paper, linked here.

3.5 Data analysis

The data analysis followed the same approach as that described for Experiment 1.

3.6 Results

Figure 2 illustrates the effects of redundancy across the different combinations of the factor levels of Polarity and Order. The descriptive pattern suggests a 3-way interaction, with a Redundancy×Order interaction present at the negative level of the Polarity-factor (different slopes in the bottom two sub-plots), but not at the positive level (parallel slopes in the top sub-plots).

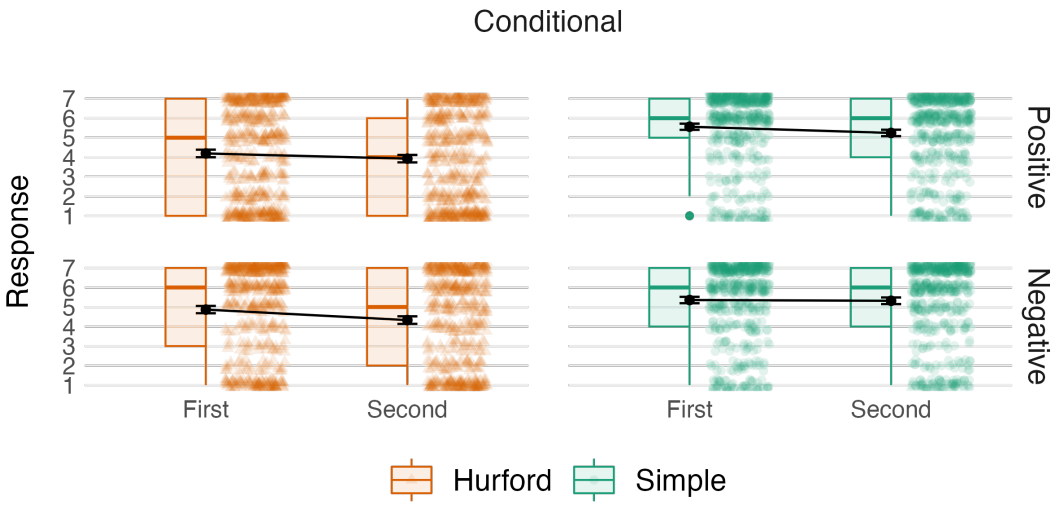

Figure 2 Responses (1-7 scale) for Hurford (HC) and Simple (SC) conditionals by Polarity and Order.

We assessed this pattern in a 3-way interaction analysis and subsequent planned comparisons via *emmeans* based on our overall questions. Initially, we fit a model predicting response from CONNECTIVE, POLARITY, REDUNDANCY and all their two- and three-way interactions. The final model included random intercepts for participant and item, as well as a by-participant random slope for POLARITY, and a by-item random slope for REDUNDANCY. The model revealed significant main effects of ORDER, POLARITY and REDUNDANCY ($\beta = 0.16$, $SE = 0.02$, $z = 5.86$, $p < .0001$; $\beta = -0.12, SE = 0.04, z = -2.92, p < .001$; $\beta = 0.52, SE = 0.1, z = 4.8$, $p < .0001$, respectively). But these effects were non-uniform across levels of respective other factors, as indicated by a significant two-way interaction of POLARITY×REDUNDANCY ($\beta = 0.13$, $SE = 0.04$, $z = 3.27$, $p < .001$) and a significant POLARITY×REDUNDANCY×ORDER interaction ($\beta = 0.08, SE = 0.02, z = 3, p < .001$). The other two-way interactions, ORDER×POLARITY and ORDER×REDUNDANCY were not significant in the overall model, ($\beta = 0.02$, $SE = 0.02$, $z = 0.84$, $p = 0.39$; $\beta = -0.04$, $SE = 0.02$, $z = -1.72$, $p = 0.08$, respectively).

Because of the the presence of the POLARITY×REDUNDANCY×ORDER interaction, we cannot simply look at the POLARITY×REDUNDANCY and ORDER×REDUNDANCY interactions in the main model to answer our questions about whether (and when) redundancy is modulated by ORDER and POLARITY; rather, these need to be looked at separately at the different levels of the other modulating factor (ORDER in the case of POLARITY×REDUNDANCY, and POLARITY in the case of ORDER×REDUNDANCY).

3.6.1 Polarity × Redundancy in Hurford conditionals

Using *emmeans* to look at the differences between REDUNDANT VS NON-REDUNDANT conditionals at all combinations of levels of the ORDER and POLARITY factors (with Tukey-adjusted p-values) reveals that redundant conditionals are always significantly different from their non-redundant counterparts, except in the case of antecedent-first conditionals at the NEGATIVE level of polarity.

Pol	Order	contrast	β	SE	z	p
Neg	First	NoRed - Red	0.52	0.254	2.049	0.4484
Pos	First	NoRed - Red	1.39	0.241	5.777	<.0001
Neg	Second	NoRed - Red	1.045	0.254	4.122	0.0010
Pos	Second	NoRed - Red	1.25	0.240	5.226	<.0001

Table 3 Differences between redundant vs. non-redundant conditionals at all combinations of Order and Polarity Levels.

The estimates here also suggest that, at least numerically, the REDUNDANCY effect is greater in POS conditionals than in their NEG counterparts. To test whether this indeed amounts to significant effects, we used *emmeans* again, and extracted the POLARITY×REDUNDANCY interaction at the different levels of the ORDER factor. For ORDER = FIRST, there was a significant interaction confirming a greater REDUNDANCY effect for POS than NEG ($\beta = -0.87$, $SE = 0.2$, $z = -4.36$, $p < .0001$); but for ORDER = SECOND, the corresponding interaction is not significant ($\beta = -0.2$, $SE = 0.19$, $z = -1.04$, $p = 0.29$).

This analysis confirms a role of polarity for redundancy effects in conditionals, albeit a more nuanced one: while redundancy effects tend to be stronger for POSITIVE Hurford conditionals (i.e., those with a negative antecedent) compared to their NEGATIVE counterparts (i.e., with positive antecedent), this only gives rise to significant interaction for antecedent-first conditionals.

3.6.2 Order × Redundancy in Hurford conditionals

Turning to order effects, we first extracted the FIRST vs. SECOND contrasts with *emmeans*, at every combination of POLARITY and REDUNDANCY (with Tukey-adjusted p-values). These results suggest a redundancy-specific order effect for NEG redundant Hurford conditionals. In contrast, POS conditionals exhibit a general order effect independent of redundancy, which is more clearly present, if anything, at the NoRed level.

Pol	Red	Order contrast	β	SE	z	p
Neg	NoRed	First - Second	0.017	0.113	0.150	1.0000
Pos	NoRed	First - Second	0.444	0.112	3.953	0.0020
Neg	Red	First - Second	0.542	0.111	4.900	<.0001
Pos	Red	First - Second	0.302	0.108	2.796	0.0960

Table 4 Differences between Order levels (First vs. Second) at combinations of Polarity and Redundancy.

Next, we extracted the RED:ORDER interactions at both levels of the POLARITY factor. There was a significant ORDER:RED interaction for POL = NEG ($\beta = -0.52$, $SE = 0.15$, $z = -3.31$, $p < .001$), but not for POL = POS ($\beta = 0.14$, $SE = 0.15$, $z = 0.91$, $p = 0.35$), meaning that the three-way POLARITY×ORDER×REDUNDANCY interaction is driven by an effect of ORDER on REDUNDANCY that is polarity-dependent (present for NEG, but absent for POS).

3.7 Discussion

Our results experimentally confirm the existence of redundancy effects in conditionals. The overall pattern w.r.t. the role of other factors is more complex than in disjunction, as there is a 3-way interaction of REDUNDANCY with POLARITY and ORDER. Our main further findings in this regard can be summarized as follows:

- With the exception of antecedent-first Hurford conditionals at the NEG-level, redundant Hurford conditionals are significantly less acceptable than their non-redundant baselines, confirming a redundancy effect, at least in three out of the four combinations of the order and polarity factor levels.
- Order and polarity do impact redundancy effects, though their effects are modulated by interactions, in that they only make a difference at certain levels of the relevant other factors.
- In the case of antecedent-first conditionals, the redundancy effect is modulated by POLARITY: it is stronger for POS compared to NEG conditionals (in line with the claims in Mandelkern & Romoli 2018). On the other hand, we found no evidence for such a polarity-based difference for antecedent-second conditionals. As such, while there was an overall effect of POLARITY on REDUNDANCY (recall the significant POLARITY:REDUNDANCY interaction in our model), this effect is crucially modulated by ORDER.
- While we found no overall effect of ORDER on redundancy (recall the null ORDER:REDUNDANCY in our overall model), this was again modulated by the POLARITY factor: for NEG conditionals there was a significant ORDER:REDUNDANCY interaction, while for POS conditionals this interaction was not significant. Therefore, we have an order effect for NEG but not for POS Hurford conditionals; thus, in contrast to disjunctions, order *does* matter for redundancy in conditionals at certain levels of other relevant factors.

A question that arises at this point is how Hurford conditionals stack up against their corresponding disjunctions in direct statistical comparison. This constitutes part of the third question we started with: is the effect of redundancy, and the way it is modulated by other factors like POLARITY and ORDER, constant or different across connectives? We investigate this in the next section.

4 Cross-connective comparison (Part 1): Disjunction vs. Conditionals

4.1 Data preparation

This section turns to a statistical comparison of disjunction and conditionals, examining whether the impact of the factors modulating redundancy effects differs in any way across connectives.

We created a combined dataset for the Hurford disjunction and the Hurford conditionals data from Experiments 1 and 2. A new CONN(ECTIVE) factor encoded whether a given observation involved conditionals (IF) or disjunction (DISJ). For the POLARITY factor, recall that our guiding intuition for comparisons between Hurford conditionals and Hurford disjunctions was grounded in the *or-to-if* equivalence; this led us to group together HD and negative antecedent conditionals as POS, while NEGHDs and positive antecedent conditionals were grouped together as NEG. The ORDER-factor levels encoded, as before, whether the linearly first or second clause would be redundant in relation to the other clause.

Given the presence of a three-way interaction in conditionals, but no corresponding evidence for disjunctions, we began with a four-way interaction analysis to test whether these three-way interactions differ significantly when compared directly. Thus, we fit a model predicting response from CONNECTIVE, POLARITY, REDUNDANCY, ORDER and all their two-, three- and four-way interactions. The final model included random intercepts for participant and item, as well as by-participant random slopes for REDUNDANCY and ORDER, and by-item random slopes for CONNECTIVE, POLARITY, REDUNDANCY as well as all their two- and three-way interactions.[9] The results of the model are summarized in Table 5.

We were interested in knowing: (i) whether different connectives exhibit redundancy effects of differential intensity, (ii) whether the way POLARITY modulates REDUNDANCY differs across connectives, and (iii) whether the way ORDER modulates REDUNDANCY differs across the levels of CONNECTIVE. Importantly, we found a significant four-way CONNECTIVE×POLARITY×ORDER×REDUNDANCY interaction, confirming that the three-way interaction observed for conditionals reflects a statistically distinct pattern from that of disjunctions, where no such interaction was found.

9 Due to the computational difficulties present in fitting a 4-way model, we employed a bottom-up model comparison process. We started with a simple 4-way model that included random intercepts for participant and item, and only included by-item and by-participant random slopes for simple effects. We subsequently attempted adding more random slopes.The model that included both two- and three-way by-item slopes did converge, and as such we decided to include the three-way slopes in the final model out of an abundance of caution. The model that excluded these three-way slopes did not differ qualitatively from the final model we report here. More details can be found in the R files on OSF.

Term	β	SE	z	p
Conn	-0.350033	0.070557	-4.961	<.0001
Order	0.103748	0.020887	4.967	<.0001
Pol	-0.049444	0.045461	-1.088	0.28
Red	0.728956	0.088080	8.276	<.0001
Conn:Order	-0.081671	0.020799	-3.927	<.0001
Conn:Pol	-0.183680	0.034758	-5.285	<.0001
Order:Pol	-0.028181	0.019299	-1.460	0.14
Conn:Red	0.114855	0.069493	1.653	0.10
Order:Red	-0.050692	0.020915	-2.424	<.05
Pol:Red	-0.245744	0.046325	-5.305	<.0001
Conn:Order:Pol	-0.002087	0.019291	-0.108	0.91
Conn:Order:Red	0.011098	0.020747	0.535	0.59
Conn:Pol:Red	-0.078006	0.032296	-2.415	<.05
Order:Pol:Red	-0.037676	0.019299	-1.952	0.05091
Conn:Pol:Order:Red	0.058314	0.019293	3.023	<.01

Table 5 Result of the model predicting Response from CONNECTIVE, POLARITY, REDUNDANCY, ORDER and all their two-, three- and four-way interactions.

Consequently, we cannot restrict our attention to the CONNECTIVE:REDUNDANCY, CONNECTIVE:POLARITY:REDUNDANCY, and CONNECTIVE:ORDER:REDUNDANCY interactions in the overall model, since the outcomes are expected to vary depending on the levels of the other interacting factors. We therefore examined these interactions separately at each relevant level of the other factors. We begin with the question of whether the effect of REDUNDANCY differs across the two connectives.

4.2 Redundancy effects

To examine whether conditionals vs. disjunctions differ in terms of the strength of the redundancy effects they exhibit, we use *emmeans* to look at the CONNECTIVE×REDUNDANCY interactions at each level of the POLARITY and ORDER factors. The results are summarized in Table 6. The main take-away is that while NEG conditionals and disjunctions do not show a significant contrast in either order, POS conditionals and disjunctions do show differences in terms of how they are affected by the RED vs. NORED contrasts: a marginal effect for ORDER = FIRST and a clearly significant effect for ORDER = SECOND.

Pol	Order	Conn contrast	Red contrast	β	SE	z	p
Neg	First	Or - If	NoRed - Red	0.425	0.334	1.271	0.20
Pos	First	Or - If	NoRed - Red	0.583	0.311	1.875	0.06
Neg	Second	Or - If	NoRed - Red	-0.130	0.336	-0.387	0.69
Pos	Second	Or - If	NoRed - Red	0.960	0.325	2.955	<.01

Table 6 Conn:Red Interaction Contrasts, by Polarity and Order

A useful way to interpret these results is as follows: the polarity factor groups together conditionals and disjunctions that are equivalent under the *or-to-if* inference. As shown above, NegHDs and conditionals at the NEGATIVE level of POLARITY (i.e., with a positive antecedent) exhibit parallel effects of redundancy. In contrast, HDs and conditionals at the POSITIVE level (i.e., with negative antecedents) display different redundancy effects in the SECOND order, and marginally different effects in the FIRST order. This pattern is illustrated in Fig. 3. Notably, the difference between Hurford conditionals and their corresponding disjunctions is most pronounced in the POL = POS case, as reflected by the steeper slope for disjunctions in the left two subplots.

We used *emmeans* to pull out the individual RED vs. NoRed contrasts for each connective, at each level of the ORDER and POLARITY factors. The results, summarized in Table 7, suggest that the intensity of redundancy effects is stronger for positive HDs compared to their corresponding positive HCs. It also interesting to note that NegFirst disjunctions come with a significant redundancy effect ($p = 0.0006$), whereas the corresponding NegFirst conditionals do not ($p = 0.1634$). While this difference does not give rise to a significant CONN:RED interaction at the NegFirst level (see table 6), it still suggests that the relevant redundancy effect is more pronounced for NegFirst disjunctions than NegFirst conditionals.

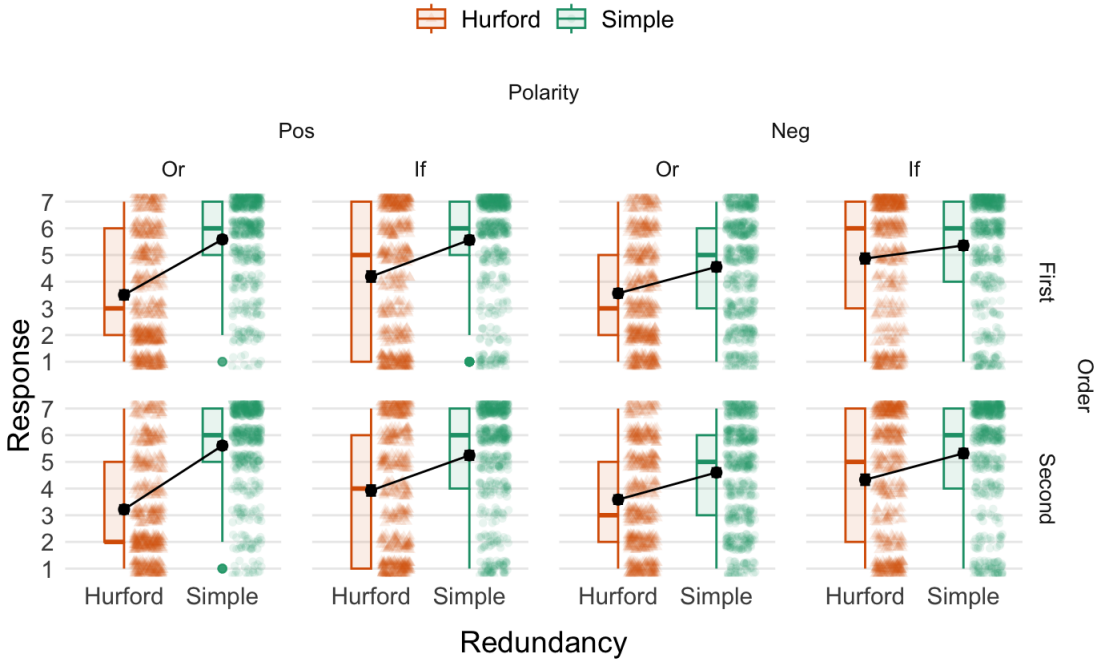

Figure 3 Responses to the NoRed vs Red disjunctions, contrasted to their corresponding conditionals, by Order and Polarity.

Pol	Order	contrast	β	SE	z	p
Neg	First	Or NoRed - Or Red	1.002	0.258	3.878	0.0006
Neg	First	If NoRed - If Red	0.577	0.279	2.069	0.1634
Pos	First	Or NoRed - Or Red	2.215	0.247	8.976	<.0001
Pos	First	If NoRed - If If Red	1.632	0.260	6.286	<.0001
Neg	Second	Or NoRed - Or Red	1.078	0.260	4.150	0.0002
Neg	Second	If NoRed - If Red	1.208	0.280	4.309	0.0001
Pos	Second	Or NoRed - Or Red	2.456	0.257	9.564	<.0001
Pos	Second	If NoRed - If Red	1.495	0.267	5.592	<.0001

Table 7 NoRed vs. Red contrasts for Or vs. If, at combinations of POLARITY and ORDER.

4.3 Effects of Polarity on Redundancy

To examine whether POLARITY affects REDUNDANCY differently across the two connectives, we use *emmeans* to pull out the CONNECTIVE×POLARITY×REDUNDANCY interaction at both levels of the ORDER factor (see Table 8).

Order	Conn	Pol	Redundancy	β	SE	z	p
First	Or - If	Neg - Pos	NoRed - Red	-0.158	0.302	-0.522	0.60
Second	Or - If	Neg - Pos	NoRed - Red	-1.091	0.300	-3.632	<.001

Table 8 Three-way interaction contrasts (Conn:Pol:Red) at each Order level.

For ORDER = FIRST, the effect of polarity on redundancy does not differ significantly across the two connectives. In contrast, a significant three-way interaction emerged for ORDER = SECOND. This pattern is further illustrated in Fig. 4. Impressionistically, this appears to reflect that, for ORDER = SECOND, the NOREDVS RED contrast is larger for OR than for IF. This impression is confirmed using *emmeans* to extract the POLARITY:REDUNDANCY interactions at each level of CONN and ORDER (see Table 9). Specifically, for ORDER = FIRST, both connectives show parallel POLARITY:REDUNDANCY interactions. However, for ORDER = SECOND, the interaction is stronger for OR than for IF.

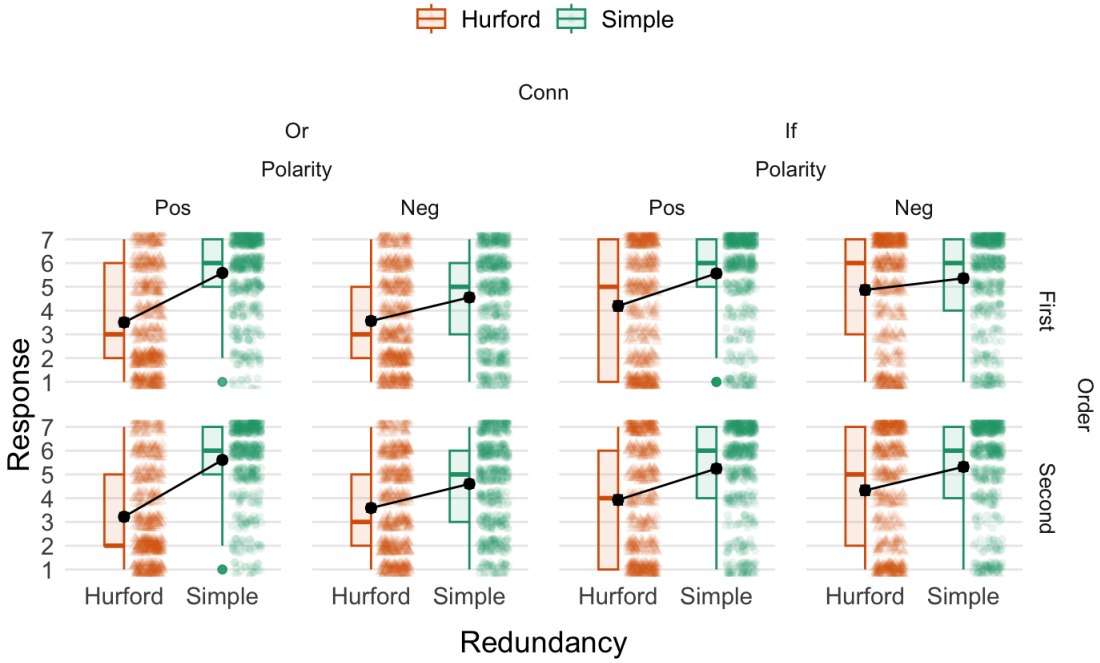

Figure 4 Responses to the NoRed vs Red conditions, contrasted by Polarity, and faceted Order and Connective.

Conn	Order	Pol	Red	β	SE	z	p
Or	First	Neg - Pos	NoRed - Red	-1.212	0.251	-4.834	<.0001
If	First	Neg - Pos	NoRed - Red	-1.055	0.252	-4.188	<.0001
Or	Second	Neg - Pos	NoRed - Red	-1.378	0.251	-5.489	<.0001
If	Second	Neg - Pos	NoRed - Red	-0.287	0.250	-1.149	0.2506

Table 9 Pol:Red interaction contrasts at combinations of Connective and Order.

In summary, polarity modulates redundancy for both connectives. However, this modulation differ across these connectives depending on ORDER: for ORDER = FIRST, the pattern is parallel, but for ORDER = SECOND, polarity significantly influences redundancy for OR but not for IF.

4.4 Effects of Order on Redundancy

Finally, we consider how the ORDER:REDUNDANCY interaction differs between the two connectives. For conditionals, we have seen that there was an ORDER:REDUNDANCY

interaction further modulated by POLARITY, yielding a three-way interaction. In contrast, disjunctions showed neither an ORDER:REDUNDANCY interaction nor a POLARITY:ORDER:REDUNDANCY interaction. The four-way model further supports this picture, with the previously reported significant four-way interaction confirming that this dimension varies across connectives. Analyses of the (NO)REDFIRST vs. (NO)REDSECOND contrasts at each level of CONNECTIVE and POLARITY (Table 10) reinforce these conclusions: NEG conditionals exhibit an order effect absent in their POS counterparts, while neither POS nor NEG disjunctions show any order effect. These polarity-mediated order differences across the two connectives are further illustrated in Fig. 5.

Conn	Pol	contrast	β	SE	z	p
Or	Neg	First NoRed - Second NoRed	-0.05430	0.108	-0.503	0.9583
Or	Neg	First Red - Second Red	0.02153	0.104	0.207	0.9969
Or	Pos	First NoRed - Second NoRed	-0.01578	0.114	-0.139	0.9991
Or	Pos	First Red - Second Red	0.22515	0.105	2.152	0.1368
If	Neg	First NoRed - Second NoRed	0.00309	0.121	0.026	1.0000
If	Neg	First Red - Second Red	0.63421	0.119	5.342	<.0001
If	Pos	First NoRed - Second NoRed	0.49143	0.121	4.061	0.0003
If	Pos	First Red - Second Red	0.35463	0.117	3.042	0.0126

Table 10 Selected Order contrasts (First vs. Second) at combinations of Connective and Polarity.

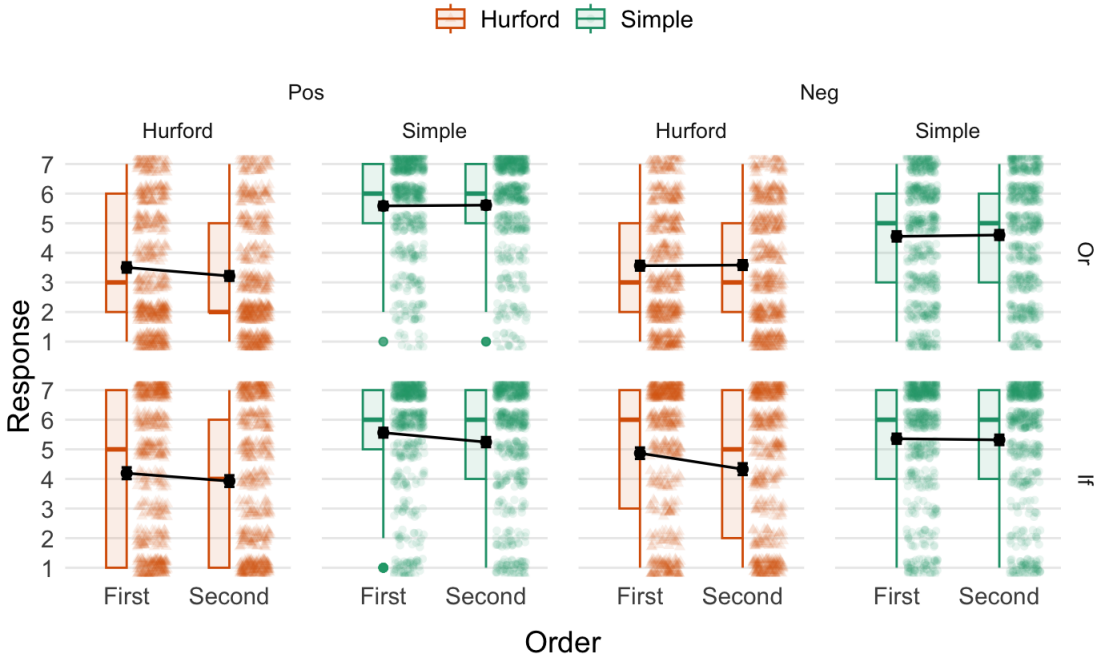

Figure 5 Responses to RedFirst vs RedSecond conditions, contrasted to their corresponding NoRed conditions, and faceted by Order and Connective.

4.5 Interim summary

We are faced with a complex landscape: overall, the two connectives differ across all three dimensions of interest, but these differences are further shaped by the presence of interactions:

- Disjunction and conditionals exhibit differential effects of redundancy, but this difference is only observed for Pos polarities, where disjunctions show a stronger effect of redundancy than conditionals.[10] For Neg polarities, the effects of redundancy appear statistically parallel.
- Polarity affects redundancy differently across the two connectives, but the difference is only observed for the Second order: the redundancy effect in

10 As noted earlier, for Order = First, the difference in the strength of redundancy between the two connectives is marginal ($p = .06$). For simplicity, we describe this contrast as occurring in the Pos polarity, since $p = .06$ is near the conventional threshold for significance, and doing so avoids over-complicating an already complex picture.

disjunctions is stronger for Pos than for Neg whereas, in the corresponding conditionals, polarity doesn't significantly affect the strength of redundancy. On the other hand, for First, Pos polarity leads to a stronger redundancy effect than Neg, for both connectives.

- Order modulates redundancy differently across the two connectives. Conditionals show a stronger order effect on redundancy than disjunctions; however, this effect is observed only for the neg polarity and is absent for pos.

In summary, disjunctions and conditionals share some common patterns: in both, switching from Pos to Neg polarity reduces the strength of redundancy, and overall there is no significant effect of order on redundancy. Crucially, however, while these patterns hold consistently for disjunctions across levels of polarity and order, for conditionals they are modulated by interactions: the ameliorating effect of Neg polarity occurs only for First order, and the absence of an order effect is observed only for Pos polarity.

These findings make it difficult to treat the two connectives on par. Setting aside order effects for now, we could, as a first pass, interpret the redundancy effects in disjunctions as follows: Neg HD disjunctions, being worse than their SD baselines, involve one type of redundancy violation. Pos HDs, which are degraded even more relative to their SD baselines, carry two types of redundancy violations: the one shared with their Neg counterparts, plus an additional violation specific to them. An example of how such a theory, based on the notion of super redundancy in Kalomoiros 2023a, can be implemented is provided in Section 8.

Now, if we assume that conditionals should behave like their *or-to-if* equivalent disjunctions in terms of the strength of redundancy, then we would expect Neg conditionals to always be less redundant than their Pos counterparts, and to not contrast with disjunctions. But our results show that, at least for Order = Second, conditionals show no effect of polarity, whereas for Order = First, they do show such an effect. This leads to a significant connective×polarity×redundancy interaction on the Second level of the Order factor, which is unexpected under a theory of complete parallelism between the two connectives. In addition, note that, even for the First order, where the two connectives pattern more closely together, it's suspicious that we see no significant redundancy effect for Neg conditionals, but do see one for Neg disjunctions (even if this doesn't lead to a significant connective×redundancy interaction). The expectation is that there should be such a significant redundancy effect for NegFirst conditionals.

A possibility then to consider is that, while two redundancy effects might be at play in disjunctions, only one is at play in conditionals: NegFirst conditionals are not redundant, whereas PosFirst conditionals are. In that respect, First conditionals mirror disjunctions, where switching from Neg to Pos adds a redundancy violation. But for Second conditionals both Pos and Neg carry just the one redundancy violation and are thus equally redundant, in contrast to disjunctions. We will return to this issue in the general discussion. For now, we turn to data on another connective, conjunction, to gain a more complete understanding of how redundancy effects vary across connectives.

5 Experiment 3: Conjunction

The third experiment explores redundancy and order effects in conjunction.

5.1 Design

The design was based on Experiments 1 and 2, but implemented in a simplified 2×2 factorial design that leaves out polarity. The manipulated factors were: (a) whether the conjunction was redundant (redundancy), manipulated between subjects, and (b) the order of the conjuncts (order), manipulated within subjects.

We did not include a polarity manipulation because, although prior literature suggests that conjunction may exhibit order effects, no analogous claims have been made regarding polarity effects for this connective. Accordingly, our critical stimuli consisted exclusively of positive redundant conjunctions in either order, which we refer to as Hurford conjunctions (HConj).

(20) *Hurford Conjunction* (HConj)
Context: John and his family want to visit Asia. They have various destinations in mind, but the most prominent ones are cities in Japan, especially Tokyo. Recently, John and his family returned from their Asia trip, and had various souvenirs that I suspect they got in Tokyo (although I'm not entirely sure). So, I thought:
a. John's family visited Japan and they visited Tokyo. (first)
b. John's family visited Tokyo and they visited Japan. (second)

To assess effects of Redundancy, we again include baselines with no violation or redundancy, parallel to Experiments 1 and 2.

(21) *Simple Conjunction* (SConj)
Context: John and his family have been wanting to visit Asia for a long

time. They recently came into a bit of money, and were talking about traveling to Tokyo and to China. They were also debating going to Australia, but not everyone was up for that. While I don't know what their final itinerary entailed, I suspect at least that:

a. John's family visited China and they visited Tokyo. (FIRST)
b. John's family visited Tokyo and they visited China. (SECOND)

The rest of the design was identical to that of the previous experiments in all relevant respects. As before, a total of 24 critical items were created, along with 24 fillers, which are omitted here for brevity.[11]

Again for ease of reference, we summarise schematically the use of the labels for each conditions in Table 12.

	Order	
Redundancy	**First**	**Second**
Hurford Conj	$J \wedge T$ (HCONJFIRST)	$T \wedge J$ (HCONJSECOND)
Simple Conj	$C \wedge T$ (SCONJFIRST)	$T \wedge C$ (SCONJSECOND)

Table 12 Positive-polarity Experiment 2 conditions: T stands for *Tokyo*, J for *Japan*, and C for *China*.

5.2 Procedure

The procedure was the same as in Experiment 1 (see Section 2.2), except for the training phase: instead of redundant vs non-redundant conjunctions, participants saw the following three training trials: (i) a simple sentence in a context, with no violations of any kind, (ii) a sentence that was contradictory in its context, and (iii) a sentence that contained an implicature violation relative to its context.

11 A note on the fillers: we kept the GOODCONJ and BADCONJ ones from the previous experiments intact; however, since redundant conjunctions represent the precise thing being tested in Experiment 3, we swapped the GOODCONJ vs BADCONJ fillers for disjunctions: 6 BADDISJ Hurford disjunctions, and 6 GOODDISJ normal disjunctions.

5.3 Data availability

All stimuli, together with the files and scripts required for the statistical analysis reported below, can be found on the *OSF* page for this paper, linked here.

5.4 Participants

A total of 201 participants were recruited from our university's Psychology subject pool, 195 of whom had not participated in Experiment 1. There was no overlap with participants in Experiment 2. All participants were undergraduate native English speakers.

5.5 Data analysis

The data analysis followed the same approach as that described in Section 2.5 for Experiment 1. Our key questions were whether there is an effect of REDUNDANCY and whether such effects are modulated by ORDER, as would be reflected in a REDUNDANCY×ORDER interaction.

5.6 Results

Figure 6 shows the distribution of the responses for the redundant and non-redundant conjunctions by ORDER.

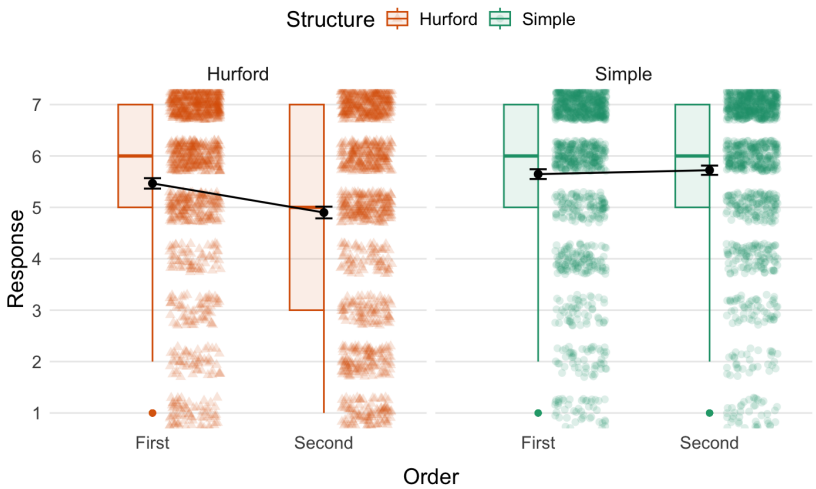

Figure 6 Responses to the Hurford and Simple conjunctions by ORDER.

We fit a model predicting Response from REDUNDANCY, ORDER and their interaction. The final model included random intercepts for participant and item, as well as a

by-item random slope for REDUNDANCY. The model revealed significant main effects of ORDER ($\beta = 0.16$, $SE = 0.02$, $z = 5.85$, $p < .001$) and REDUNDANCY ($\beta = -0.38$, $SE = 0.13$, $z = -2.8$, $p < .01$), as well as a significant interaction between these two factors ($\beta = 0.17$, $SE = 0.02$, $z = 6.36$, $p < .001$). It is clear that this interaction is driven by an order effect that is present for RED but absent in the NORED baseline. Pulling out the relevant contrasts with *emmeans*, we see a significant difference for REDFIRST vs. REDSECOND ($\beta = 0.68$, $SE = 0.07$, $z = 8.8$, $p < .0001$), but no such difference for NOREDFIRST vs. NOREDSECOND ($\beta = -0.02$, $SE = 0.08$, $z = -0.34$, $p = 0.98$). Note also that it is only the SECOND level where a redundancy effect is present ($\beta = 1.12$, $SE = 0.28$, $z = 4$, $p < .001$; FIRST Hurford Conjunctions do not significantly differ from their Simple baseline ($\beta = 0.42$, $SE = 0.28$, $z = 1.48$, $p = 0.44$).

5.7 Discussion

The results of Experiment 3 confirm the standard claim that $p^+ \wedge p$ is infelicitous. They also reveal an interaction between REDUNDANCY and ORDER for conjunctions, driven by an order effect at the RED-level, whereas no such effect was found for the control NORED conjunctions. This experimentally supports prior reports, based on informal judgments, that order modulates redundancy effects in conjunctions. Importantly, this contrasts with our findings for disjunctions and conditionals (at least for the POS polarity), highlighting a theoretical challenge: standard accounts of redundancy generally predict uniform (a-)symmetries across connectives, yet our experiments reveal a more complex pattern.

We now turn to a cross-connective comparison of conjunction with disjunctions and conditionals, analyzing pooled data for the relevant pairings.

6 Cross-connective comparison (Part 2): Conjunction vs. Disjunction and Conditionals

This section presents statistical comparisons of conjunction with disjunctions and conditionals, pooling data from the respective sub-experiments. Our goal is to systematically test whether these connectives differ in their redundancy and order-based effects.

6.1 Data preparation

Comparing the effects of redundancy and order in conjunction with those in the other two connectives required combining different parts of our original datasets from Experiments 1, 2, and 3. In particular, since we did not manipulate polarity

for conjunction in Experiment 3, and since polarity played an important role in disjunction and conditionals, we will only compare the conjunction data to what seem like the most comparable polarity-variants. For disjunction, this is the HD-variant, with two positive disjuncts and no negation. By extension, for conditionals, we look at the variant that stands in the *or-to-if*-inference relation to HD, that is, the NegAnt-conditionals. We analyzed the two pairings of connective separately in the corresponding pooled datasets. For each dataset, we then coded a conn(ective) factor to indicate whether each observation involved If, Disj, or Conj, based on its source dataset. The coding for Order and Redundancy factors was the same as before.

6.2 Conjunction vs. Disjunction

A visual comparison of Figure 6 (conjunction) and Figure 1 (disjunction) suggests differences in whether redundancy×order interact. To assess this statistically, we fit a model predicting responses from connective, redundancy, order and their interactions. The final model included random intercepts for participant and item, as well as by-item random slopes for connective, redundancy, and the connective×redundancy interaction. Additionally, a by-participant random slope for order was included. The model revealed a significant three-way interaction ($\beta = -0.06$, $SE = 0.02$, $z = -2.18$, $p < .05$). Planned comparisons using *emmeans*, indicated that this interaction was driven by a redundancy:order interaction for conjunctions ($\beta = -0.8$, $SE = 0.14$, $z = -5.68$, $p < .0001$), which, recall, was not observed for disjunction ($\beta = -0.31$, $SE = 0.17$, $z = -1.77$, $p = 0.07$).

Beyond order, the results also indicate that while both conjunctions and disjunctions exhibit redundancy effects, the impact is significantly stronger for disjunctions. Figure 7 visualizes this contrast, plotting positive Hurford disjunctions against their SD baselines and comparing them to conjunctions (also plotted against their SC baselines).

To assess this statistically, we carried out planned comparisons that tested whether the difference between Red vs NoRed conditions differed between disjunction and conjunction. We evaluated this comparison at the Second level of the Order factor for conjunction (since in that case we know that conjunctions show an effect of redundancy – no effect of redundancy is found in conjunction for Order = First.[12]); but since disjunction exhibited no order effect, we averaged over the level of the Order factor for disjunction. The result was that indeed the two connectives differ

12 Using *emmeans* on the model of section 5 to extract the Red vs NoRed at Order = First we get: $\beta = 0.42$, $SE = 0.28$, $z = 1.48$, $p = 0.44$

in how strong a redundancy effect they exhibit, leading to significant interaction ($\beta = 2.41$, $SE = 0.36$, $z = 6.56$, $p < .0001$).

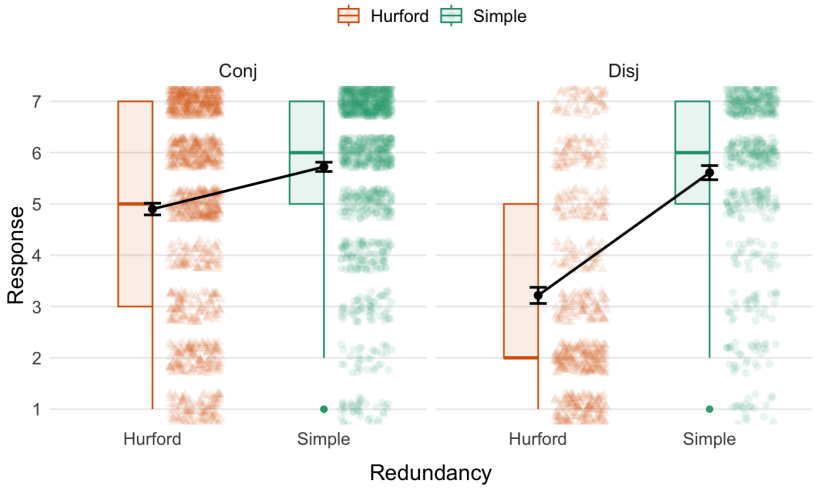

Figure 7 Responses to Red vs NoRed grouped by CONNECTIVE. Both connectives are visualized only at the Second level of the ORDER factor.

6.3 Discussion

We contrasted the conjunction results from Experiment 3 with the disjunction data from Experiment 1, yielding two main conclusions. First, the two connectives differ in how order affects redundancy: conjunctions show a strong order effect, whereas disjunctions do not, resulting in a significant CONNECTIVE×ORDER×REDUNDANCY interaction. This further supports the absence of an order effect for disjunctions. Second, redundancy effects differ by connective: disjunctions exhibit stronger redundancy effects than conjunctions.

6.4 Conjunction vs. Conditionals

To assess how redundancy effects in conditionals relate to redundancy effects in conjunctions, we subsetted our data to include only Pos conditionals and conjunctions.[13] As before, we were interested in knowing whether the strength of redundancy differs between the two connectives, and whether the two connectives behave differently in terms of the modulating effect of order on redundancy.

13 Recall our reasoning: we aim to compare conjunctions to the conditionals most similar to them. Since conjunctions were previously compared to Pos disjunctions (as they lack a polarity manipulation), we now compare them to the conditionals equivalent to Pos disjunctions under the *or-to-if* mapping—namely, Pos conditionals.

To answer the questions, we fit a model predicting Response from CONNECTIVE, REDUNDANCY, ORDER and all their two- and three-way interaction. The final model included random intercepts for participant and item, as well as a by-participant random slope for ORDER, and by-item slopes for CONNECTIVE, REDUNDANCY, ORDER, and CONNECTIVE:REDUNDANCY. The model revealed significant main effects of CONNECTIVE, REDUNDANCY and ORDER (CONN: $\beta = 0.38$, $SE = 0.09$, $z = 4.01$, $p < .001$, REDUNDANCY: $\beta = 0.58$, $SE = 0.09$, $z = 6.09$, $p < .001$, ORDER: $\beta = 0.18$, $SE = 0.03$, $z = 5.34$, $p < .001$). There were also two significant two-way interactions: CONNECTIVE:REDUNDANCY ($\beta = -0.22$, $SE = 0.09$, $z = -2.36$, $p < .05$), and REDUNDANCY:ORDER ($\beta = -0.07$, $SE = 0.03$, $z = -2.34$, $p < .05$); the CONNECTIVE:ORDER interaction did not rise to significance ($\beta = -0.04$, $SE = 0.03$, $z = 1.44$, $p = 0.14$). Finally, the CONNECTIVE:REDUNDANCY:ORDER interaction was significant ($\beta = -0.1$, $SE = 0.03$, $z = -3.56$, $p < .001$)

With this in mind, we ask whether the effect of order on redundancy differs between the two connectives. The answer is emphatically 'yes', as indicated by the significant CONNECTIVE×REDUNDANCY×ORDER interaction. Figure 8 illustrates this clearly: conjunctions show an order effect that is absent for POS conditionals. Planned comparisons in Table 13 further confirm this pattern.

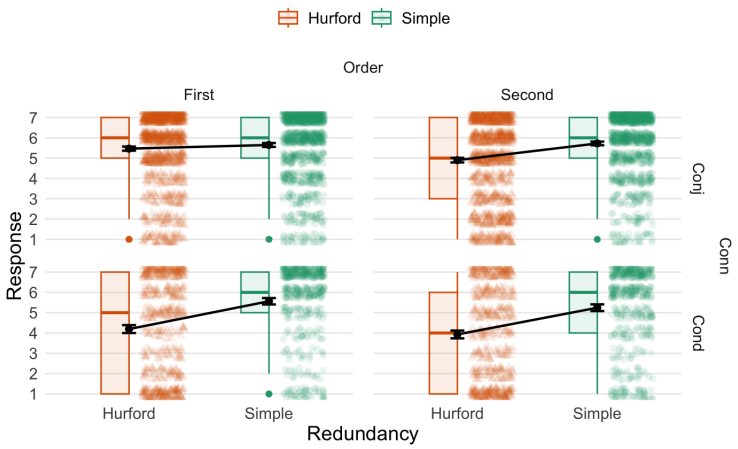

Figure 8 Responses to REDUNDANT vs SIMPLE conjunctions and conditionals, faceted by ORDER.

Moving on to the question of whether the strength of redundancy differs between the two connectives, the significant CONNECTIVE: REDUNDANCY interaction would indicate a positive answer to this. However, recall that, in our data, the effect of redundancy in conjunctions is only truly present for SECOND conjunctions, whereas for POS conditionals it was present for both orders. Therefore, we used *emmeans* to

Conn	Red	Order	β	SE	z	p
Conj	NoRed - Red	First - Second	-0.73	0.15	-4.81	<.0001
If	NoRed - Red	First - Second	0.14	0.19	0.76	0.44

Table 13 Red:Order interactions at each level of Connective

extract a custom contrast comparing NoRed vs. Red across the two connectives in the following manner: the NoRed vs. Red contrast was computed averaged across both order levels for If, but only on the second order level for and. This contrast is depicted in Fig. 9 and summarized in Table 14. While it looks like the effect might be stronger for conditionals than conjunctions, this difference is not significant.

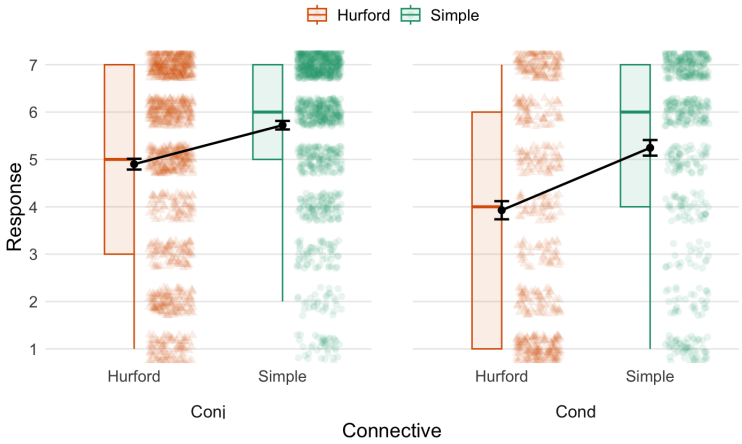

Figure 9 Responses to the Pos conditionals (Redundant vs Simple), averaged across Order levels, and contrasted with responses to Second conjunctions.

Conn	Red	β	SE	z	p
Conj - If	NoRed - Red	-0.51	0.38	-1.33	0.18

Table 14 Pairwise interaction contrast for connective and redundancy

6.5 Discussion

When comparing conjunctions to disjunctions, we found that these connectives differ in terms of both order effects and strength of redundancy. The comparison of conjunctions to the relevant conditionals corresponding to Pos disjunctions upheld these results only for order effects: conjunctions show an order effect that

is absent for Pos conditionals, just as it was absent for disjunctions. However, the strength of redundancy isn't statistically distinguishable between conjunctions and conditionals, whereas Pos disjunctions showed stronger effects of redundancy than conjunctions. This follows a motif that we have already encountered: Pos conditionals aren't as extreme in the strength of their redundancy violation as Pos disjunctions.

The variance in how strongly redundancy is perceived across the different connectives is perhaps the most striking finding so far in this paper. A standard assumption of classical approaches has been the uniformity of redundancy effects, and while there have been intuitions that polarity is a modulating factor in this respect, no similar intuition is to be found that connective identity can also be such a factor.[14] Thus, our findings across experiments that connective identity does matter after all has been surprising. At the same time, these comparisons are the result of cross-study comparisons, which come with potential issues. To address concerns in this regard, we conducted a fourth experiment, which attempts a replication of our results regarding the role of connective identity in redundancy. We turn to this in the next section.

7 Experiment 4: Within-subject comparison

Experiment 4 was designed to provide a more stringent test of the pattern observed in Experiments 1–3. Specifically, Experiment 4 employed a within-subject design in order to address potential concerns about cross-experiment comparisons. The study was also preregistered (see link here), ensuring that the replication constituted a fully confirmatory test of the previous findings.

7.1 Design

The design was a 3×2 factorial design aimed at replicating and further exploring the cross-connective comparisons within a fully within-subjects design. To keep the number of conditions manageable, we manipulated only two factors: Connective (Conjunction vs. Disjunction vs. Conditional) and Redundancy (Hurford vs. Simple), restricting the materials to positive-polarity sentences throughout.

Moreover, since Order was not manipulated in this experiment, we selected only those orders that are uncontroversially redundant under any approach to the phenomenon, namely, what we have referred to in this paper as Second order.

14 *Super-redundancy* is an exception in predicting an effect of connective. But in terms of the intuitive judgments discussed in Kalomoiros (2023a), differences between the redundancy of conjunctions vs disjunctions are not a central concern. We return to these issues in the section 8.

As a result, the design comprised six conditions of the following form (contexts ommitted):

(22) *Hurford Conjunction* (HConj)
John's family visited Tokyo and they visited Japan.

(23) *Simple Conjunction* (SConj)
John's family visited Tokyo and they visited China.

(24) *Positive Hurford Disjunction* (HD)
Either John's family visited Japan or they visited Tokyo.

(25) *Positive Simple Disjunction* (SD)
Either John's family visited China or they visited Tokyo.

(26) *Positive Hurford Cond* (HC)
John's family didn't visit Tokyo, if they visited Japan.

(27) *Positive Simple Cond* (SC)
John's family didn't visit Tokyo, if they visited China.

The 24 critical items were identical to the corresponding cases in Experiments 1-3. We also included 24 fillers, as we did in the previous experiments.[15]

7.2 Procedure

The general procedure was the same as in Experiment 3. As for the training trials, participants saw three such trials: (i) a simple sentence in a context, with no violations of any kind, (ii) a sentence that was contradictory in its context, and (iii) a sentence that contained an implicature violation relative to its context.

7.3 Participants

We recruited 150 participants via Prolific. Participants were screened so that they would only be able to participate in the study if their first language was English; they received monetary compensation for their participation, labeled 'Good' by the platform's payment standards. To ensure high data quality, we applied a pre-registered exclusion criterion: participants were excluded if the mean difference in their ratings between GoodCond and BadCond fillers was less than 2 points on

15 Once again, we kept the 12 GoodCond vs BadCond fillers from previous experiments. But since now redundant conjunctions and disjunctions are being explicitly tested in the experiment, the second filler category took the form of sentences that were either explicitly true (FillerTrue) or explicitly false (FillerFalse) in their context, with 6 instances of each being constructed.

the response scale. Recruitment continued until the target sample of $N = 150$ was reached post-exclusion, in accordance with our pre-registration.

7.4 Data availability

All stimuli, together with the files and scripts required for the statistical analysis reported below, can be found on the *OSF* page for this paper, linked here.

7.5 Data analysis

The data analysis followed the same approach as before. Our key questions were whether there is an overall effect of Redundancy and whether such effects are modulated by Connective. One key difference with our previous experiments is that we preregistered both a frequentist and a Bayesian analysis. The aim was to get complimentary perspectives, and especially be in a better position to judge the significance of any null effects. Our question was whether the strength of redundancy, measured as the difference between Hurford vs Simple sentences, varied across connectives. Based on our previous results, we expected that disjunctions would show the strongest effect of redundancy, contrasting with conjunctions and conditionals; the latter two would conversely show parallel effects of redundancy.

7.6 Results

The results are summarized in Fig.10. Visually, the redundancy effect for disjunctions appears substantially steeper than for the other two connectives. In contrast, conjunctions and conditionals show very similar patterns, although—consistent with previous experiments—the slope for conditionals appears slightly steeper than that for conjunctions.

This visual pattern is confirmed by the statistical analyses. We first fit a mixed-effects ordinal regression model predicting Response from Connective, Redundancy, and their interaction. The final model included a by-item random slope for Connective, and by-participant slopes for Connective, Redundancy, and their interaction. We then used the *emmeans* package to extract pairwise contrasts comparing redundancy effects across connective types, which constitute the primary quantities of interest. The results are shown in Table 7.6. The redundancy effect for disjunctions differed significantly from that for both conjunctions and conditionals, whereas the difference between the latter was not significant.

To better interpret potential null effects, we also conducted a Bayesian analysis, as specified in our preregistration. Constructing the Bayesian model required specify-

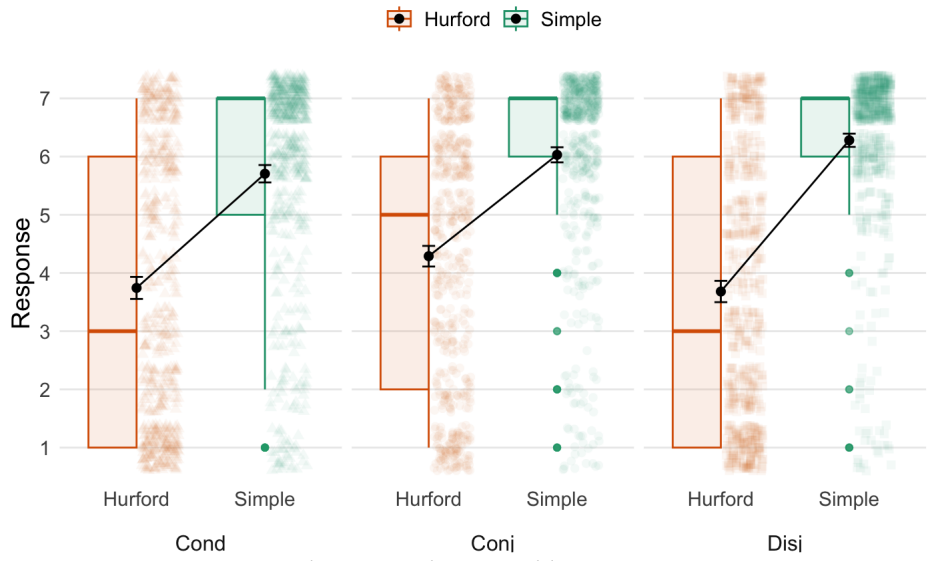

Figure 10 Responses to Red vs NoRed grouped by CONNECTIVE.

Conn	Red	β	SE	z	p
Cond – Conj	NoRed – Red	-0.008	0.4	-0.021	0.98
Cond – Disj	NoRed – Red	-0.9	0.29	-3.057	0.0022
Conj – Disj	NoRed – Red	-0.89	0.39	-2.259	0.02

Table 15 Pairwise Comparisons of Redundancy Effects across Connectives

ing priors for the model parameters. To inform these priors, we first aggregated all relevant conditions from previous experiments into a single dataset (i.e., all SECOND and POS conditions from Experiments 1-3). We then fit a Bayesian ordinal mixed-effects model to this dataset using the *brms* package with its default priors. The posterior means and standard errors from this model were subsequently used to construct informed priors for the subsequent analysis.[16]

To facilitate direct model comparisons and explicit tests of equality between interaction terms, we reparameterized the model by manually dummy-coding the

16 Priors for fixed effects and interaction terms were specified as normal distributions centered on the posterior estimates from the previous model, with standard deviations set to twice the estimated error (SE) in order to remain weakly informative. Intercepts were similarly centered on the posterior estimates with a standard deviation of 0.5. For group-level effects (random intercepts for participants and items), we employed exponential priors with $\lambda = 1/\mu$, where μ corresponds to the posterior estimate of the relevant standard deviation. The exact numerical values are provided in the R files on OSF (see here).

interactions as separate fixed effects (Int_{Cond}, Int_{Conj}, Int_{Disj}). We first applied sum-coding to the REDUNDANCY factor (Non-Redundant: -1, Redundant: 1). We then created an indicator variable for each connective-specific interaction. Concretely, for a given connective, the corresponding interaction column was coded as 0 for all other connective types; for the target connective, it mirrored the sum-coded redundancy values (1 for non-redundant and -1 for redundant). Hence, this construction isolates the redundancy slope for each connective, allowing direct tests of null hypotheses by constraining slopes to equality in nested model comparisons. We then fit an ordinal mixed effects model predicting Response from REDUNDANCY, CONNECTIVE, and the three interaction terms: Int_{Cond}, Int_{Conj}, and Int_{Disj}. The model included the maximal random-effects structure justified by the design (decorrelated) for both participants and items.

The results indicated a robust main effect of REDUNDANCY ($\beta = 1.21$, $SE = 0.13$, 95% CI $[0.94, 1.47]$). Given our coding (Non-Redundant: 1, Redundant: -1), this estimate corresponds to a significant overall redundancy penalty across the dataset. Inspection of the interaction terms revealed a clear divergence across connective types. The interaction estimates for conditionals ($\beta = -0.07$, $SE = 0.15$, 95% CI $[-0.35, 0.22]$) and conjunctions ($\beta = -0.14$, $SE = 0.15$, 95% CI $[-0.43, 0.16]$) were small, with credible intervals broadly overlapping zero. By contrast, disjunctions exhibited a substantial positive interaction ($\beta = 0.47$, $SE = 0.14$, 95% CI $[0.20, 0.74]$). This pattern indicates that the redundancy penalty is considerably stronger for disjunctions than for the other two connectives.

As specified in our preregistration, we used two methods to examine pairwise contrasts between interaction terms. First, we used the *hypothesis()* function of *brms* to test whether the difference between each pair of interaction parameters was equal to zero. The results, summarized in Table 16, support the conclusion that disjunctions exhibit a stronger redundancy effect than conjunctions and conditionals. By contrast, conjunctions and conditionals do not meaningfully differ: the evidence ratios provide positive support for the null hypothesis that their redundancy effects are equivalent.

Second, we conducted a series of model comparisons quantifying the support for maintaining three distinct interaction terms versus collapsing specific pairs. Specifically, we compared the maximal model—containing independent interactions for each connective—with restricted models in which particular interaction parameters were constrained to equality.[17] These comparisons yield Bayes Factors

17 The original model, with the full random-effects structure, proved unstable during bridge sampling. Thus, we re-fit a slightly simplified model retaining random intercepts and by-participant and by-item random slopes for REDUNDANCY and CONNECTIVE. This simplification did not materially

Hypothesis	Contrast	Estimate	Est. Error	Evid. Ratio	Post. Prob
$\text{Int}_{\text{Cond}} = \text{Int}_{\text{Conj}}$	Cond − Conj	0.07	0.21	12.85	0.93
$\text{Int}_{\text{Cond}} = \text{Int}_{\text{Disj}}$	Cond − Disj	-0.54	0.21	0.02	0.02
$\text{Int}_{\text{Conj}} = \text{Int}_{\text{Disj}}$	Conj − Disj	-0.61	0.21	0.01	0.01

Table 16 Bayesian hypothesis tests for differences between interaction terms. Evidence Ratios > 1 indicate evidence in favor of the null (equality), while ratios near 0 indicate evidence for a difference.

(BF_{10}), providing a model-level measure of whether the additional complexity of the three-way distinction is warranted by the data.

The model comparison results were fully consistent with the evidence-ratio analysis. The maximal model was decisively preferred over a restricted model collapsing Int_{Cond} and Int_{Disj} into a single parameter ($BF_{10} > 100$), as well as over a model collapsing Int_{Conj} and Int_{Disj} ($BF_{10} > 100$). In both cases, the Bayes Factors provide decisive evidence for maintaining Int_{Disj} as a distinct interaction term. Finally, when comparing the maximal model to a more parsimonious model where Int_{Conj} and Int_{Cond} were collapsed into $\text{Int}_{\text{ConjCond}}$, the simpler model was preferred ($BF_{01} = 10.69$). This result provides strong evidence that there is no meaningful difference between the redundancy effects for conjunctions and conditionals.

7.7 Discussion

The results of Experiment 4 replicate and confirm the pattern of the previous three experiments. First, disjunctions form a distinct category: redundant material produces a markedly stronger penalty for disjunctions than for the other two connectives. Second, conjunctions and conditionals exhibit functionally identical behavior.

Importantly, Experiment 4 strengthens these conclusions in several methodological respects. Unlike the earlier studies, the experiment employed a fully within-subjects design, thereby controlling for between-participant variability in redundancy sensitivity. In addition, the conclusions are supported by two complementary statistical analyses—a frequentist mixed-effects analysis and a Bayesian model-comparison framework—which converge on the same pattern of results. Together, these features

affect the results: the evidence ratios obtained using *hypothesis()* remained qualitatively identical. For the simplified model, the evidence ratios were: $\text{Int}_{\text{Cond}} = \text{Int}_{\text{Conj}}$: 4.16; $\text{Int}_{\text{Cond}} = \text{Int}_{\text{Disj}}$: 0; $\text{Int}_{\text{Conj}} = \text{Int}_{\text{Disj}}$: 0. Full details are available on OSF.

provide a particularly robust confirmation of some of the key empirical findings presented in this paper.

8 General discussion

8.1 Summary of the findings

We have provided the first, to our knowledge, experimental *vindication* of the core intuitions driving standard approaches to redundancy: namely, that Hurford disjunctions, redundant conjunctions, and Hurford conditionals are degraded relative to non-redundant baselines.

Second, we find that redundancy is less of a binary phenomenon than previously assumed; instead, it can be modulated by factors such as polarity, order and the identity of the connective. At a high level, these modulating effects can be described as follows:

- Differential effects of order across connectives.
- Polarity sensitivity of redundancy judgments.
- Differential strength of redundancy effects across connectives.

As we have emphasized throughout this paper, this general picture is further shaped by additional interactions. Yet even at this general descriptive level, it is evident that these patterns are not predicted by standard versions of the Simplification and Local Contexts theories. First, these theories are most naturally implemented to predict *either* uniform asymmetries *or* uniform symmetries across connectives. Second, they rely on notions of (contextual) entailment that are insensitive to the presence or absence of negation, as long as the entailment relation is held fixed. Finally, these theories produce binary judgments for a sentence and lack the resources to account for differential effects of redundancy across connectives.

At this stage, it is helpful to synthesize the patterns in our experiments that any theory aiming to account for our results will need to accommodate:

i. Both Positive and Negative Hurford disjunctions exhibit redundancy effects; but the relevant effect is stronger for the Positive cases.

ii. Redundancy effects for disjunction are not modulated by Order.

iii. Redundancy effects for conjunction are modulated by Order: the Second order (i.e., $p^{+} \wedge p$) exhibits effects of redundancy, but the First order (i.e., $p \wedge p^{+}$) does not.

iv. The redundancy effect observed with the SECOND order in conjunctions is weaker than that observed in POSITIVE disjunctions.

v. NEGFIRST conditionals show no effect of redundancy, but NEGSECOND ones do. POSFIRST and POSSECOND conditionals show comparable redundancy effects. As such, conditionals exhibit a polarity-dependent order effect.

vi. POSITIVE conditionals are less redundant than POSITIVE disjunctions.

vii. The strength of redundancy in POSITIVE conditionals does not significantly differ from that of SECOND conjunctions.

In what follows, we will suggest possible directions for capturing these effects. Specifically, we will suggest order effects might profitably be derived from a theory that more closely integrates redundancy and presupposition. Effects that have to do with the differential strength of redundancy between connectives will be examined via the lens of the theory of *super-redundancy*: this approach can help account for the relevant 'strength' and polarity effects that we see in conjunctions and disjunctions, but does not straightforwardly extend to conditionals, which are then left as a puzzle.

8.2 Order effects and presupposition

Order sensitivity varies by connective: effects are present in conjunctions but absent in disjunctions, mirroring patterns that have emerged in recent work on presupposition projection. It has long been argued, since at least Karttunen (1974), that presupposition filtering is sensitive to order in conjunctions, but not in disjunctions. For example, consider the following:

(28) a. John used to smoke Marlboros and he stopped.
b. John stopped smoking and he used to smoke Marlboros.

While (28a) is not felt to presuppose that John used to smoke, (28b) is interpreted as presupposing this, a conclusion experimentally confirmed by Mandelkern et al. (2020).[18] By contrast, in disjunctions like the examples below, no presupposition is felt to arise, regardless of order (see Kalomoiros & Schwarz 2024 for recent experimental confirmation).[19] Unlike conjunction then, disjunction exhibits symmetric behavior with respect to presupposition filtering.

18 In cases where one conjunct is equivalent to the presupposition of the other (e.g., *John used to smoke and he stopped*), one might be tempted to attribute the order effects to redundancy/triviality. Using asymmetric entailment controls for this confound (Mandelkern et al. 2020).

19 One issue that must be controlled for when reasoning about symmetric filtering with disjunctions is the possibility that symmetry arises from local accommodation (Schlenker 2008, Hirsch & Hackl

(29) a. Either John didn't use to smoke or he stopped.
b. Either John stopped smoking or he didn't use to smoke.

The above patterns suggest a parallelism between order effects in presupposition projection and order effects in redundancy, concordant with the idea that positions where a presupposition can be filtered are positions where it has somehow become known information (Stalnaker 1974, Schlenker 2009: a.o.). In the domain of filtering, various theoretical frameworks have been developed to try to account in an explanatory way for the differential order effects between conjunction vs disjunction (George 2008b, 2007, Kalomoiros 2023b, Kalomoiros & Schwarz 2024).

While these frameworks have not yet been extended to the redundancy domain, the account in Kalomoiros 2023b can be adapted to a Local Context implementation (Kalomoiros 2024). We do not pursue that possibility here, but if it is correct, it would open the way to an integrated account of non-uniform order effects in presupposition and redundancy alike. By contrast, it is not immediately clear how to plug accounts of presupposition like George (2008a) or Kalomoiros (2023b) into the Simplification approach. Therefore, between the two main approaches we have considered in this paper, Local Contexts vs Simplification, this constitutes an indirect argument against Simplification and for Local Contexts.

Finally, given the parallelism outlined above between presupposition and redundancy, it is natural to ask whether order effects in presupposition filtering with conditionals follow the same pattern that we found for their redundant Hurford counterparts. Recent work suggests that this may indeed be the case. In particular, Kalomoiros et al. (2024) present experimental results suggesting that conditionals with ***negated*** antecedents exhibit symmetric filtering. More specifically, their results indicate that the presupposition of the antecedent is filtered in both (30a) and (30b):

(30) a. If John isn't studying in Japan too, Mary is not studying in Tokyo.
b. Mary is not studying in Tokyo, if John isn't studying in Japan too.

This mirrors the absence of order effects in Positive Hurford conditionals, whose antecedents were negated. Extending this line of reasoning, we expect that, given the order effect we found with Negative Hurford conditionals, a similar effect should arise on the filtering side once negation is removed from the antecedents in (31). More specifically, we would expect less presupposition filtering in (31a), given that we found the effect of redundancy to be weaker in NegFirst conditionals—in fact, there was no evidence for it; see Table 7—than in (31b), where the effect

2014). The experiments we reference include explicit controls to rule out this potential confound (see Kalomoiros & Schwarz 2024).

of redundancy was stronger in NegSecond conditionals. If this expectation is borne out, it would provide further support for the parallelism between the two phenomena.

(31) a. If John is studying in Japan too, Mary is not studying in Tokyo.
b. Mary is not studying in Tokyo, if John is studying in Japan too.

Having highlighted the attested and potential parallels between the two phenomena, we must note an important caveat. Unlike the presupposition literature, we did not test *embeddings* of our target sentences, so it is possible that the contrast we observed between disjunction and conjunction is a discourse-level contrast. That is, perhaps $p \wedge p^{+}$ can be interpreted as a successive assertion, of p and then p^{+}, allowing us to make sense of it pragmatically, while $p^{+} \wedge p$ cannot. By contrast, no such parallel discourse-integration strategy arises in the case of disjunction. Thus, before conclusively claiming a strong parallelism between redundancy and presuppositions, we would need to test embeddings of our target cases in future work.[20,21]

With this in mind, let's assume for the sake of argument that there is indeed a parallel between presupposition and redundancy, and it's what accounts for the order-based contrast between conjunction and disjunction (points (ii) and (iii) in 8.1). Let's also assume that the same parallelism is what eventually explains the polarity-dependent order effect in conditionals (point (v) in 8.1): Positive conditionals are redundant in both orders, but Negative conditionals are only redundant in Second order.[22] We then still need to account for the following points:

i. Positive disjunctions are more redundant than Negative disjunctions

iv. Positive disjunctions are more redundant than Second conjunctions.

vi. Positive disjunctions are more redundant than Positive conditionals.

20 At the same time, it seems less likely that the polarity-dependent order effect that we found for conditionals can be explained via different strategies for asserting a conditional with a positive vs a negative antecedent. Thus, if a parallel order effect is confirmed on the filtering side, this will constitute clearer evidence that filtering and redundancy are indeed parallel.

21 A recent line of research attempts to derive redundancy effects by assuming that different structures associate with different QUDs (Zhang 2025, Hénot-Mortier 2025). On the basis of this difference, one can then attempt to derive further distinctions between the two connectives, such as the order-sensitivity of conjunction vs the order-insensitivity of disjunctions (see Haslinger (2025) for a sketch). A full evaluation of this kind of framework will have to await another occasion.

22 Attributing these facts to the parallelism between filtering and redundancy is not an arbitrary decision. The theory in Kalomoiros (2023b) predicts exactly this constellation of facts for filtering: the presuppositions of a positive antecedent in a conditional like (31) are projected in the antecedent-first order but filtered in the antecedent-final order. Conversely, for a conditional with a negative antecedent like (30), the presuppositions of the antecedent are filtered in either order.

vii. Positive conditionals and Second conjunctions exhibit parallel strength of redundancy.

We now turn to the notion of super-redundancy and how it can help here.

8.3 Super-redundancy

8.3.1 Intuitions and definition

Super-redundancy was first developed in Kalomoiros 2023a. Kalomoiros builds on the notion of a redundant constituent from the Simplification theory of redundancy. Recall that a constituent is redundant in S if the result of deleting that constituent is contextually equivalent to S. A constituent is said to be *super-redundant* if it is not only redundant, but also irredeemably so—that is, if any attempt to strengthen the constituent still results in redundancy.

(32) **Super-redundant constituent:** Given a sentence S, a context C, a constituent E of S is super-redundant iff for all atomic constituents E' of E, and for all D: $E[E'|E' \wedge D]$ is redundant in S' in C, where: $E[E'|E' \wedge D]$ is identical to E except that the atomic constituent E' has been replaced with $(E' \wedge D)$; and S' is a sentence identical to S but where E has been replaced by $E[E'|E' \wedge D]$.[23]

The idea is that a sentence which contains a constituent which is redundant will strike us as odd, while a sentence which contains a constituent which is redundant and also super-redundant will strike us as odder still.

8.3.2 Conjunction vs Disjunction

The notion of super-redundancy can help account for two key aspects of our results: why negative Hurford disjunctions are judged to be less odd than positive Hurford disjunctions, and why positive Hurford disjunctions are judged to be more odd than redundant conjunctions.

First, note that positive Hurford disjunctions are both redundant and super-redundant. $p^+ \vee p$ (and its reverse order) is equivalent to p, which means that p^+ is redundant here. Moreover, p^+ is super-redundant in this case: no matter what we attempt to conjoin it with, its redundancy cannot be eliminated, because $(p^+ \wedge D) \vee p$ is

23 Here, we underlyingly assume a garden variety propositional language consisting of propositional constants, and complex sentences formed via negation, conjunction, disjunction and implication. As such, 'atomic constituent' refers to the simple propositional constants in this language.

always equivalent to p, no matter what D is. So positive Hurford disjunctions contain a constituent which is not only redundant but irredeemably so.

By contrast, negative Hurford disjunctions are not super-redundant. $\neg p$ is redundant in $\neg p \vee \neg p^+$, because the latter is equivalent to $\neg p^+$; but it is not super-redundant, because we can select a D to conjoin with one of its atomic constituents in a way that eliminates the redundancy of the constituent. For instance, $\neg(p \wedge \bot) \vee \neg p^+$ is not generally equivalent to to $\neg p^+$ but rather to $\top$. So $\neg p$ is redundant but not irredeemably redundant in $\neg p \vee \neg p^+$.

Super-redundancy likewise lets us distinguish between the level of oddness observed in positive Hurford disjunctions vs. that seen in redundant conjunctions. We have seen that $p^+ \vee p$ is super-redundant. By contrast, $p^+ \wedge p$ is only redundant: the conjunct p is redundant, but it is not super-redundant, since, e.g., $p^+ \wedge (p \wedge \bot)$ is not generally equivalent to p^+ but rather to $\bot$.

8.3.3 Conditionals

What about the remaining effects with conditionals, i.e., why:

vi. Pos disjunctions are more redundant than Pos conditionals.

vii. Pos conditionals and First conjunctions exhibit parallel strength of redundancy.

Here we briefly explore the predictions super-redundancy makes for conditionals if we assume a simplified material implication semantics. That is, we briefly put aside the non-committal approach we maintained throughout this paper about the semantics of conditionals to illustrate the predictions of super-redundancy. We of course acknowledge that the resulting account of Hurford conditionals is only a promissory note, since the natural language conditional cannot realistically be treated as the material conditional.

Having said that, for now, assume that $\rightarrow$ is just the material conditional. In $(\neg p^+ \rightarrow p)$, $\neg p^+$ is redundant, since $\neg p^+ \rightarrow p$ is equivalent to p. But $\neg p^+$ is also super-redundant, since attempting to strengthen its atomic sub-constituents doesn't break the equivalence of $\neg p^+ \rightarrow p$ with p.[24] By contrast, $p \rightarrow \neg p^+$ is not super-

24 Note that the requirement that atomic sub-constituents of $\neg p^+$ be the ones subject to strengthening is crucial. If we allowed a redundant constituent E to escape super-redundancy simply because any strengthening of any of its sub-constituents (regardless of their granularity) made E non-redundant, then $\neg p^+$ would no longer count as super-redundant in $\neg p^+ \rightarrow p$ since e.g. $(\neg p^+ \wedge \bot) \rightarrow p$ is equivalent to $\top$, not (generally) to p.

redundant: p is redundant, but it is not super-redundant, since, e.g., $(p \wedge \bot) \rightarrow \neg p^{+}$ is no longer equivalent to $\neg p^{+}$ but rather to $\top$.

There are three issues with this account of redundancy effects in Hurford conditionals: first it predicts that Negative and Positive Hurford conditionals should contrast, with the latter being more strongly redundant than the former. As we have already seen, such a contrast holds only for Order = First. But even in that case, it's not clear that that the contrast was due to the fact that NegFirst conditionals were redundant, and PosFirst conditionals were redundant to an even greater extent – in fact there is no evidence for the presence of a redundancy violation in NegFirst conditionals in the first place.

The other two issues relate to how connectives should differ with respect to their redundancy violations. Indeed, super-redundancy predicts that Negative and Positive conditionals should pattern like their corresponding disjunctions. While we saw that this was the case for Negative conditionals (modulo the discussion in the previous paragraph), we found a contrast between Positive conditionals and Positive disjunctions: the latter showed a stronger effect of redundancy than the former. Relatedly, Positive conditionals are predicted to be more redundant than Second conjunctions: the former are super-redundant while the latter only redundant. But we found no significant contrast in this respect, and in fact the Bayesian analysis of Experiment 4 provided statistical evidence against it.

Thus, to maintain an account of conditionals along the lines predicted by super-redundancy, one would have to come up with a explanation as to why Positive conditionals are not as redundant as Positive disjunctions. This explanation should also provide an answer to why Positive conditionals are on par with Second conjunctions in terms of redundancy. We do not currently have such an answer, so for the time being we leave this as a puzzle.

Finally, super-redundancy must be eventually integrated into a framework that can handle both presupposition and Hurford phenomena (recall also our conclusion earlier that it's hard to see how to fit differential order effects within Simplification). As such, future research should explore whether making the requisite moves of adopting a more plausible conditional semantics and better integrating redundancy and presupposition might hold solutions to the remaining puzzles we have outlined here.[25]

25 It should be noted that Kalomoiros (2023a) discusses the application of super-redundancy to the Stalnaker-style variably strict semantics for conditionals. A primary challenge for this approach is that, under such semantics, antecedents are inherently non-redundant (cf. Mandelkern & Romoli (2018)). Consequently, they they also cannot be super-redundant, since super-redundancy is strictly stronger than redundancy. This theoretical prediction, however, stands in tension with the observed

9 Conclusion

We have presented four experiments that advance our understanding of redundancy in multiple ways. On the one hand, our results validate a key empirical observation motivating much of this literature: Hurford disjunctions, conditionals, and redundant conjunctions all exhibit redundancy effects. On the other hand, they unveil a range of additional effects – related to order, polarity, and the connective-type – that are not straightforwardly predicted by the standard Simplification or Local-Context approaches. We have sketched directions for two (currently partial) accounts of these phenomena: one linking order effects to analogous patterns in presupposition filtering, and another relating differences in the strength of redundancy to the notion of super-redundancy. While these proposals account for a substantial portion of the effects we observed, several theoretical and empirical questions remain, particularly concerning how (super-)redundancy operates in conditionals. We suggested that further progress may come from investigating how constraints on the redundancy of at-issue content can be integrated with constraints governing presupposition.

oddness of Hurford conditionals such as: *If John isn't in Paris, he's in France*. This infelicity can only be accounted for within a redundancy-based framework if the antecedent is indeed treated as redundant. Thus, reconciling (super-)redundancy notions with a variably strict semantics remains a significant challenge for future research.

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