# This better be interesting: A speaker's decision to speak cues listeners to expect informative content

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## Abstract

In anticipating upcoming content, comprehenders are known to rely on real-world knowledge. This knowledge can be deployed directly in favor of upcoming content about *typical situations* (implying a transparent mapping between the world and what speakers say about the world). Such knowledge can also be used to estimate the likelihood of speech, whereby *atypical situations* are the ones newsworthy enough to merit reporting (i.e. a non-transparent mapping in which improbable situations yield likely utterances). We report four forced-choice studies (three pre-registered) testing this distinction between situation knowledge and speech production likelihood. Comprehenders are shown to anticipate situation-atypical meanings more when guessing content (a) that a speaker announces (rather than thinks), (b) that is said out of the blue (rather than produced when prompted), and (c) that is addressed to a large audience (rather than a single listener). The findings contrast with prior work that emphasizes a comprehension bias in favor of typicality, and they highlight the need for comprehension models that incorporate expectations for informativity (as one of a set of inferred speaker goals) alongside expectations for content plausibility.

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## INTRODUCTION

The process of producing natural language requires making a number of informational decisions, both about what content to express and how much detail to include. These decisions reflect well-studied pressures related to efficiency and expressivity (e.g., Degen, Hawkins, Graf, Kreiss, & Goodman, 2020; M. C. Frank & Goodman, 2012; Franke & Jäger, 2016; Grice, 1975; Levy & Jaeger, 2007; Rubio-Fernandez, 2016), which are captured in generalisations about cooperative speakers for whom "what is not said is the obvious" (Atlas & Levinson, 1981; Levinson, 2000). Content decisions have primarily been studied in contexts in which a speaker's productions are already underway (e.g., modifier inclusion/omission and choices among semantically equivalent complex/simple predicates for M/I-implicatures) rather than content selection when a speaker is deciding whether to speak at all. If one way that an utterance can be relevant to the discourse is via its newsworthiness and if speakers therefore have a bias towards producing informative and newsworthy content, a concomitant comprehension bias ought to arise such that listeners come to expect newsworthy content.[1]

To illustrate, consider the passages about housing prices in (1) and whether comprehenders have different expectations for a value that denotes what Sue *thinks* someone paid (something close to the average housing price?) versus what Sue believes would be newsworthy enough to merit *telling* (something more extreme than the average?).

(1)    a.    Sue lives in New York. She **thinks** that her new neighbors bought their apartment for $____

        b.    Sue lives in New York. She **told me** that her new neighbors bought their apartment for $____

If there is no distinction between what a speaker thinks and what they say out loud, then the completions for (1-a) and (1-b) ought to align. On the other hand, if comprehenders think that speakers in communicative contexts will use language to convey newsworthy content, then the context that emphasizes information exchange ((1-b) *She told me*) ought to elicit more extreme values than one without such emphasis ((1-a) *She thinks*). Note that (1-a) and (1-b) are both communicative contexts in that there is an author/narrator producing information about Sue in both cases. If comprehenders expect

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[1] Language users of course do many things with language aside from conveying newsworthy information, but the use of language as a channel for relevant information transfer nonetheless represents a fundamental reason to communicate.

newsworthiness from language, then both (1a) and (1b) may induce a preference for a value that deviates from the average housing price, but the prediction is that such a preference ought to be stronger in the context that more explicitly emphasizes information exchange. Current models of language comprehension portray a close link between what comprehenders know about the world and the kinds of sentences they expect to encounter, insofar as sentences about situation-typical meanings are reported to be easier to process than situation-atypical meanings (e.g. Kutas & Hillyard, 1980). Such models do not deny a role for informativity or, more generally, relevance, but by emphasizing a comprehension preference for typicality and plausibility, they in effect depict language as a transparent modality that speakers use to convey what they observe in the world. In contrast, the approach we take here highlights the importance of speaker goals: In contexts where newsworthiness is a plausible speaker goal, models ought to make explicit a distinction between the prior probability of a certain meaning and the (inversely related) likelihood of a speaker choosing to produce an utterance to convey that meaning.

Modelling speaker goals — and comprehenders' inferences about those goals —is fundamental to work on experimental pragmatics (A. Frank & Jaeger, 2008; M. C. Frank & Goodman, 2012; Sperber & Wilson, 1995). We follow researchers like A. Frank and Jaeger and M. C. Frank and Goodman in taking an information-theoretic approach to message encoding and decoding. Such an approach is apparent in a number of processing models, particularly those for speech production (Aylett & Turk, 2004; Gahl, 2008; Hale, 2006; Jurafsky, Bell, Fosler-Lussier, Girand, & Raymond, 1998; Levy & Jaeger, 2007; Piantadosi, Tily, & Gibson, 2011; Zerkle, Rosa, & Arnold, 2017) but has received less attention for modelling comprehension (cf. Rohde, Futrell, & Lucas, 2021; Sedivy, 2003). Regarding speaker goals of newsworthiness, there is evidence that in production, speakers are more likely to mention elements that are real-world atypical — e.g., object color (YELLOW VS. BLUE BANANAS; Engelhardt, Bailey, & Ferreira, 2006; Engelhardt & Ferreira, 2014; Rubio-Fernandez, 2016; Sedivy, 2003), object material (CERAMIC VS. WOOL BOWLS; Mitchell, Reiter, & Van Deemter, 2013), or the instrument used for an action (STAB WITH A KNIFE VS. ICE PICK; Brown & Dell, 1987; Grigoroglou & Papafragou, 2016; Lockridge & Brennan, 2002). Brown and Dell's (1987) classic production study on content selection shows that while a particular object (a knife) may be the (presumed) preferred instrument for stabbing, the mention of that typical instrument is dispreferred. Rather, it is only when a story involves an atypical stabbing (with an icepick) that speakers prefer to mention the instrument. If it is the case that listeners

77  track these real-world priors and speech production likelihoods, then these probabilities should be

78  reflected in their comprehension biases — we don't expect a speaker to have encountered an icepick

79  stabbing (one hopes) or a blue banana or a woolen bowl, but we would expect them to mention it if they

80  did.

81  The relationship between speakers' productions and listeners' interpretations in such contexts is well

82  captured by models that are built on principles of rational communication (Maxims of cooperative

83  conversation (Grice, 1975) and later developments of generalized conversational implicatures (Levinson,

84  2000), the Rational Speech Act model (M. C. Frank & Goodman, 2012), rational redundancy (Degen et

85  al., 2020), efficiency and pertinence (Rubio-Fernandez, 2016), and game theory (Benz, Jäger, & van

86  Rooij, 2006; Franke, 2009)). Such models are relevant to understanding speakers' choice among

87  available forms, as well as comprehenders' response when such forms are used: see work on scalar

88  implicatures (Augurzky, Franke, & Ulrich, 2019; Hunt III, Politzer-Ahles, Gibson, Minai, & Fiorentino,

89  2013; Spychalska, Kontinen, & Werning, 2016), particularly using EEG to test the interplay of prior and

90  likelihood for scalars, (Werning & Cosentino, 2017; Werning, Unterhuber, & Wiedemann, 2019), and on

91  M-implicatures (Bergen, Levy, & Goodman, 2016). However, few models explicitly include the speaker's

92  choice to speak up in the first place (but see Lassiter & Goodman, 2017; Rohde et al., 2021) and their

93  prediction has not been tested empirically. However, these models usually consider cases where the

94  speaker must choose a form to convey a given message, but not the decision of whether to speak or what

95  message to convey in the first place, but see Rohde et al. (2021) for a recent account of explicit message

96  choice framed within a Bayesian approach to informativity. In that approach, comprehenders' processing

97  of a particular form is influenced by two factors. One is the prior, the probability of a particular meaning,

98  whereby more typical situations will have a higher prior. The other is the likelihood, the conditional

99  probability of a speaker articulating a meaning given that that meaning holds; if one of the speaker's

100  goals is to be informative, atypical situations will have a higher likelihood of being mentioned.

101  There are several key insights afforded by this Bayesian conceptualization. First is that the prior and

102  likelihood can each be considered in their own right — when a comprehender estimates the probability of

103  encountering different utterances, their assessment reflects not only an estimate of whether the meaning

104  is probable but also their estimate of whether a speaker would have selected a particular surface form to

105  convey that meaning. Second is that the available surface forms can include silence. Indeed a

comprehender should be surprised (and seek out alternative intended meanings) if a speaker formulates an utterance about content that is too easily inferable (see Kravtchenko & Demberg, 2015). Lastly, estimates of the prior and likelihood can be adjusted independently. The prior may shift if the context moves from the familiar real world to an alternative reality (e.g. Troyer & Kutas, 2018); the likelihood may adjust in more subtle ways depending on factors like who the speaker is, why they are speaking, or who they are speaking to. The studies presented here test this approach and contrast its predictions with those of a simpler model that only emphasizes typicality, with no difference predicted between comprehenders' estimates of speakers' thoughts and their utterances, as is implicit in comprehension models that link situation typicality directly to processing ease (Bicknell, Elman, Hare, McRae, & Kutas, 2010; Hagoort, Hald, Bastiaansen, & Petersson, 2004; Kuperberg, 2021; Kutas & Hillyard, 1980; Matsuki et al., 2011; Stanovich & West, 1979).

Prior work shows that comprehenders can favor messages that are sufficiently newsworthy to merit sending (faster reading times for a newsworthy message about socks that cost $100 than socks that cost $2; Rohde et al., 2021). While Rohde et al.'s reading-time results establish slower processing for situation-typical meanings compared with situation-atypical meanings, their studies do not probe the *content* of participants' expectations — which meanings do comprehenders believe speakers are likely to have *encountered* in the world (the prior) versus have chosen to *talk* about (the likelihood) and what factors affect these expectations?

The studies presented here use forced-choice tasks to test comprehenders' guesses about an upcoming numeric value in a proposition across conditions that vary the emphasis on information exchange. Experiment 1 manipulates the status of the proposition as either an individual's internal thought versus an articulated utterance. Experiments 2 and 3 manipulate the context of production — a statement produced when prompted versus out of the blue and when addressed to a single listener versus a crowd. Experiment 4 combines the conditions in a single study, testing 3 conditions that vary the emphasis on information exchange. The results suggest that comprehenders estimate the likelihood of utterance production in favor of content that deviates from real-world priors and they do so in context-sensitive ways.

**EXPERIMENT 1: PRIOR VERSUS LIKELIHOOD**

132 This first experiment tests comprehenders' expectations about upcoming content when it constitutes a

133 character's reported thought versus their reported speech, see (2).

134 (2)     Liam is a man from the US. Liam lives down the street from Rebecca.

135     a.     Rebecca **thinks** that Liam has . . . T-shirts.

136     b.     Rebecca **announced to me** that Liam has . . . T-shirts.

137                 **O** 21            **O** 29

138 We manipulate whether a character is said to THINK or ANNOUNCE something. Participants chose

139 between a 'low' value approximating the mean and a 'high' one that is expected to be more newsworthy.

140 If participants expect speakers to transparently map thoughts into speech, then a character's reported

141 thoughts ought to parallel that character's reported speech. If, however, participants distinguish between

142 the prior probability of a situation occurring and the likelihood that a speaker would choose to produce a

143 sentence about that situation, the THINK condition ought to yield estimates that are closer to participants'

144 real-world priors than the ANNOUNCE condition.

145 Note that the paradigm we are using involves a character's reported thoughts and speech, with an implicit

146 narrator who is reporting these situations as in (2). It is also possible that participants will expect the

147 narrator themselves to have something newsworthy to say, inducing expectations that both Rebecca's

148 thoughts and her announcements ought to be newsworthy. As we will show, despite this double-nesting,

149 participants do distinguish the two conditions and favor the less real-world-typical value when the

150 passage involves reported speech.

151 *Method*

152 *Materials*     Each of 12 experimental passages introduced an individual (Liam in (2)) and someone who

153 would know that individual reasonably well (neighbor, Rebecca). The final sentence described this

154 second person's thought or announcement about some aspect of the first individual's life (Appendix A).

155 The manipulation here and in Experiments 2 and 3 was implemented as a within-participants and

156 within-items design. The two numeric values for each passage were selected via a pre-test (Appendix B)

157 where participants provided free responses to questions about the number of items or frequency of events

158 in someone's life (*Liam is a man from the US. How many T-shirts does he have?*).

159 The 'low' value was selected as a value slightly above that item's pre-test mean (mean + 1/5*standard

160 deviation) and the 'high' one as a value farther above the mean (mean + 4/5*standard deviation, with

161 rounding strategy explained in Appendix B; see also Cummins, 2015).[2]

162 Both values were 'plausible' in that they represented values in the range elicited in the pre-test, but the

163 high values were less probable (and therefore more newsworthy). Participants also saw 8 filler passages:

164 Four required speculation; four were catch trials with a correct answer (Appendix C). Participants who

165 made mistakes on catch trials were excluded from analysis.

166 *Participants*    97 native-English speakers were recruited through Amazon Mechanical Turk and paid for

167 their participation ($2). We excluded participants with catch trial mistakes, leaving 90 participants (mean

168 age 41.1, range 23-77).

169 *Data analysis*    For all experiments, we analyzed the binary outcome of participants' forced-choice

170 selection (low versus high value) with logistic mixed effects models (GLMM: Jaeger (2008)) using the

171 lme4 package (Bates, Mächler, Bolker, & Walker, 2015) in R (R Core Team, 2019) with random slopes

172 and intercepts of condition for participants and items (Barr, Levy, Scheepers, & Tily, 2013). The

173 significance of the categorical fixed effect of *condition* was determined via a likelihood ratio test

174 comparing the fit of the model to one with the same random effects structure but no fixed effect.

### Results

176 The ANNOUNCE condition yielded more selections of the higher value than the THINK condition

177 ($\beta = 0.40, SE = 0.15, z = 2.66, p < .001$). Figure 1 shows a preference for the lower, more typical,

178 value in the THINK condition and a 50-50 split between the lower and higher values in the ANNOUNCE

179 condition.

### Discussion

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[2] It is worth highlighting that this simple operationalization in terms of empirical means and standard deviations may be problematic in the sense that these

summary statistics are not meaningful in the same way for different kinds of distributions (see Appendix Figures 5, 6 and 7.)
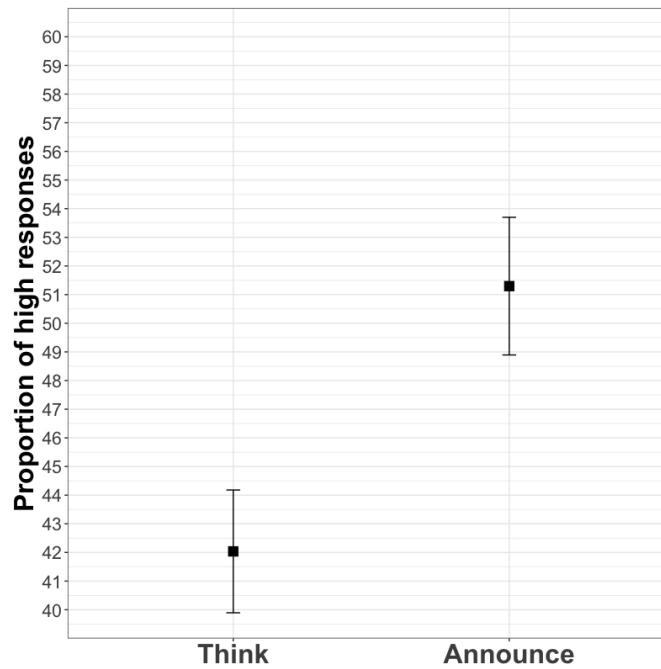
**Figure 1.** Proportion of high responses in Experiment 1. Error bars here and in other figures represent standard error of participant means.

As predicted by a model in which expectations for newsworthiness influence comprehenders' guesses about upcoming content, comprehenders showed a stronger preference for the situation-typical value (close to the estimated real-world mean) when the passage reported someone's thoughts rather than their speech. The finding that the THINK condition showed a substantial rate of higher value responses could reflect participants' low sensitivity to the contrast between the chosen numbers or their consideration that the THINK sentences were themselves utterance productions from a narrator and thus may contain information that is interesting enough to utter.

## EXPERIMENT 2: LIKELIHOOD OF SPEECH

If comprehenders estimate utterance likelihood when making guesses about upcoming content, a question is whether that likelihood is malleable. If it is, certain discourse contexts may increase the expectation for newsworthiness —for example, spontaneous speech would be predicted to contain more newsworthy content than speech that is produced as an answer to a question.[3]

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[3] This experiment was preregistered: osf.io/dhm5g

### *Method*

*Materials*    35 experimental passages followed the structure from Experiment 1, except that the final sentence varied whether the narrator reports that a character said something OUT OF THE BLUE or WHEN ASKED (Appendix D).

(3)    Liam is a man from the US. Liam lives down the street from Rebecca. Last week,

    a.    **when asked about it**, Rebecca said that Liam has …T-shirts.

    b.    Rebecca **out of the blue** said that Liam has …T-shirts.

              **O** 21          **O** 31

As in Experiment 1, the values were selected via a free-prompt pre-test (Appendix F). Here, the lower value corresponds to the mean of the pre-test responses and the higher value to (approximately) the mean + 1SD of the pre-test responses. The fillers matched those from Experiment 1.

*Participants*    110 native speakers of English were recruited through Amazon Mechanical Turk and paid for their participation ($5). We excluded participants with catch trial mistakes, leaving 103 participants (mean age 37.7, range 19-68).

### *Results*

As predicted, the OUT OF THE BLUE condition yielded more selections of the higher value than the WHEN ASKED condition ($\beta = -0.34, SE = 0.11, z = -3.16, p < .01$; deviation coding was used for *condition* here and in Experiments 2 and 3). Figure 2 shows a preference for the lower, more typical, value in the WHEN ASKED condition and a 50-50 split between the lower and higher values in the OUT OF THE BLUE condition.

### *Discussion*

Experiment 2 shows that comprehenders prefer the atypical (newsworthy) value more when a narrator reports on speech that is spontaneous. This finding is again in line with the informativity-driven model. While participants' baseline prior is unlikely to be affected by our manipulations, our results show that the discourse context informs participants' estimate of a speaker's sentence, presumably via the
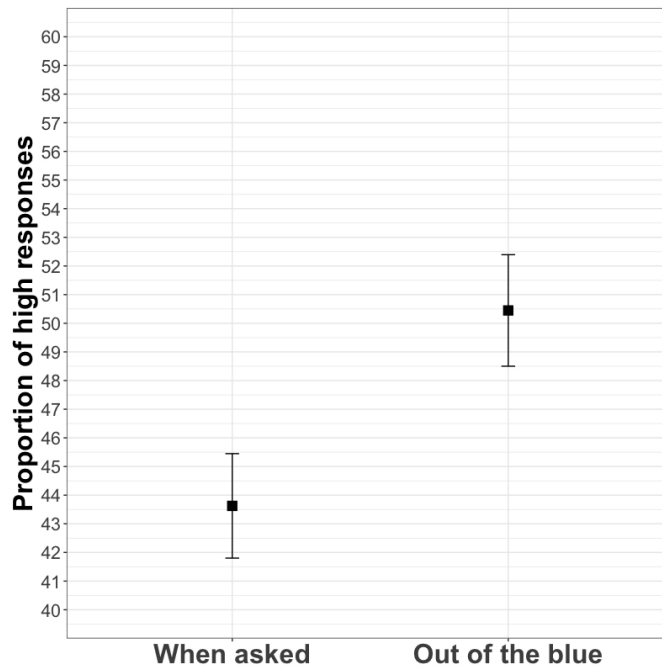
**Figure 2.**   Mean proportion of high responses in Experiment 2.

likelihood. The fact that the WHEN ASKED condition showed a substantial rate of higher value responses could, in addition to the reasons mentioned in Experiment 1, reflect participants' guess that the posed question (*when asked*) itself presupposed some potential newsworthiness of the value.

The mean of the WHEN ASKED condition aligns with that of the THINK condition in Experiment 1. This suggests that participants believe that answers to questions reflect what speakers think, which is in turn different from that they choose to talk about.

## EXPERIMENT 3: AUDIENCE SIZE

The third experiment tests whether comprehenders use information about the speaker's audience to adjust their expectations about upcoming content. The larger the audience that a narrator describes, the more newsworthy the expected content of reported speech ought to be.[4]

### *Method*

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[4] This experiment was preregistered: `osf.io/6t5ze`

*Materials*     35 experimental passages were adapted from Experiment 2 such that the reported speech was said TO ME or TO EVERYONE (Appendix E).

(4)     Liam is a man from the US. Liam lives down the street from Rebecca. Last week at the conference,

　　a.     Rebecca said **to me** that Liam has . . . T-shirts.

　　b.     Rebecca stood up and said **to everyone** that Liam has . . . T-shirts.

<div align="center">

**O** 21　　　　　**O** 31

</div>

The numeric values were the same as in Experiment 2, as were the filler items.

*Participants*     203 native speakers of English were recruited through Amazon Mechanical Turk and paid for their participation ($5). We excluded participants with catch trial mistakes, leaving 152 participants (mean age 37.2, range 22-71).

### *Results*

As predicted, participants selected the higher value more in the TO EVERYONE condition than in the TO ME condition ($\beta = 0.17, SE = 0.06, z = 2.59, p < .05$). As can be seen in Figure 3, the effect, though statistically significant, is modest.

### *Discussion*

The results from Experiment 3 show that comprehenders expect the content of an utterance to be more newsworthy when a narrator describes that the content is shared with a large group of people rather than an audience consisting of a single person. This is in line with recent findings showing that manipulating the relationship between a speaker and addressee (stranger vs. family member) can alter comprehenders' lexical predictions (Rubio-Fernandez, Mollica, Ali, & Gibson, 2019). Comparing Figure 3 to Figures 1 and 2 shows that the proportion of high responses in the TO ME condition matches that of the ANNOUNCE condition from Experiment 1 and the OUT OF THE BLUE condition from Experiment 2. This is to be expected, since the prompts, though formulated slightly differently, correspond to similar conversational
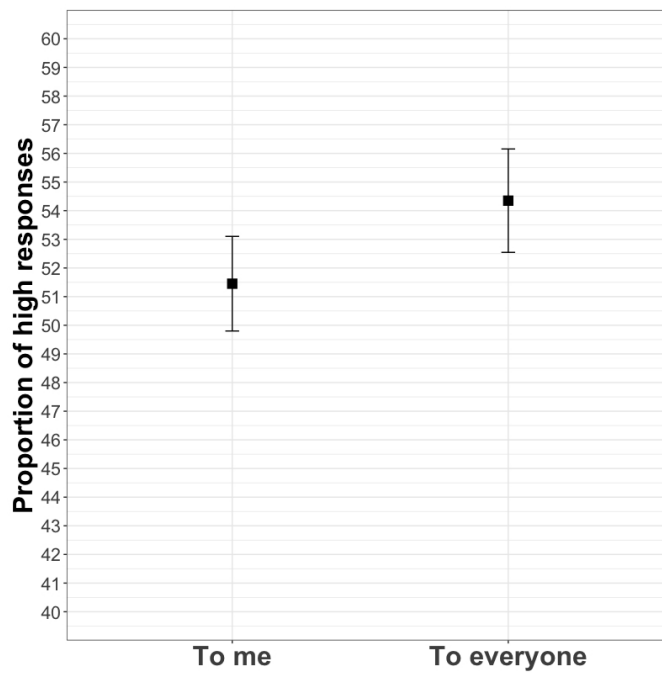
**Figure 3.**   Mean proportion of high responses in Experiment 3.

scenarios: a speaker, of their own volition, decides to convey a piece of information in an utterance to a (presumably) single other person.

## EXPERIMENT 4: VARIATION ACROSS THREE CONTEXTS

This experiment combines the conditions from Experiments 1-3 to create three levels of emphasis on information exchange. We vary the phrasing in order to avoid task-specific strategies that may have arisen in Experiments 1-3 from the lack of variation (in conditions and phrasing).[5]

*Method*

*Materials*      42 experimental passages included 21 adapted from Experiments 2 and 3, plus 21 additional passages (Appendix G). Three conditions were devised based on the earlier studies' manipulations.

(5)      Liam is a man from the US. Liam lives down the street from Rebecca.

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[5] This experiment was preregistered: `osf.io/xsjqn`

a.   LOW: Last week, **when asked about it**, Rebecca said that Liam has . . . T-shirts

b.   MID: Last week, Rebecca **announced** that Liam has . . . T-shirts.

c.   HIGH: Last week at the conference, Rebecca **stood up and said to everyone** that Liam has . . . T-shirts.

                    **O** 18              **O** 28

The numeric values were derived via a free-prompt pre-test (Appendix H). The lower value corresponds to the mean of the pre-test responses and the higher value to (approximately) the mean + 1SD of the pre-test responses. Each condition used two formulations, distributed between-items (LOW: *thought/when asked about it said*, MID: *announced/out of the blue said to me*, HIGH: *stood up and said to everyone/stood up and announced to the crowd*. Ten new fillers were added as attention checks (Appendix I).

*Participants*     300 native speakers of English were recruited through Prolific and paid for their participation (pro-rated at £7.50). We excluded participants with more than two attention check errors, leaving 275 participants.

*Results*

Participants selected the higher value at different rates across conditions ($p < 0.01$; *condition* with baseline MID), with a significant difference between MID~LOW ($\beta$=-0.17, SE=0.06, z=-2.62, p<.01) but not MID~HIGH ($\beta$=0.05, SE=0.07, z=0.69, p=.49). See Figure 4.

*Discussion*

Experiment 4 confirms that comprehenders' expectations for newsworthy content is malleable, and it does so using a design that combines conditions from the previous three experiments. Specifically, the results show more high-value selections for the MID condition than the LOW condition: The lower-informativity expression *thought* from Experiment 1 and *when asked* from Experiment 2 induce fewer selections of an atypical value. The MID condition contained expressions with some elements that emphasized information exchange (*announced* from Experiment 1 and *out of the blue* from Experiment 2) as well as one that de-emphasized information exchange (*said to me*, as opposed to *said to everyone*
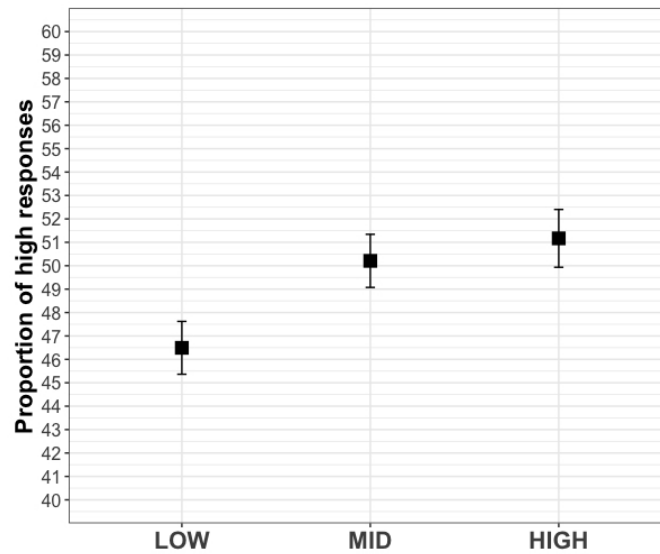
**Figure 4.**    Mean proportion of high responses in Experiment 4.

from the HIGH condition). The LOW~MID difference confirms that participants expect more

newsworthy content when a speaker chooses to speak, rather than when they are thinking or being asked.

The lack of MID~HIGH difference may indicate that audience size has less of an impact, but it may also

simply show that *speaking out of the blue* and *announcing* are cues to informativity that rival *speaking to*

*a crowd*.


**GENERAL DISCUSSION AND CONCLUSION**

Across four experiments, we measured comprehenders' informativity expectations. Comprehenders

favored an atypical (high) value more in passages that depict a speaker announcing something out loud

(rather than thinking it), speaking out of the blue (rather than when asked), and, less consistently, when

the speaker is depicted as addressing a large audience (rather than a single listener). The act of choosing

to convey content in speech, as well as the context of that speech, affects comprehenders' expectations.

These findings can be captured in a Bayesian approach in which the probability comprehenders assign to

a particular utterance rationally combines the probability of the described situation ($p(meaning)$) and the

conditional probability that a speaker would articulate a linguistic form to describe such a situation to a

certain audience ($p(form|meaning)$). Our findings suggest that the prior and likelihood are separable

and that the likelihood can be manipulated independently of the prior.

305 It is worth noting that although the observed effects are statistically robust, the numeric differences seem
306 fairly small. Overall selection rates in this study were close to chance level (ranging between 42-55%).
307 The relatively small difference between conditions could be related to the fact that the two values that
308 participants had to choose between were relatively similar. Only one standard deviation distinguishes the
309 typical and atypical values. Thus, it could be that participants are not fully aware of the contrast. It could
310 even be that for some participants, the higher value is perceived as more probable, given that the higher
311 values were provided by some participants in the pre-tests as their 'best guess'. It is possible that with
312 more prominently discriminated values, participants' preferences would be even clearer. Another
313 possibility is that participants perceived the low-informativity conditions (THINK, WHEN ASKED, and TO
314 ME) as still intended to be informative. Under a general presumption of relevance, participants would
315 consider that there is a narrator, the experimenter, who reports the newsworthy thoughts and statements
316 of different characters. A narrator could be relevantly informative by describing a character who thinks
317 surprising thoughts or who boldly produces a highly uninformative utterance. Indeed, across
318 experiments, the pre-test participants produced values either below the lower response value or up to the
319 halfway point between the lower and higher response values roughly 3/4 of the time (i.e., they favored
320 'typical' values in the pre-test task that did not emphasize information exchange), whereas the main-task
321 participants chose the lower value closer to half the time. This may indicate that that the main task
322 yielded a decreased preference for the typical values, possibly because all main-task conditions were
323 'communicative' to some degree.

324 The contrast between the conditions in Experiment 3 was even smaller than in Experiments 1-2 and it did
325 not replicate in Experiment 4. This could mean that the choice to spontaneously produce an utterance
326 (rather than remaining silent) has more influence on informativity expectations than audience design
327 considerations. However, it is also possible that the cues used in the Experiment 3 (and the MID and
328 HIGH conditions in Experiment 4) all emphasize information exchange to some degree — either by
329 invoking a narrator who themselves may be conveying information to the reader ("said to **me**") or by
330 describing bolder communicative acts ("stood up and said to everyone"), which perhaps are more likely
331 to be retold by a narrator.

332 To address these issues, future studies should consider more direct assessment of listeners' expectations
333 of speaker content, ideally using 1st person speech ("I think Liam has ... T-shirts") and manipulating the

speech scenarios in more direct ways that avoid the need for a narrator's description of the situation. The goal would be to avoid the nested descriptions ("Rebecca thinks that Liam has ... T-shirts") and instead present participants with the communicative scenarios via videos or perhaps the use of confederates who produce the target sentences. As is, we cannot rule out an account in which participants are tracking the co-occurrence statistics of expressions like those in our materials rather than modelling the deeper reasoning behind speakers' language production decisions. Our materials may have also introduced additional processing complexity via the double-nesting, which future work would be wise to avoid.

That said, our results are in line with a bias for newsworthiness (atypicality) in speaking. However, one might ask whether an expectation for accuracy (typicality) when thinking or answering could also explain our results. However, it is not clear why participants would not also expect accuracy when a speaker goes on record. Expectations for newsworthiness should not undermine expectations for accuracy; atypical meanings simply constitute content that is rare (but true) and whose rarity makes a speaker more likely to mention it.

To conclude, we argue that comprehenders consider both content plausibility and utterance likelihood, such that a 'good' utterance is one that balances the prior probability of the content with its novelty. Our focus on content selection goes beyond prior studies of rational speaker-listener behavior, by considering message-level production choices rather than the inclusion/omission of linguistic elements, or the choice between semantically equivalent forms, once an utterance is already underway. In addition, we find context-driven effects on comprehenders' estimates of utterance likelihood. The current study thus emphasizes the importance of including a bias for informativity in models of language comprehension, a bias that may pull linguistic expectations away from situation-typical content. Importantly, this bias is not a uniform one but varies systematically with the speaker's context of use. This sets the stage for additional psycholinguistic research to consider different metrics of what makes language use efficient and relevant.

## ACKNOWLEDGEMENTS

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362 arising from this submission.

## SUPPLEMENTARY MATERIALS

363 All materials, datasets, and analysis scripts can be found at https://osf.io/9eg34/.

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## APPENDIX A: ITEMS EXPERIMENT 1

burger  Joseph is a man from the US. Joseph lives next door to Sue. Sue thinks / announced to me that Joseph ate . . . burgers last month. 8 / 11

calls  Lisa is a woman from the US. Lisa has a friend, Kevin. Kevin thinks / announced to me that Lisa made . . . phone calls last week. 22 / 32

class  Erin is a first grade student in primary school. Erin has an uncle, Josh. Josh thinks / announced to me that there are . . . children in Erin's class. 24 / 27

coffee  Andy is a man from the US. Andy has an aunt, Katherine. Katherine thinks / announced to me that Andy drank . . . cups of coffee last week. 14 / 20

cook  Tony is a man from the US. Nick has a sister, Emily. Emily thinks / announced to me that Tony cooked . . . meals at home last month. 12 / 17

facebook  Judith is a woman from the US. Judith has a brother, Bill. Bill thinks / announced to me that Judith has . . . Facebook friends. 207 / 268

friends  Lelia is a woman from the US. Lelia lives around the corner from Brandon. Brandon thinks / announced to me that Lelia has . . . friends. 10 / 14

hair  Betty is a woman from the US. Betty works at an office with David. David thinks / announced to me that Betty washed her hair . . . times last month. 21 / 27

movie  Nick is a man from the US. Nick went to school with Stephanie. Stephanie thinks / announced to me that Nick saw . . . movies last year. 22 / 36

restaurants  Sarah is a woman from the US. Sarah has an acquaintance, Eric. Eric thinks / announced to me that Sarah went to . . . restaurants last year. 46 / 78

shoes  Melanie is a woman from the US. Melanie has a colleague, Bob. Bob thinks / announced to me that Melanie owns . . . pairs of shoes. 73 / 152

tshirts  Liam is a man from the US. Liam lives down the street from Rebecca. Rebecca thinks / announced to me that Liam has . . . T-shirts. 21 / 29

## APPENDIX B: EXPERIMENT 1 PRE-TEST

The pre-test for Experiment 1 was used to estimate participants' priors. The pre-test participants (N=31 after elimination of participants who failed the catch trials) did not participate in any other experiment in

this paper. They were recruited on Amazon Mechanical Turk and paid $2. Each participant saw the same 12 target scenarios from the Experiment 1 materials. They were asked in a free-response task to answer questions about things like the number of objects in someone's possession or the frequency of events in someone's life (*Sarah is a woman from the US. How many restaurants did Sarah go to last year?*). When choosing the alternatives for experimental materials rounded values to the nearest whole number, except if one of the values for a specific item was a multiple of 5. In that case, we rounded one of the values to the closest other whole number to make sure that both values were either a multiple of 5 or not to avoid a confound where a precise (non-multiple-of-5) value seemed more informative. This reflects findings that 'random-seeming' numbers receive a more precise interpretation than numbers that are a multiple of 5 or 10 (e.g., Cummins (12 February 2019)). Making sure that both values seem equally 'precise' avoids a potential confound of precise values (versus estimates) seeming more informative (for instance because saying that someone did 17 loads of laundry not only provides information about the number of times someone did laundry, but also implies that the speaker somehow counted/obtained/remembered the exact number). The distribution of the 31 responses for each item is shown in Figure 5.
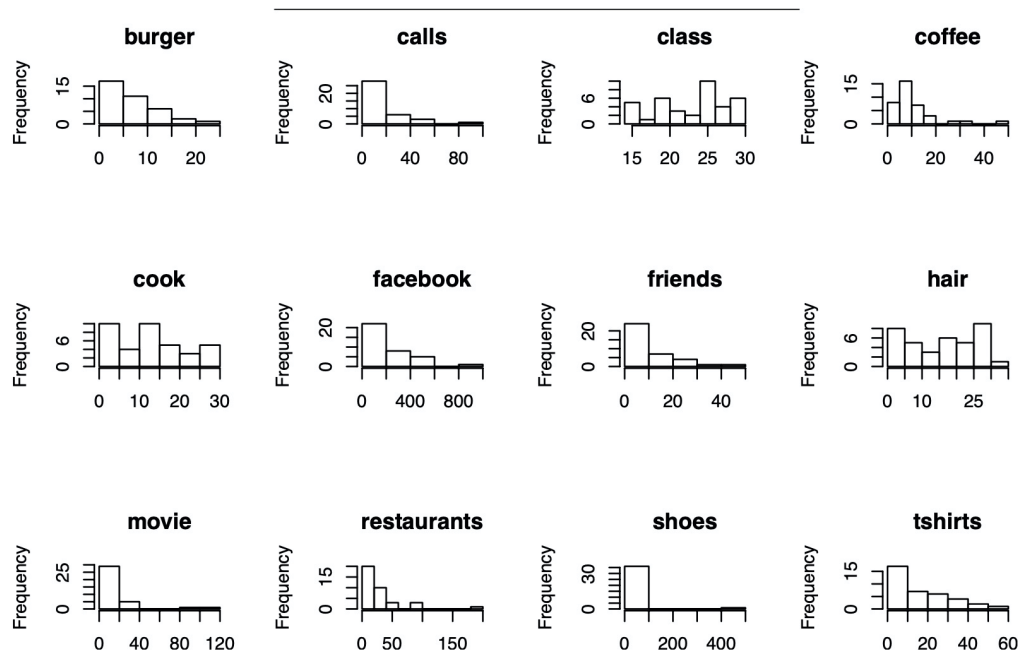


**Figure 5.** Frequencies of different values in pre-test norming for Experiment 1

## APPENDIX C: FILLER ITEMS (EXPERIMENTS 1-3)

correct1
500
No one knows exactly when the Roman alphabet was first invented. The letters correspond roughly to spoken sounds but not exactly. There are . . . letters in the modern alphabet. 26 / 70

correct2
502
Johnny and his brother are looking forward to the holidays. They've made a gingerbread house and decorated the tree. Johnny's favorite Christmas carol is 'The . . . days of Christmas' 14 / 12

correct3
504
My best friend always reminds me to take a break. She quotes Roald Dahl that 'a little nonsense now and then, is cherished by the wisest men.' It's true that there are only . . . hours in a day. 24 / 8

correct4
506
Everyone eventually has to leave home and make their way in the world. You have to face earning a living and doing your own laundry. You have to stand on your own . . . feet. 6 / 2

speculation1
508
Corey and Charlotte are professional tuba players. They recently had a conversation about how old the tuba actually is. They concluded that the tuba is at most . . . years old. 151 / 217

speculation2
510
The Grongitts went to a barbecue party again last weekend. Mr Grongitts was very bored. He decided he would not visit another barbecue party for at least . . . weeks. 4 / 6

speculation3
512
513
Gina discovered a new band on the internet. It's called 'This will destroy you' and she immediately purchased their debut album. As soon as she can afford it she intends to buy . . . more of their albums. 3 / 4

speculation4
515
Amtrak operates trains in the US. The passengers know that delays are common. Indeed, yesterday's 8:30 Amtrak train from NYC to Boston was . . . minutes late. 27 / 37

## APPENDIX D: ITEMS EXPERIMENT 2

516
517
518
beer John is a man from the the US. John lives in the same apartment building as Anton. About an hour ago, when asked about it, Anton said that / Anton out of the blue said that John drank . . . beers last month. 15 / 25

519
520
521
birthday Samantha is a 14-year-old girl from the US. Samantha has an aunt, Caroline. On Wednesday, when asked about it, Caroline said that / Caroline out of the blue said that Samantha attended . . . birthday parties last year. 5 / 8

522
523
books Nathalie is a woman from the US. Nathalie often has dinner with Alice. A few days ago, when asked about it, Alice said that / Alice out of the blue said that Nathalie read. . . . books last year. 7 / 11

524 burger  Joseph is a man from the US. Joseph has a girlfriend, Sue. Yesterday, when asked about it, Sue said

525    that / Sue out of the blue said that Joseph ate . . . burgers last month. 6 / 9

526 calls  Lisa is a woman from the US. Lisa has a stepmother, Mona. Today, when asked about it, Mona said

527    that / Mona out of the blue said that Lisa made . . . phone calls last week. 17 / 26

528 candy  Scott is a 12-year-old from the US. Scott has a classmate, Matt. Today, when asked about it, Matt

529    said that / Matt out of the blue said that Scott ate . . . candy bars last week. 9 / 14

530  car  Jeff is a man from the US. Jeff lives across the street from Amy. A few minutes ago, when asked

531    about it, Amy said that / Amy out of the blue said that Jeff spent . . . hours in his car last week. 11 / 16

532 cards  Wanda is a woman from the US. Wanda carpools with Adam. Last Saturday, when asked about it,

533    Adam said that / Adam out of the blue said that Wanda has . . . cards in her wallet. 6 / 8

534 chairs  Rob and Wendy are a couple from the US. Rob and Wendy have a friend, Katie. The other day,

535    Katie, when asked about it, said that / Katie out of the blue said that Rob and Wendy own . . . chairs.

536    8 / 12

537 class  Erin is a first grade student in primary school. Erin has an uncle, Josh. This morning, when asked

538    about it, Josh said that / Josh out of the blue said that there are . . . children in Erin's class. 23 / 44

539 coffee  Andy is a man from the US. Andy has an aunt, Katherine. This afternoon, when asked about it,

540    Katherine said that / Katherine out of the blue said that Andy drinks . . . cups of coffee per day. 2 / 3

541 colleagues  Linda is a woman from the US. Linda plays tennis with Beth. About a week ago, when asked about

542    it, Beth said that / Beth out of the blue said that Linda has . . . colleagues. 13 / 19

543 concert  Zach is a man from the US. Zach has a brother, Jim. A few days ago, when asked about it, Jim said

544    that / Jim out of the blue said that Zach went to . . . concerts last year. 3 / 5

545 cook  Tony is a man from the US. Nick has a sister, Emily. This afternoon, when asked about it, Emily

546    said that / Emily out of the blue said that Tony cooked . . . meals at home last month. 36 / 101

547 cousin  Jess is a woman from the US. Jess takes sewing classes with Anna. On Tuesday, when asked about

548    it, Anna said that / Anna out of the blue said that Jess has . . . cousins. 6 / 9

549 date  Trey and Tina are a couple from the US. Trey and Tina live next door to Paul. The other day, when

550    asked about it, Paul said that / Paul out of the blue said that Trey and Tina hired a babysitter . . . times

551    last year. 24 / 52

dishwasher Lily is a woman from the US. Lily has a nephew, Bob. On Monday, when asked about it, Bob said

553   that / Bob out of the blue said that Lily ran her dishwasher . . . times last month. 18 / 27

554   dog Hugh is a man from the US. Hugh has a neighbor, Jenn. Just now, when asked about it, Jenn said

555   that / Jenn out of the blue said that Hugh walked his dog . . . times last week. 9 / 13

556   football Kyle is a teenager from the US. Kyle has a friend, Wade. A few minutes ago, when asked about it,

557   Wade said that / Wade out of the blue said that Kyle had football practice . . . times last month. 10 /

558   15

559   friends Lelia is a woman from the US. Lelia lives around the corner from Brad. Tonight, when asked about

560   it, Brandon said that / Brandon out of the blue said that Lelia has . . . friends. 9 / 13

561   hair Betty is a woman from the US. Betty works at an office with David. Tonight, when asked about it,

562   David said that / David out of the blue said that Betty washed her hair . . . times last month. 18 / 29

563   keys Brendan is a man from the US. Brendan has a gym buddy, Ryan. Just now, Ryan when asked about

564   it, Ryan said that / out of the blue said that Brendan has . . . keys on his keychain. 5 / 7

565   laundry Peter is a man from the US. Peter shares an apartment with Jeffrey. Two days ago, when asked about

566   it, Jeffrey said that / Jeffrey out of the blue said that Peter washed . . . loads of laundry last month. 7 /

567   11

568   movie Nick is a man from the US. Nick went to school with Stephanie. Yesterday, when asked about it,

569   Stephanie said that / Stephanie out of the blue said that Nick saw . . . movies last year. 19 / 31

570 order online Robert is a man from the US. Robert has a co-worker, Margaret. About a week ago, when asked

571   about it, Margaret said that / Margaret out of the blue said that Robert ordered something online

572   . . . times last year. 24 / 78

573   phone Jill is a woman from the US. Jill has a best friend, Kevin. A few hours ago, when asked about it,

574   Kevin said that / Kevin out of the blue said that Jill spent . . . hours on her phone last week. 15 / 24

575 plane Gary is a man from the US. Gary has a cousin, Alexander. On Tuesday, when asked about it,

576   Alexander said that / Alexander out of the blue said that Gary was on . . . flights last year. 2 / 4

577 plants Pauline is a woman from the US. Pauline is in a reading group with Jack. Last Saturday, when asked

578   about it, Jack said that / Jack out of the blue said that Pauline has . . . house plants. 4 / 7

restaurants Sarah is a woman from the US. Sarah has an acquaintance, Eric. Last week, when asked about it,

580     Eric said that / Eric out of the blue said that Sarah went to eat out in a restaurant . . . times last year.

581     24 / 49

582 shoes Melanie is a woman from the US. Melanie has a colleague, Amber. This morning, when asked about

583     it, Amber said that / Amber out of the blue said that Melanie owns . . . pairs of shoes. 12 / 18

takeout Ralph is a man from the US. Ralph has an uncle, Harry. A few hours ago, when asked about it,

585     Harry said that / Harry out of the blue said that Ralph ordered take-out . . . times last month. 7 / 11

tshirts Liam is a man from the US. Liam lives down the street from Rebecca. Last week, when asked about

587     it, Rebecca said that / Rebecca out of the blue said that Liam has . . . T-shirts. 13 / 21

vacuum Patricia is a woman from the US. Patricia lives next-door to Nora. On Monday, when asked about it,

589     Nora said that / Nora out of the blue said that Patricia vacuumed . . . times last month. 6 / 9

590 wine Gilly is a woman from the US. Gilly has a roommate, Denise. About an hour ago, when asked about

591     it, Denise said that / Denise out of the blue said that Gilly drank . . . glasses of wine last month. 8 / 13

workout Jennifer is a woman from the US. Jennifer has a sister, Holly. On Wednesday, when asked about it,

593     Holly said / Holly out of the blue said that Jennifer worked out . . . times last month. 11 / 16

## APPENDIX E: ITEMS EXPERIMENT 3

594 beer John is a man from the the US. John lives in the same apartment building as Anton. About an hour

595     ago at the beach, Anton said to me / stood up and said to everyone that John drank . . . beers last

596     month. 15 / 25

birthday Samantha is a 14-year-old girl from the US. Samantha has an aunt, Caroline. On Wednesday at the

598     library, Caroline said to me / stood up and said to everyone that Samantha attended . . . birthday

599     parties last year. 5 / 8

books Nathalie is a woman from the US. Nathalie often has dinner with Alice. A few days ago at the bus,

601     Alice said to me / stood up and said to everyone that Nathalie read . . . books last year. 7 / 11

burgers Joseph is a man from the US. Joseph has a girlfriend, Sue. Yesterday at the local bar, Sue said to me

603     / stood up and said to everyone that Joseph ate . . . burgers last month. 6 / 9

604 calls Lisa is a woman from the US. Lisa has a stepmother, Mona. Today at the post office, Mona said to

605     me / stood up and said to everyone that Lisa made . . . phone calls last week. 17 / 26

606 candy  Scott is a 12-year-old from the US. Scott has a classmate, Matt. Today at the playground, Matt said

607       to me / stood up and said to everyone that Scott ate . . . candy bars last week. 9 / 14

608  car  Jeff is a man from the US. Jeff lives across the street from Amy. A few minutes ago at a work dinner,

609       Amy said to me / stood up and said to everyone that Jeff spent . . . hours in his car last week. 11 / 16

610 cards  Wanda is a woman from the US. Wanda carpools with Adam. Last Saturday at our drama group,

611       Adam said to me / stood up and said to everyone that Wanda has . . . cards in her wallet. 6 / 8

612 chairs  Rob and Wendy are a couple from the US. Rob and Wendy have a friend, Katie. The other day at the

613       shop, Katie said to me / stood up and said to everyone that Rob and Wendy own . . . chairs. 8 / 12

614 class  Erin is a first grade student in primary school. Erin has an uncle, Josh. This morning at the office,

615       Josh said to me / stood up and said to everyone that there are . . . children in Erin's class. 23 / 44

616 coffee  Andy is a man from the US. Andy has an aunt, Katherine. This afternoon at the museum, Katherine

617       said to me / stood up and said to everyone that Andy drinks . . . cups of coffee per day. 2 / 3

618 colleagues  . Linda is a woman from the US. Linda plays tennis with Beth. About a week ago at the mall, Beth

619       said to me / stood up and said to everyone that Linda has . . . colleagues 13 / 19

620 concert  Zach is a man from the US. Zach has a brother, Jim. A few days ago at work, Jim said to me / stood

621       up and said to everyone that Zach went to . . . concerts last year. 3 / 5

622 cook  Tony is a man from the US. Nick has a sister, Emily. This afternoon at our pottery class, Emily said

623       to me / stood up and said to everyone that Tony cooked . . . meals at home last month. 36 / 101

624 cousin  Jess is a woman from the US. Jess takes sewing classes with Anna. On Tuesday at the market, Anna

625       said to me / stood up and said to everyone that Jess has . . . cousins. 6 / 9

626 dates  Trey and Tina are a couple from the US. Trey and Tina live next door to Paul. The other day at the

627       swimming pool, Paul said to me / stood up and said to everyone that Trey and Tina hired a babysitter

628       . . . times last year. 24 / 52

629 dishwasher  Lily is a woman from the US. Lily has a nephew, Bob. On Monday at the train, Bob said to me /

630       stood up and said to everyone that Lily ran her dishwasher . . . times last month. 18 / 27

631 dog  Hugh is a man from the US. Hugh has a neighbor, Jenn. Just now at the store, Jenn said to me /

632       stood up and said to everyone that Hugh walked his dog . . . times last week. 9 / 13

633 football  Kyle is a teenager from the US. Kyle has a friend, Wade. A few minutes ago at school, Wade said to

634       me / stood up and said to everyone that Kyle had football practice . . . times last month. 10 / 15

635 friends  Lelia is a woman from the US. Lelia lives around the corner from Brad. Tonight at our family

636  dinner, Brandon said to me / stood up and said to everyone that Lelia has . . . friends. 9 / 13

637  hair  Betty is a woman from the US. Betty works at an office with David. Tonight at the restaurant, David

638  said to me / stood up and said to everyone that Betty washed her hair . . . times last month. 18 / 29

639  keys  Brendan is a man from the US. Brendan has a gym buddy, Ryan. Just now on the street, Ryan said to

640  me / stood up and said to everyone that Brendan has . . . keys on his keychain. 5 / 7

641 laundry  Peter is a man from the US. Peter shares an apartment with Jeffrey. Two days ago at our school

642  reunion, Jeffrey said to me / stood up and said to everyone that Peter washed . . . loads of laundry last

643  month. 7 / 11

644 movies  Nick is a man from the US. Nick went to school with Stephanie. Yesterday at my party, Stephanie

645  said to me / stood up and said to everyone that Nick saw . . . movies last year. 19 / 31

646 phone  Jill is a woman from the US. Jill has a best friend, Kevin. A few hours ago at our work meeting,

647  Kevin said to me / stood up and said to everyone that Jill spent . . . hours on her phone last week. 15 /

648  24

649 plane  Gary is a man from the US. Gary has a cousin, Alexander. On Tuesday at the baseball game,

650  Alexander said to me / stood up and said to everyone that Gary was on . . . flights last year. 2 / 4

651 order online  Robert is a man from the US. Robert has a co-worker, Margaret. About a week ago at the cafeteria,

652  Margaret said to me / stood up and said to everyone that Robert ordered something online . . . times

653  last year. 24 / 78

654 plants  Pauline is a woman from the US. Pauline is in a reading group with Jack. Last Saturday the park,

655  Jack said to me / stood up and said to everyone that Pauline has . . . house plants. 4 / 7

656 restaurants  Sarah is a woman from the US. Sarah has an acquaintance, Eric. Last week at our choir rehearsal,

657  Eric said to me / stood up and said to everyone that Sarah went to eat out in a restaurant . . . times last

658  year. 24 / 49

659 shoes  Melanie is a woman from the US. Melanie has a colleague, Amber. This morning, at the subway,

660  Amber said to me / stood up and said to everyone that Melanie owns . . . pairs of shoes. 12 / 18

661 takeout  Ralph is a man from the US. Ralph has an uncle, Harry. A few hours ago at the fair, Harry said to

662  me / stood up and said to everyone that Ralph ordered take-out . . . times last month. 7 / 11

663 tshirts  Liam is a man from the US. Liam lives down the street from Rebecca. Last week at the conference,

664      Rebecca said to me / stood up and said to everyone that Liam has . . . T-shirts. 13 / 21

665 vacuum  Patricia is a woman from the US. Patricia lives next-door to Nora. On Monday at the square, Nora

666      said to me / stood up and said to everyone that Patricia vacuumed . . . times last month. 6 / 9

667 wine  Gilly is a woman from the US. Gilly has a roommate, Denise. About an hour ago at the movies,

668      Denise said to me / stood up and said to everyone that Gilly drank . . . glasses of wine last month. 8 /

669      13

670 workout  Jennifer is a woman from the US. Jennifer has a sister, Holly. On Wednesday at the cafe, Holly said

671      to me / stood up and said to everyone that Jennifer worked out . . . times last month. 11 / 16

## APPENDIX F: EXPERIMENTS 2 AND 3 PRE-TEST

The pre-test for Experiments 2 and 3 followed that of Experiment 1 and was used to estimate

participants' priors. The pre-test participants (N=20 after elimination of participants who failed the catch

trials) did not participate in any other experiment in this paper. They were recruited on Amazon

Mechanical Turk and paid $4. Each participant saw the same 35 target scenarios from the Experiment

2&3 materials. They were asked in a free-response task to answer questions about things like the number

of objects in someone's possession or the frequency of events in someone's life (*Jeff is a man from the*

*US. How many hours did Jeff spend in his car last week?*). Participants were asked to provide their 'best

guess' as well as a maximum and minimum. The distribution of the 20 responses for 'best guess' for

each item is shown in Appendix Figures 6-7.
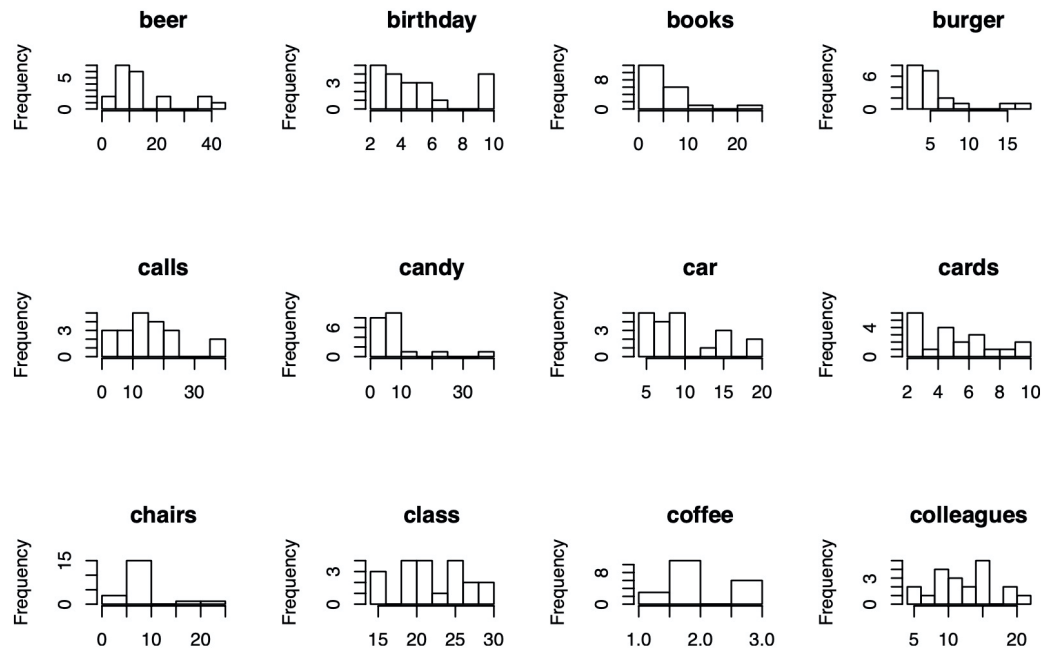


**Figure 6.**   Frequencies of different values in pre-test norming for Experiments 2 and 3, *beer-colleagues*

## APPENDIX G: ITEMS EXPERIMENT 4

Conditions below correspond to HIGH/MID/LOW.

1. Mary is a woman from the US. Mary lives next door to Paul. The other day at the swimming pool, Paul stood up and said to everyone / The other day, Paul announced / Paul thinks that Mary owns . . . purses and handbags. 8 / 14

2. John is a man from the US. John lives in the same apartment building as Anton. About an hour ago at the beach, Anton stood up and announced to the crowd / About an hour ago, Anton out of the blue said to me / About an hour ago, when asked about it, Anton said that John drank . . . beers last month. 22 / 39

3. Charlotte is a woman from the US. Charlotte has a sister, Emily. This afternoon at our pottery class, Emily stood up and said to everyone / This afternoon, Emily announced / Emily thinks that Charlotte has . . . books at home. 24 / 49

4. Joseph is a man from the US. Joseph has a girlfriend, Sue. Yesterday at the local bar, Sue stood up and announced to the crowd / Yesterday Sue announced / Yesterday, when asked about it, Sue said that Joseph ate . . . burgers last month. 8 / 13

5. Scott is a 12-year-old boy from the US. Scott has a classmate, Matt. Today at the playground, Matt stood up and said to everyone / Today Matt announced / Matt thinks that Scott ate . . . candy bars last month. 9 / 14

6. Wanda is a woman from the US. Wanda carpools with Adam. Last Saturday at our drama group, Adam stood up and announced to the crowd / Last Saturday, Adam out of the blue said to me / Last Saturday, when asked about it, Adam said that Wanda has . . . cards in her wallet. 4 / 6

7. Rose is a 60-year-old woman from the US. Rose lives around the corner from Brad. Tonight at our family dinner, Brandon stood up and said to everyone / Tonight Brandon announced / Tonight, when asked about it, Brandon said that Rose has owned . . . cars. 4 / 7

8. Rob and Wendy are a couple from the US. Rob and Wendy have a friend, Katie. The other day at the shop, Katie stood up and announced to the crowd / The other day, Katie out of the blue said to me / Katie thinks that Rob and Wendy own . . . chairs. 7 / 11

9. Erin is a first grade student in primary school. Erin has an uncle, Josh. This morning at the office, Josh stood up and said to everyone / This morning, Josh announced / This morning, when asked about it, Josh said that there are . . . children in Erin's class. 22 / 26

10. Andy is a man from the US. Andy has an aunt, Katherine. This afternoon at the museum, Katherine stood up and announced to the crowd / This afternoon, Katherine announced / Katherine thinks that Andy drinks ... cups of coffee per day. 3 / 4

11. Gary is a man from the US. Gary often has dinner with Alice. A few days ago at the bus, Alice stood up and said to everyone / A few days ago, Alice announced / A few days ago, when asked about it, Alice said that Gary owns ... coffee cups. 6 / 9

12. Linda is a woman from the US. Linda plays tennis with Beth. About a week ago at the mall, Beth stood up and announced to the crowd / About a week ago, Beth out of the blue said to me / About a week ago, when asked about it, Beth said that Linda has ... colleagues. 13 / 23

13. Jess is a woman from the US. Jess takes sewing classes with Anna. On Tuesday at the market, Anna stood up and said to everyone / On Tuesday, Anna announced / Anna thinks that Jess has ... cousins. 6 / 11

14. Sylvie is a woman from the US. Sylvie has an acquaintance, Eric. Last week at our choir rehearsal, Eric stood up and announced to the crowd / Last week, Eric out of the blue said to me / Last week, when asked about it, Eric said that Sylvie visits a doctor ... times a year. 3 / 6

15. Hugh is a man from the US. Hugh has a neighbor, Jenn. Just now at the store, Jenn stood up and said to everyone / Just now Jenn announced / Jenn thinks that Hugh walked his dog ... times last week. 7 / 9

16. Rebecca is a woman from the US. Rebecca has a stepmother, Mona. Today at the post office, Mona stood up and announced to the crowd / Today Mona announced / Today, when asked about it, Mona said that Rebecca owns ... pairs of earrings. 13 / 23

17. Sidney is a man from the US. Sidney has a brother, Jim. A few days ago at work, Jim stood up and said to everyone / A few days ago, Jim announced / A few days ago, when asked about it, Jim said that Sidney receives ... emails each day. 17 / 32

18. George is a single 30-year-old man from the US. George has a cousin, Gregory. On Tuesday at the baseball game, Gregory stood up and announced to the crowd / On Tuesday, Gregory out of the blue said to me / Gregory thinks that George has been on ... first dates in his life. 15 / 32

19. Noah and Ava are an 80-year-old couple from the US. Noah and Ava live across the street from Amy. A few minutes ago at a work dinner, Amy stood up and said to everyone / A few minutes ago,

741    Amy announced / A few minutes ago, when asked about it, Amy said that Noah and Ava have

742    . . . grandchildren. 8 / 13

743 20. Betty is a woman from the US. Betty works at an office with David. Tonight at the restaurant, David

744    stood up and announced to the crowd / Tonight David out of the blue said to me / David thinks that

745    Betty washed her hair . . . times last month. 16 / 24

746 21. Brendan is a man from the US. Brendan has a gym buddy, Ryan. Just now on the street, Ryan stood

747    up and said to everyone / Just now Ryan out of the blue said to me / Just now, Ryan when asked

748    about it, Ryan said that Brendan has . . . keys on his key chain. 6 / 9

749 22. Henry is a man from the US. Henry has an aunt, Caroline. On Wednesday at the library, Caroline

750    stood up and announced to the crowd / On Wednesday, Caroline announced / Caroline thinks that

751    Henry owns . . . lamps. 4 / 6

752 23. Peter is a man from the US. Peter shares an apartment with Jeffrey. Two days ago at our school

753    reunion, Jeffrey stood up and said to everyone / Two days ago, Jeffrey out of the blue said to me /

754    Jeffrey thinks that Peter washed . . . loads of laundry last month. 6 / 9

755 24. Caroline is an employee at a US company. Caroline has a sister, Holly. On Wednesday at the cafe,

756    Holly stood up and announced to the crowd / On Wednesday, Holly out of the blue said to me / On

757    Wednesday, when asked about it, Holly said that Caroline had . . . meetings last week. 4 / 6

758 25. Nick is a man from the US. Nick went to school with Stephanie. Yesterday at my party, Stephanie

759    stood up and said to everyone / Yesterday Stephanie announced / Stephanie thinks that Nick saw

760    . . . movies last year. 23 / 45

761 26. Robert is a man from the US. Robert has a co-worker, Margaret. About a week ago at the cafeteria,

762    Margaret stood up and announced to the crowd / About a week ago, Margaret out of the blue said to

763    me that / About a week ago, when asked about it, Margaret said that Robert ordered something

764    online . . . times last year. 29 / 63

765 27. Jasper is a 70-year-old man from the US. Jasper has a nephew, Bob. On Monday at the train, Bob

766    stood up and said to everyone / On Monday, Bob out of the blue said to me / On Monday, when

767    asked about it, Bob said that Jasper has owned . . . pets in his life. 7 / 12

28. Paul and Jacky are a couple from the US. Paul and Jacky live across the hall from Steve. Last week at the barbecue, Steve stood up and announced to the crowd / Last week, Steve announced / Steve thinks that Paul and Jacky own ... throw pillows. 6 / 9

29. Pauline is a woman from the US. Pauline is in a reading group with Jack. Last Saturday the park, Jack stood up and said to everyone / Last Saturday, Jack out of the blue said to me / Pauline is in a reading group with Jack. Jack thinks that Pauline has ... house plants. 6 / 11

30. Ann is a woman from the US. Ann has a house cleaner Maya. Last week at the yard sale, Maya stood up and announced to the crowd / Last week, Maya out of the blue said to me / Maya thinks that Ann eats ... sandwiches in a week. 4 / 7

31. Melanie is a woman from the US. Melanie has a colleague, Amber. This morning at the subway, Amber stood up and said to everyone / This morning, Amber announced / This morning, when asked about it, Amber said that Melanie owns ... pairs of shoes. 16 / 28

32. Olivia is a 20-year-old woman from the US. Olivia has a housemate, Michael. Yesterday evening at the pub, Michael stood up and announced to the crowd / Yesterday evening, Michael out of the blue said to me / Yesterday evening, when asked about it, Michael said that Olivia has had ... smartphones in her life. 4 / 6

33. Ryan is a 50-year-old man from the US. Ryan has a golf buddy, Chris. This morning at the clubhouse, Chris stood up and said to everyone / This morning, Chris out of the blue said to me / Chris thinks that Ryan has received a speeding ticket ... times in his life. 7 / 16

34. Samantha is a woman from the US. Samantha works in the same company as Ronny. On Saturday at the company picnic, Ronny stood up and announced to the crowd / On Saturday, Ronny announced / On Saturday, when asked about it, Ronny said that Samantha has visited ... states. 8 / 14

35. James is a 5-year-old child from the US. James has a friend, Wade. A few minutes ago at school, Wade stood up and said to everyone / A few minutes ago, Wade out of the blue said to me / Wade thinks that James has ... stuffed animals. 9 / 17

36. Ralph is a man from the US. Ralph has an uncle, Harry. A few hours ago at the fair, Harry stood up and announced to the crowd / A few hours ago, Harry out of the blue said to me / Harry thinks that Ralph ordered take-out ... times last month. 11 / 18

37. Liam is a man from the US. Liam lives down the street from Rebecca. Last week at the conference, Rebecca stood up and said to everyone / Last week, Rebecca announced / Last week, when asked about it, Rebecca said that Liam has ... T-shirts. 18 / 28

38. Patricia is a woman from the US. Patricia lives next-door to Nora. On Monday at the square, Nora stood up and announced to the crowd / On Monday, Nora out of the blue said to me / Nora thinks that Patricia vacuumed ... times last month. 6 / 11

39. Zach is a man from the US. Zach has a best friend, Kevin. A few hours ago at our work meeting, Kevin stood up and said to everyone / A few hours ago, Kevin out of the blue said to me / A few hours ago, when asked about it, Kevin said that Zach played ... hours of video games last week. 13 / 22

40. Alexander is a 1-year-old baby from the US. Alexander has a godmother Liane. This weekend at the gymboree, Liane stood up and announced to the crowd / This weekend, Liane announced / Liane thinks that Alexander wakes up ... times a night. 3 / 4

41. Roy and Emma are a couple from the US. Roy and Emma are in a book club with Kenny. A few weeks ago at the pub, Kenny stood up and said to everyone / A few weeks ago, Kenny announced / A few weeks ago, when asked about it, Kenny said that Roy and Emma have ... windows in their 2-bedroom apartment. 4 / 8

42. Gilly is a woman from the US. Gilly has a roommate, Denise. About an hour ago at the movies, Denise stood up and announced to the crowd / About an hour ago, Denise out of the blue said to me / Denise thinks that Gilly drank ... glasses of wine last month. 16 / 31

## APPENDIX H: EXPERIMENT 4 PRE-TEST

We conducted a pre-test of 60 candidate items (*Liam is a man from the US. How many T-shirts do you think Liam has?*). Even though some items were adapted from Experiments 2-3, we wanted to establish up-to-date low/high values, given that estimates of typical behavior might have changed over the course of the COVID-19 pandemic. Participants (n=24) after elimination of participants who failed the catch trials) were recruited from Prolific and paid $3 for their time. None participated in any other experiment in this paper. Participants were asked to provide their 'best guess' as well as a maximum and minimum. The goal was to find a set of items whose mean of the maximum was less than 1 standard deviation from

823 the mean 'best guess' in order to ensure that the value we selected as the 'high' response was still a

824 plausible value. That criterion eliminated 17 items, and we also eliminated a further outlier item whose

825 mean maximum was proportionally much larger than the mean best guess compare to other items. This

826 left 42 items for the experiment.

## APPENDIX I: EXPERIMENT 4 FILLERS

827 For this experiment, we used 12 fillers with correct answers to serve as attention checks.

828 1. Ben is a man from the US. Ben has a stepfather Daniel. Select the higher number. Daniel thinks that
829 Ben has . . . power outlets in his office. 5 / 9

830 2. Dexter is a man from the US. Dexter has an aunt Emily. Select the lower number. The other day,
831 Emily announced that Dexter shaves . . . times each month. 14 / 25

832 3. Tony is a man from the US. Select the higher number. Tony has an uncle Max. This morning at the
833 bakery, Max stood up and said to everyone that Tony cooked . . . meals at home last month. 19 / 39

834 4. Ted is a manager at a US company. Select the lower number. Ted has a cousin Kyle. Yesterday,
835 when asked about, Kyle said that Ted held . . . job interviews last year. 17 / 39

836 5. Lily is a woman from the US. Lily has a sister Tina. Choose the odd number. About an hour ago,
837 Tina out of the blue said to me that Lily ran her dishwasher . . . times last month. 19 / 30

838 6. Lelia is a woman from the US. Leila has a brother Andrew. Choose the odd number. About an hour
839 ago at the bookstore, Andrew announced that Lelia has . . . friends. 12 / 27

840 7. Nathalie is a woman from the US. Choose the even number. Nathalie has a hairdresser Lisa. Choose
841 the even number. Lisa thinks that Nathalie read . . . books last year. 11 / 30

842 8. Sarah is a woman from the US. Choose the even number. Sarah has an aromatherapist Jill. Last
843 weekend, Jill announced that Sarah had . . . exams as a senior in college. 24 / 33

844 9. Sophia is a woman from the US. Sophia has a dogwalker Roger. Pick the bigger value. Yesterday at
845 the lake, Roger stood up and said to everyone that Sophia mowed her lawn . . . times in the last year.
846 20 / 42

847 10. Jennifer is a woman from the US. Pick the smaller value. Jennifer has a psychiatrist Elizabeth. Last
848 week, when asked about it, Elizabeth said that Jennifer worked out . . . times last month. 17 / 40
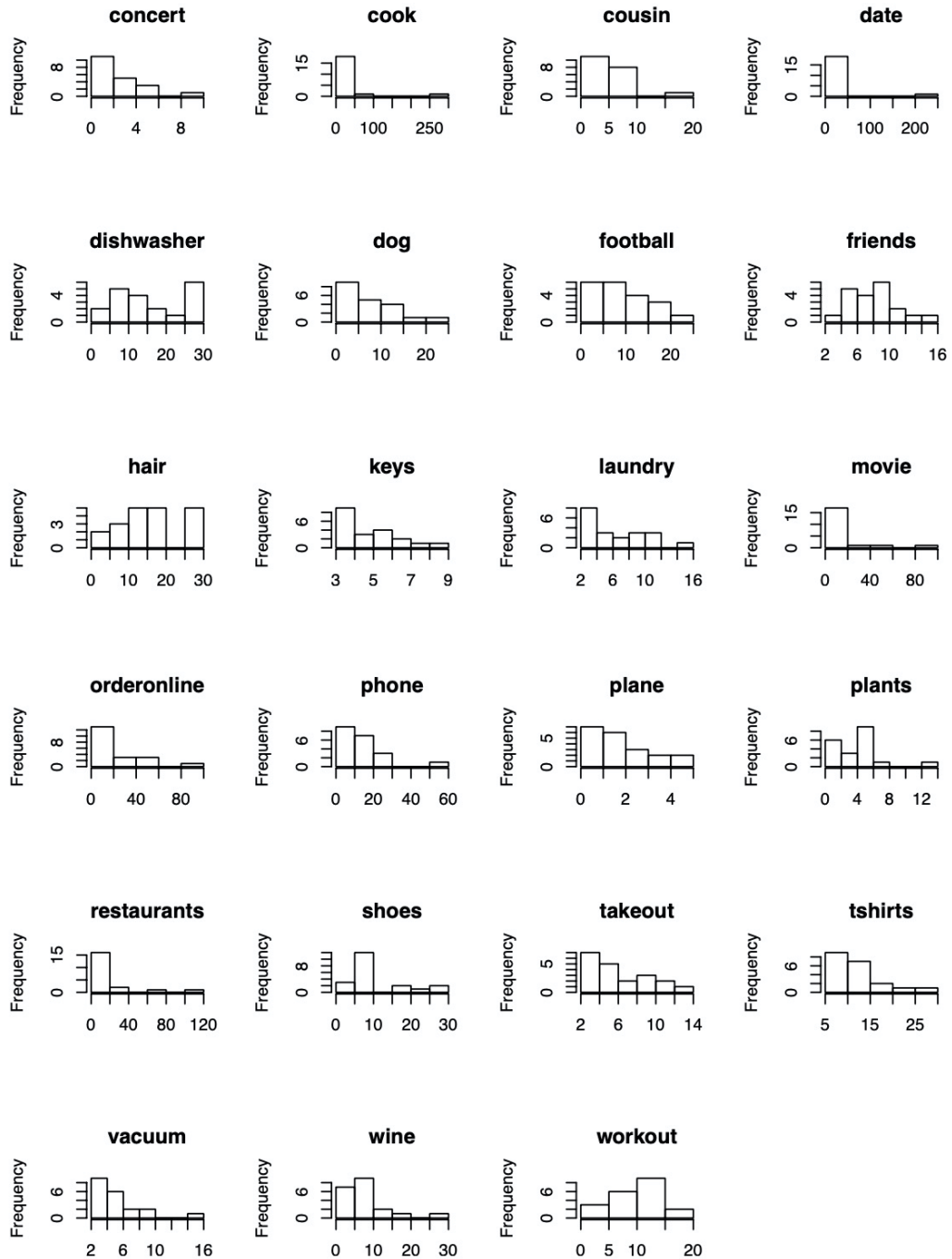
**Figure 7.**   Frequencies of different values in pre-test norming for Experiment 2 and 3, *concert-workout*