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Is Syntactic Priming from Multiple Speakers Stronger?

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Abstract: Syntactic priming in dialogue occurs when exposure to a particular syntactic structure implicitly induces a speaker's subsequent preference for the same syntactic structures in their own speech. Here, we asked whether this priming effect is boosted when individuals are primed by several different speakers as opposed to one. In an initial baseline session involving a picture description task, we assessed adult participants' production of double object/DO (vs. prepositional/PO) dative and passive (vs. active) transitive structures. Subsequently, participants played a picture description and verification game, in turns, with six other players (confederates). During verification turns, confederates primed participants by using DO and passive utterances. Crucially, participants were primed either by a single confederate (single-speaker priming condition, SSP) or by five confederates (multi-speaker priming condition, MSP). Across conditions, the same priming stimuli were presented in the same order, leaving speaker source/variation as the only different feature. The degree to which participants were primed for the target structures compared to baseline was measured. Results indicated a robust priming effect in both conditions. Nevertheless, the increase in the target structures' use did not differ significantly between the SSP and MSP conditions, suggesting that speaker variation did not promote stronger priming.

Keywords: syntactic priming; structural priming; syntactic choice; linguistic alignment; social network; speaker source; multi-party dialogue

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1. Introduction

Syntactic priming (SP) in psycholinguistics—also referred to as structural priming, structural persistence, adaptation, or alignment—occurs when exposure to a syntactic structure influences a person's subsequent language comprehension and production, making them more likely to process or produce a similar structure (Bock 1986). Research has established syntactic priming effects outside a discourse context (e.g., Bock 1986, 1989; Bock and Loebell 1990; Hartsuiker et al. 1999), as well as in a conversation (e.g., Branigan et al. 2000; Branigan et al. 2007; Balcetis and Dale 2005; Schoot et al. 2014). Speakers demonstrate an implicit tendency for linguistic convergence, starting to express themselves in similar ways as the conversation unfolds (Branigan et al. 2000, 2007). What an individual hears as a listener in one conversation turn influences their subsequent contributions as a speaker in the following exchange. Over conversational turns, alignment can emerge across multiple linguistic levels during a conversation (Pickering and Garrod 2004), at the semantic, lexical, and syntactic levels (Garrod and Anderson 1987; Brennan and Clark 1996; Clark and Schaefer 1989; Clark and Wilkes-Gibbs 1986; Branigan et al. 2000).

The Interactive Alignment Model (IAM) of dialogue draws on the psycholinguistic observations of priming effects between speakers and posits that as speakers influence each other and generate similar linguistic representations, their level of alignment with one another increases. The model predicts that conversation is successful to the extent that the situation representations of conversation partners become aligned (Pickering and Garrod 2004). Similar to IAM, the Shared-Workspace Framework (Pickering and Garrod 2021) emphasizes the importance of alignment between interlocutors. Speakers' linguistic

choices can influence listeners' comprehension processes, and vice versa. This reciprocal influence contributes to the ongoing alignment of mental representations and a successful conversation. The extent of syntactic alignment increases when speakers interact with a conversational partner, as opposed to performing the experiment alone, supporting a mediated account of syntactic priming, in which the communicative intention influences linguistic behavior (Schoot et al. 2019). Branigan et al. (2000) reported larger syntactic priming effects in dialogue versus monologue situations, providing additional evidence that speakers are sensitive to the communicative context and the linguistic choices of their conversational partners during language production.

Less is known about how differences in the communicative environment influence language production. One study showed that speakers' tendency to clarify their utterances increased when the visual context was potentially ambiguous, in contrast to cases without such ambiguity, reflecting awareness of the importance of facilitating comprehension. Findings highlighted the significance of speakers' attention to the addressees' perceived capacity for ease of comprehension (Haywood et al. 2005). Reitter et al. (2006) investigated the effect of syntactic priming in a dialogue where interlocutors either aimed solely to communicate casually or to collaborate on a task. Syntactic persistence effects were more robust in task-oriented interactions compared to casual conversations. Moreover, various characteristics of communication, such as individuals' perception of their addressees' comprehension ease, influenced the alignment between the conversational partners. For instance, speakers tend to align their syntactic choices to a greater extent in situations where the conversational partner benefits from language adaptations tailored to the audience. This adaptation phenomenon became more pronounced when the recipient was less likely to understand the speaker (Branigan et al. 2003). Together, these studies emphasize the importance of communicative context and suggest that speakers' communicative intent influences linguistic behavior.

Priming from Multiple Speakers

Most psycholinguistic research on dialogue has investigated dyadic communication (e.g., Brennan and Clark 1996; Garrod and Anderson 1987), with an emphasis on exploring the cognitive mechanisms that underpin language use in dyadic dialogues (e.g., Horton and Gerrig 2005). However, less is known about priming in more complex communicative situations, notably the cognitive processes engaged during multi-party dialogues. Branigan et al. (2007) investigated the role of the speaker in multi-party dialogue and showed that individuals who were formerly in the role of addressee exhibited stronger syntactic priming effects from their conversation partners, compared to individuals who were previously overhearers. Their results suggested that the alignment of syntactic structures is influenced by the participant's specific role during comprehension in a multi-party dialogue.

The purpose of this study is to examine a dimension of priming in multi-party communication that, to our knowledge, has not been explored before, notably speaker source (also speaker variation). We asked whether the syntactic priming effect is boosted when experienced by different sources (here, individuals), compared to a single source/individual, everything else being equal.

This question derives from considering language behavior as a form of social behavior that is adopted via a process termed complex contagion in the sociology literature (Centola 2019; Centola and Macy 2007). Complex behavioral contagions are behaviors, beliefs, or attitudes for which adoption by an individual requires contact with multiple sources of activation and are contrasted with simple contagions that require a single source (Centola 2019; Centola and Macy 2007). In that literature, the emphasis is on *single* versus multiple *sources* (i.e., speaker source/variation) rather than merely multiple exposures (which may still be required for priming to take effect). Complex behavioral contagions have been shown empirically in various forms of human behavior, for example, in the adoption of healthier behavior practices (Centola 2010), people's diffusion of political hashtags in social media (Romero et al. 2011), and other forms of innovation diffusion (for a review, see Guilbeault

et al. 2018). This concept of complex behavioral contagion in the sociology literature may, at first blush, appear distant from the phenomenon of priming in psycholinguistics as used here. However, linguistic productions such as utterances in dialogue are a spontaneous human behavior, so the concept of behavioral contagion should, in principle, extend to language behavior as well. In addition, the empirical evidence for complex contagions via multiple sources all occurred with participants using language, i.e., ideas were adopted via linguistic messages, thus possibly with the help of linguistic priming. Finally, the term 'contagion', as used in the sociology literature, only alludes to an analogy of the idea of pathogenic contagions and lacks a cognitive psychological explanation. Perhaps implicit priming is the cognitive mechanism that drives the complex contagion of ideas and behaviors and this links directly to our proposed hypothesis that linguistic priming could be mediated by speaker variability.

Our proposed hypothesis that speaker variability could boost linguistic priming also aligns with the idea that adapting one's language to the listener serves the purpose of enhancing message comprehension. This adaptive behavior contributes to the establishment of shared understanding, fostering successful communication (Branigan et al. 2000; Branigan 2006). In everyday interactions, individuals engage in conversations with various people, processing diverse linguistic inputs to achieve communicative goals (Clark 1996). If individuals implicitly adopt linguistic patterns common among a diverse group, their behavior is more generalizable and their chances of aligning with the larger community increase. Consequently, individuals may implicitly incorporate prevalent linguistic behaviors within their social context. This adoption, of course, results from repeated exposure to specific linguistic structures, leading to an accumulation of experience (Kaschak et al. 2011; Hartsuiker and Westenberg 2000; Kaschak and Borreggine 2008). However, the complex contagion theory emphasizes the role of multiple sources, not just repeated exposures. Consequently, syntactic priming effects may be more pronounced in multi-party conversations with several speakers compared to single-speaker scenarios, even when the exposure instances are similar.

To examine whether speaker variation amplifies syntactic priming, we employed an online picture description game where adult participants were primed to produce passive and double object (DO) syntactic uses. There were two conditions, as follows: in the single-speaker priming (SSP) condition, participants were primed with passive and DO forms by one confederate, while in the multi-speaker priming (MSP) condition, participants were primed by five different confederates. Participants' production of dative and transitive structures without priming was assessed in a baseline session prior to the experimental priming session. We expected to find a priming effect in both SSP and MSP groups from baseline to the experimental session. Furthermore, in line with the proposed hypothesis, the MSP condition should promote a greater difference from baseline in primed grammatical structures compared to the SSP condition.

There have been relatively few studies on more complex dialogues; in particular, little empirical investigation has been carried out on the cognitive processes involved in multi-speaker dialogues. To our knowledge, no mechanistic account of syntactic priming explicitly incorporates speaker variation as a moderator of the priming effect. In models that interpret priming as implicit learning (Chang et al. 2006), prior exposure to a specific structure alters the weights of connections within the language processing system, regardless of who says what. However, these models could accommodate the effects of speaker variation by introducing a threshold parameter for the degree of priming. For example, exposure to a structure from multiple people could trigger larger weight changes, resulting in a stronger tendency to re-use a linguistic structure compared to exposure from a single individual. In other words, participants' syntactic procedures and representations could be influenced to a greater extent when they understand an utterance they hear from multiple people, as opposed to hearing it from a single person (see Lou-Magnuson and Onnis 2018 for a computational simulation that explicitly incorporates such a threshold parameter to account for the spread of syntactic complexity in a community of agents).

2. Materials and Methods

This study was preregistered on the Open Science Framework (OSF) prior to data collection. The preregistration document can be accessed at https://osf.io/5k8dp/?view_only=4243cd5c1c3a40a583a512c73a7b4824 (accessed on 2 April 2024) and includes details about the research questions, hypotheses, study design, sample size determination, data collection procedures, and planned statistical analyses.

2.1. Manipulation Update

Drawing on the prior literature, the original preregistered plan was to induce a priming effect through the exposure of participants to prepositional object (PO) and passive forms, as their use appeared less common in English, by perusing the prior literature (Bock and Griffin 2000). However, in the baseline session our participants showed a greater tendency to use the PO structure. Given the observed facilitation in priming participants with less preferred structures, the experimental approach was, thus, adjusted to prime participants with DO structures rather than PO forms in the experimental session. The same priming sentences were presented to participants in the DO form instead of the originally intended PO form. The same passive structures for transitive priming were maintained in accordance with the original preregistered plan.

2.2. Participants

Participants were recruited via the online crowdsourcing platform (Prolific 2014) (www.prolific.com, accessed on 2 April 2024.). They were compensated financially for their participation at the recommended prevailing rate. Informed consent was obtained from all participants. The participants were 18–40 years old and were native English speakers. Sample size estimation was based on the meta-analysis of Mahowald et al. (2016), who estimated that with 16 items and 96 subjects, and without lexical overlap, it is possible to obtain 0.81 power to detect a true effect size of 0.51. In the baseline session, 319 participants were initially recruited. Exclusion criteria: Participants (n = 38) whose verbal descriptions were categorized as "neither" (see Scoring) for more than 50% of the time were excluded from the study. Moreover, participants (n = 18) who produced more DO than PO forms in the baseline session were excluded from the study, as the experimental session involved priming the DO form. In total, 23 participants had technical problems where either the microphone was not working or the internet connection was disrupted. Finally, 10 participants showed low effort while completing the task (e.g., texting on their phone, performing the task with a friend). In summary, 89 participants were excluded after completing the baseline session, and 230 participants were invited to the experimental session. In total, 96 participants completed the experimental session. In the experimental session, 15 participants were not included in the analysis, as, in a debriefing part, they mentioned realizing that the experiment was not interactive. One participant was excluded from the analysis as he failed to follow the instructions of the study.

2.3. Materials

2.3.1. Verification Task

We created 36 prime pictures and their descriptions, produced by the confederates. Half of the images depicted actions involving an agent, a patient, and a beneficiary, which were described in DO form (e.g., a boy is giving his teacher an apple) as opposed to the PO form (e.g., a boy is giving an apple to his teacher). The other half of the pictures represented an action involving an agent and a patient and were described using the passive form (e.g., the fisher was swallowed by a whale), as opposed to an active sentence (e.g., the whale swallowed the fisher). Target pictures and their descriptions were split into two sets of 36. One set was used in the baseline session, while the other set was used in the experimental session.

Descriptions of the confederates were pre-recorded in a video-recording format. To ensure better authenticity and naturalness, the descriptions were collected from confeder-

ates while they were completing a sentence completion task. Six confederates were asked to describe a picture using the sentence template given to them and filling in the blanks with the words suggested. The words they filled the sentences with initially appeared in random order and confederates reordered them into a grammatically correct sentence during recording. The verbs were given in the infinitive form. Therefore, the confederates could use the tense that they felt best fit the picture. This strategy was adopted to elicit more natural responses from confederates, thereby enhancing the interactive feel of the experiment and avoiding robotic or scripted sounding descriptions. Videos were recorded in a quiet room with a background, giving no cues as to the time of the day. This was important as participants could take the study online at any time of the day. Noticing time differences could reveal that the experiment was, in fact, not interactive. Due to the nature of the manipulation, in the two experimental conditions (SSP vs. MSP), the same picture was described by a different confederate. To ensure uniformity of prime items across conditions, the descriptions of confederates corresponding to the same picture were edited to maintain a difference in enunciation duration of no more than one second. The prime pictures and descriptions were arranged in a fixed order to be presented across sessions and experimental conditions.

2.3.2. Description Task

We used 72 cue verbs and related target pictures (see Appendix A). Half of the target pictures were selected to elicit simple active transitive sentences or full passive sentences. The other half of the target pictures were selected to elicit PO dative sentences or DO sentences. The majority of dative cue verbs employed in this study were derived from the research conducted by Scheepers et al. (2017). Cue verbs were presented below each picture. Target stimuli in both baseline and experimental sessions were arranged in a fixed order. To prevent the 'lexical boost' in the priming effect, in case of lexical overlap (Kaschak et al. 2011), each cue verb was presented only once across conditions. That is, there was no lexical overlap between the cue verbs, neither within nor between the two sessions.

2.4. Procedure

2.4.1. Baseline Session—Picture Description Task

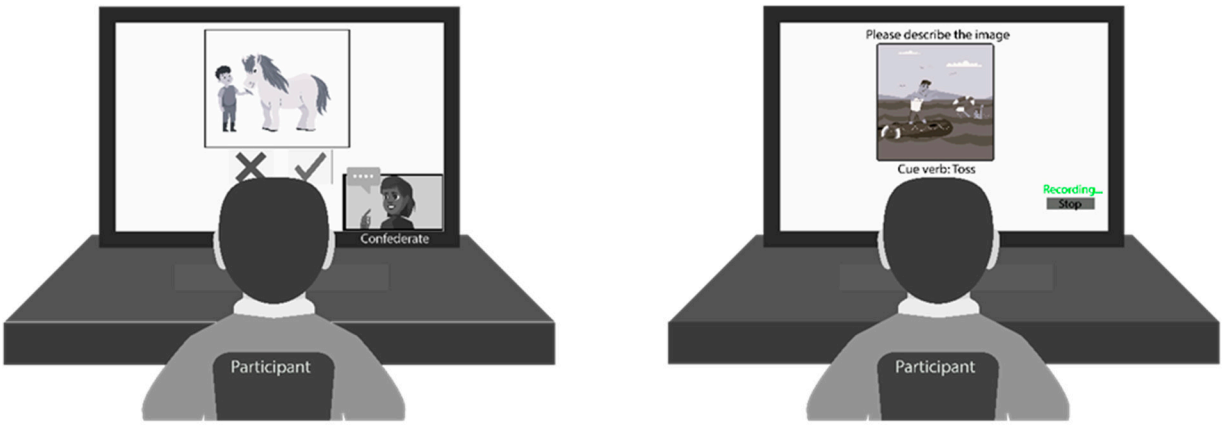
After agreeing to participate in the study, participants first completed a baseline session in which their unprimed rates of production for DO versus PO constructions, and passive versus active constructions, were assessed. To do so, the participants completed a picture description task meant to elicit full transitive and dative constructions. They were instructed to describe 36 images in sequence, using a concise sentence containing a cue verb presented with the image. Images were obtained from the study of Bock and Griffin (2000) and Freepik.com. Eighteen images could be described either in the DO or PO form. Another 18 images could be described using either an active or a passive sentence.

Participants were given 15 s for each picture to submit their answer. This session was not interactive, but the answers of the participants were collected in video format to maintain the uniformity of the answer format across baseline and experimental sessions.

2.4.2. Experimental Session—Picture Verification and Description Task

After the baseline session, participants were randomly assigned to one of two conditions in the experimental session, where they were told that the purpose of the study was to understand how people communicate ideas to each other and they would be asked to play an interactive game online with other players. Participants were primed toward the production of the DO and passive constructions, as these were less preferred, on average, in the baseline session. The experimental task was modeled after Branigan et al.'s (2000) confederate scripting. It involved a picture verification and description game played in pairs. On a verification (prime) turn, the naïve participant watched a pre-recorded video of the confederate that they were told was sent to them by the other player. In the video, the confederates described an image that they supposedly saw on their own screen. The

participants had to decide whether the description of the confederate matched the picture displayed on-screen. Each verbal description by a confederate constituted a priming event. On a description (target) turn, the participants were presented with a novel target picture and a cue verb and were instructed to use the cue verb to describe the image. They video-recorded a description for a target picture displayed on screen; they were told that this description would be sent to the other player (a confederate) so that the player could make a verification decision in turn (see Figure 1).

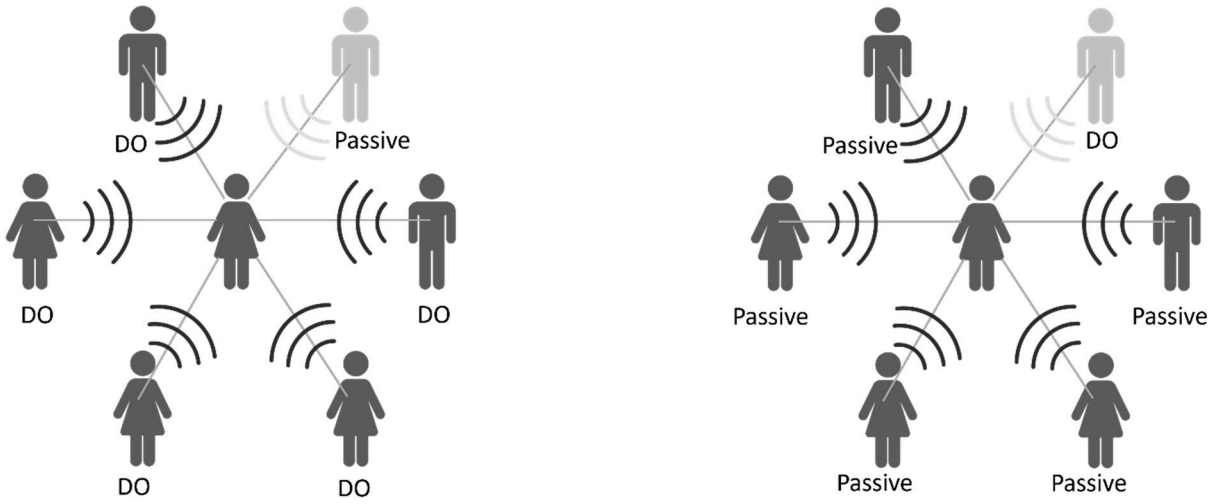


(**a**) (**b**)

Figure 1. (**a**) The picture verification task and (**b**) the description task used in the experiment. The baseline session included only the picture description task. Visuals of Figure 1 have been designed using assets from https://www.freepik.com/ (accessed on 2 April 2024).

Items in the experimental session consisted of a prime picture, its description by the confederate, a target picture, and a cue verb to describe the target picture. There were 36 prime pictures and their descriptions and 36 target pictures and cue verbs. The experiment consisted of 18 blocks. In each block, the participant completed two picture verification and description turns with one confederate. The dative and transitive structures were presented to the participants in alternating blocks. For this reason, they served as fillers for each other. The participants played with six confederates in total and the confederates changed in each block throughout the game. In one block, there were two prime pictures with their descriptions by a confederate, and two target pictures and cue verbs to be described by the participants. All the prime sentences that confederates described were in video format. Also, participants submitted their answers as a video.

Participants were randomly assigned to one of two groups. In one group, participants received DO prime sentences from five confederates and passive prime sentences from one confederate. This was the multi-speaker priming (MSP) condition for DO structures and single-speaker priming (SSP) condition for passives. In the other condition, participants received passive primes from five confederates and DO primes from one confederate. This condition served as MSP for passives and SSP for the DO voice. Therefore, the speaker_source (SSP vs. MPS) for a particular syntactic construction was a between-subjects factor, manipulating how many different people the subject was primed from (see Figure 2).



(**a**) (**b**)

Figure 2. Schematic of the two experimental conditions of multi-party dialogic turns. (**a**) Multi-speaker priming (MSP) for double object (DO) constructions and single-speaker priming (SSP) for passive constructions; (**b**) MSP for passive constructions and SSP for DO constructions. Visuals of Figure 2 have been designed using assets from https://www.freepik.com/ (accessed on 2 April 2024).

2.5. Scoring

Transitive sentences produced by participants in their picture descriptions were transcribed and coded as active, passive, or neither. To be scored as passive, a description had to involve a patient of the picture as the subject of the sentence, a verb in passive voice, a by phrase following the verb, and the agent of the action as the object of by. Descriptions scored as active contained the agent as subject, a verb in active voice, and the patient as a direct object. Neither category included truncated passives, adjectival passives, or active sentences with intransitive verbs (Bock and Loebell 1990). In addition, if the participant did not use the transitive cue verb as the first verb, the description was scored as neither. Dative items were coded as PO, DO, or neither. PO datives must have a dative verb, the direct object, and a PO phrase incorporating the indirect object; DO datives involve the verb followed by the indirect and direct object noun phrases, in that order. PO datives without the corresponding DO forms were scored as neither (Bock 1986).

3. Results

In the baseline session, the mean proportion of active construction use was 0.95, while the mean proportion of passive construction was 0.05. The PO constructions constituted a mean proportion of 0.74. The DO constructions, while present, were less prevalent, representing a mean proportion of 0.26. Inferential model comparison was adopted for the data analysis, fitting nested mixed-effects binary logistic regressions of different complexities with the *lme4* package (Bates et al. 2015). To find the best parsimonious fit of the data, we compared the models with the *flexplot* package (Fife 2022) in R (R Core Team 2021). The dependent variable was whether participants used the target alternative of each syntactic construction (coded as 1 for passive and DO forms) in the picture description task versus the non-target alternatives (coded as 0 for active and PO forms). Productions categorized as neither (see scoring criteria above) were excluded from the analysis (in total, 20% of data points were excluded). The fixed effects were session (levels: baseline vs. experimental), speaker_source (levels: SSP vs. MSP), and construction (transitive vs. dative).

model0: As suggested by Barr et al. (2013), a maximal random effects structure model with no fixed effects was first attempted. We incorporated random intercepts for both item and subject, alongside random slopes for subject and the interaction involving speaker_source, session, and construction within subject. The model was simplified step

by step until it converged without singularity issues. First, random slopes for item were removed (Segaert et al. 2016; van Lieburg et al. 2023). Subsequently, random slopes for the interaction between speaker_source, session, and construction by subject were excluded from the model. The model converged without singularity issues after all random slopes were removed. Thus, the final random effects model included random intercepts for both item and subject.

model0 <- glmer (target~1 + (1 | item) + (1 | subject), data = data, family = binomial)

model1: Main predictors of session, speaker_source, and construction were added as fixed effects to model0. Sum coding was used to interpret the output of the models in terms of the main effects, and main interactions in later models:

model1 <- glmer (target~1 + (1 | item) + (1 | subject) + session + speaker_source + construction, data = data, family = binomial)

model2: To test the proposed central hypothesis that priming of target syntactic forms should increase in the multi-speaker priming condition relative to the baseline productions of those forms, an interaction term between speaker_source and session was added to model1:

model2 <- glmer (target~1 + (1 | item) + (1 | subject) + session + speaker_source + construction + session: speaker_source, data = data, family = binomial)

model3: To test whether priming of target syntactic forms was larger for one construction relative to baseline, the interaction between construction, session, and speaker_source was added in a third model (Figure 3). This specific prediction is more speculative than our central hypothesis, tested with model2. However, it is possible to conjecture that the effect of speaker_source (relative to baseline), if it exists, may be larger for constructions that are harder to prime. In such a case, the construction that has been demonstrated to be harder to prime should be more sensitive to the effect of speaker source (this specific hypothesis is exploratory and did not form part of the initial preregistration plan):

model3 <- glmer (target~1 + (1 | item) + (1 | subject) + session + speaker_source + construction + session: speaker_source + session: speaker_source: construction, data = data, family = binomial)

Model comparison is the process of selecting the best model among a set of competing models based on fit indices and hypothesis testing. Nested models are models that can be derived from each other by adding or removing parameters or constraints, such as the ones specified above. Nested models can be compared using the likelihood ratio chi-square difference test, which probes whether the difference in chi-square values between two models is significant or not. A significant chi-square difference indicates that the more complex model fits the data better than the simpler model. Nested models can also be compared using information criteria, such as AIC or BIC, which balance the fit and the complexity of the models. A lower information criterion indicates a better model. A further measure of the relative evidence for one model over the other is the Bayes factor (BF). While BF values are not interpreted as thresholds like *p*-values, values larger than around 10 are considered fairly strong evidence in favor of a model, while, conversely, values much smaller than 0 are considered strong evidence against a model.

In Tables 1 and 2, we report chi-square test, BF, AIC, and BIC values in pairwise comparisons between model1 vs. model2, as well as model2 vs. model3. All indexes converge toward model1 being the best fitting and most parsimonious model to fit our data (all models were fit to the same data). First, using likelihood ratio tests, no significant difference exists between model1 and model2 ($\chi^2 = 0.0005$, $p = 0.98$), suggesting that adding an interaction term between session and speaker_source did not significantly improve

the model. Similarly, the results revealed no significant difference between model2 and model3 ($\chi^2 = 5.2$, $p = 0.16$), indicating the addition of three-way interaction between session, speaker_source and construction did not significantly improve the model.

Table 1. Indexes of model comparison of model1 vs. model2.

	AIC	BIC	Bayes Factor	*p* (Chi-Square Test)
model2	3862.224	3907.282	0.015	0.983
model1	3860.224	3898.846	67.911	

Table 2. Indexes of model comparison of model2 vs. model3.

	AIC	BIC	Bayes Factor	*p* (Chi-Square Test)
model3	3863.024	3927.392	0.018	0.158
model2	3862.224	3907.282	23,277.67	

Second, the BF also strongly favored model1 over model2 (BF = 67.91). Additionally, model1 yielded lower AIC and BIC values compared to model2, indicating a better fit to the data. Further comparison between model2 and model3 indicates that model3 exhibited higher AIC and BIC values than model2 and the BF very strongly favored model2 over model3 (BF = 23,277.67). In summary, the data provided stronger support for the simpler model1 over the more complex model2, and model2 over model3. This is in line with the likelihood ratio tests, suggesting that including interaction terms did not significantly improve the model.

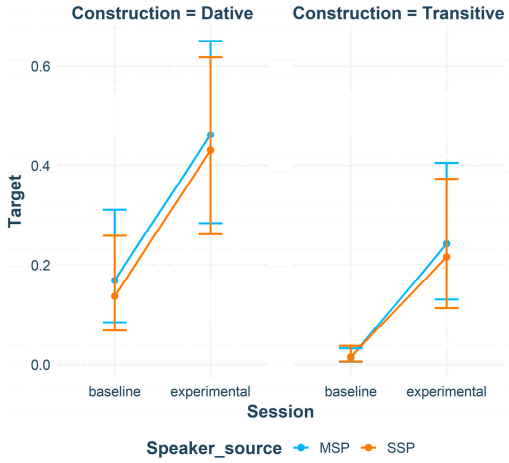


Figure 3. Partial effects from model3 of the three-way interaction between session, speaker_source, and syntactic construction on the production of target DO and passive forms. Error bars indicate 95% confidence intervals.

Table 3 reports a summary of model1 in an analysis of deviance with Type III Wald chi-square tests for each predictor in the model (obtained with the Anova function from the *car* package). This revealed a significant effect of session ($\chi^2 = 33.65$, $p < 0.001$) on target responses, such that participants in the experimental session produced target (primed) responses in the passive and DO structures significantly more often than in the baseline session. Moreover, there was a significant effect of construction ($\chi^2 = 20.51$, $p < 0.001$), indicating that target structure use was higher for dative than transitive forms. Also, across sessions, there was no significant effect of speaker_source ($\chi^2 = 2.70$, $p = 0.099$). Note that this last effect is meaningless per se, as the baseline session did not include a manipulation of speaker_source and subjects were randomly assigned to each speaker_source condition.

Table 3. Analysis of deviance of fixed effects for model1.

	Chisq	Df	Pr (>Chisq)
(Intercept)	72.5615	1	$<2.2 \times 10^{-16}$ ***
session	33.6459	1	6.612×10^{-9} ***
speaker_source	2.7089	1	0.09979 .
construction	20.5067	1	5.942×10^{-6} ***

Signif. codes: '.' $p < 0.1$ and *** $p < 0.001$.

In summary, as model2 and model3 are not better than model1, the conclusion one can derive from inferential model comparison is that there was a general priming effect from baseline to experimental session, but this was not modulated by the number of speakers who produced the priming sentences.

4. Discussion

We asked whether the implicit selection of syntactic structures in adult participants engaged in a multi-party dialogic task is influenced by the number of individuals who primed such structures. Two main hypotheses were put forth. Firstly, we expected all participants to exhibit a syntactic priming effect from the baseline session of no priming to the following experimental session. The inferential statistics models, including model1 which fits our data best, indicate that participants were primed from baseline to experimental session. This finding contributes to the existing literature demonstrating the priming effect in spoken production (for a review, see Mahowald et al. 2016). Furthermore, our study adds to the literature on syntactic priming in an online setting (Corley and Scheepers 2002; van Lieburg et al. 2023). It demonstrates that the phenomenon of syntactic priming persists even in conditions where both the experimental environment and participant selection are relatively less controlled, compared to a typical laboratory-based study. Observing a priming effect in both groups was in line with our expectations. These results highlight the robust and highly replicable nature of syntactic priming.

Second, we expected to find a greater priming effect in MSP compared to SSP condition, under the hypothesis that the adoption of syntactic choices is a form of complex contagion from multiple speakers. Contrary to our expectations, there was no difference in the degree of priming between MSP and SSP conditions. Likelihood ratio tests, as well as AIC and BIC values, confirmed these results by showing that including interaction terms did not significantly improve the model. BF analysis, which quantifies the relative evidence for one model over another, also further supported the results by favoring model1 over the more complex model2 and model2 over model3. The inclusion of two-way interaction terms in model2 and a three-way interaction term in model3 did not improve the model's fit based on the data.

The absence of an effect related to speaker variation in our models prompts several considerations about the specific task we used. One plausible factor could be attributed to the online nature of the study. Simulating an online social game that convincingly delivers the feeling of genuine social interaction for participants can be challenging. During real-life interactions, coordination of body postures, gaze patterns (Shockley et al. 2007, 2009), and temporal coordination (Verga and Kotz 2017) typically occur between conversational partners. In the current study, participants communicated by sending each other their responses in the form of video messages, which lacked the immediacy of real-time interaction. Therefore, certain key elements inherent to face-to-face conversations were absent in our study's design. In addition, the physical presence of another person can affect the linguistic behavior of the person. A recent study found that the physical, but not virtual, presence of others potentiates implicit learning (Sarasso et al. 2022). This finding would suggest that an effect of speaker variation on syntactic priming may be visible only during in-person contact. However, this finding would be at odds with the literature on complex social contagions of ideas, where most of the findings were obtained via online experiments, where participants did not even interact face-to-face (e.g., Centola 2010).

In addition to the missing elements of face-to-face communication, previous research emphasized the role of the task on syntactic priming. Reitter et al. (2006) investigated the effect of syntactic priming in a dialogue where interlocutors either aimed to engage in casual conversation or collaborated on a shared task. Syntactic persistence effects were more pronounced in task-oriented interactions compared to casual conversations. In the current study, the communicative goal was essential to examine the effect of multi-party group on syntactic choices. The aim was to create an environment in which participants felt they were working together to achieve a common goal within their group. However, participants might not feel that they were part of a group that was trying to reach a common goal. Instead, they may have viewed their participation as merely playing a game without a clear collective purpose. Alternatively, their experience might have resembled a series of dyadic interactions rather than collaborative group work, potentially leading to the dominance of dyadic turn-taking dynamics over the intended multi-party nature of the experiment. Such deviations from the intended group-oriented setup could compromise the study's aim of investigating the influence of multi-person interactions on linguistic behavior, potentially explaining the lack of evidence for an effect of speaker variability.

We suggested that the syntactic choices of an individual act as a form of complex contagion, where social context is important for linguistic behavior and the number of sources would lead to a difference in linguistic behavior. Also, by basing our hypothesis on the implicit learning account (Chang et al. 2006), we suggested that exposure to a syntactic structure from multiple individuals could reinforce more substantial cognitive adjustments, leading to an increased tendency to incorporate that structure into one's own language use compared to exposure from a single individual. However, our results may imply that syntactic priming is a form of automatic behavior that is less sensitive to contextual and social situations (Pickering and Garrod 2004; Pickering and Garrod 2006), here whether the source of priming comes from one versus many different speakers. In that respect, it would suggest that this form of linguistic behavior might diffuse through a social network in a manner more like a simple form of contagion. It could be that the cognitive weighting of utterances is not affected by the number of speakers the individual interacts with.

Centola (2019, p. 90) reported that behaviors can spread as a form of simple contagion, as well as complex contagion. He argued that low-cost behaviors spread more effectively through networks of simple contagions, as the barriers to participation in low-cost behaviors are primarily associated with access rather than resistance. Even minimal contact with an individual exhibiting a specific behavior can offer social incentives to induce behavioral change. In this case, syntactic adaptations in terms of active/passive voice or the choice of the alternating form of a dative could be low-cost behaviors for fluent adult speakers to induce priming by a single speaker. However, language is a highly complex communication system with multiple levels and can be affected by numerous interplaying factors. Several studies showed that social context affects language learning and linguistic behavior (e.g., De Felice et al. 2021; Sarasso et al. 2022; Schoot et al. 2019). Additionally, group size has been shown to influence people's opinions about the discussed topics in that group, suggesting characteristics of the group affect communication (Fay et al. 2000). It is evident that social context influences linguistic behavior. Further research is essential to gain a more comprehensive understanding before reaching a conclusion on whether syntactic behavior is sensitive to speaker variation.

Another finding was that the use of PO dative structures was more prevalent among our participants compared to the use of DO forms. While Bock and Griffin (2000) suggested that American English speakers have a 2:1 bias toward DO forms, different studies have shown a tendency for PO dative structures over DO datives (Corley and Scheepers 2002; Pickering and Branigan 1998; van Lieburg et al. 2023). In the current experiment, 36 dative verbs were used, primarily taken from the study of Scheepers et al. (2017). In their study, participants were about twice as likely to produce PO datives rather than DO structures overall. A similar trend was mirrored in the current experiment, where speakers have a 3:1

bias toward the PO construction. Thus, the higher production of PO structure in our study aligns with the findings of Scheepers et al. (2017).

Preference for DO or PO structures may be related to the probabilistic nature of the verbs that were used in the study. Frequency-based properties of words and words within specific constructions have been demonstrated to be relevant to various linguistic and psycholinguistic issues and models. Certain verbs exhibit a tendency to occur in a specific structure (Gries 2005). In the present experiment, the probabilistic properties of words may lead to a greater bias towards the use of PO construction. For instance, prior studies have identified 'give', 'show', and 'offer' as significant collexemes of the dative construction, while 'sell' and 'hand' are significant collexemes of PO datives. Moreover, 'lend' and 'send' did not show a significant preference for either construction (Gries 2005). The verbs used in this experiment may be significant collexemes of PO datives. This is consistent with the similar proportions of PO and DO forms found in both our study and Scheepers et al.'s (2017) research, given that most of the verbs used in both studies were the same. Another factor that could influence participants' preferences for DO and PO structures is the presented visual stimuli in the task. A previous study found that the left–right orientation of pictures has a significant effect on how participants began describing the pictures (Gleitman et al. 2007). In this experiment, most of the pictures depicted the object positioned between the agent and the recipient, with the agent typically located on the left side, thus mirroring the left-to-right order of PO form. Consequently, the order of objects in the pictures may contribute to an increased likelihood of participants using PO structures over DO.

5. Conclusions

We aimed to investigate whether linguistic alignment, more specifically syntactic priming, behaves as a form of complex social contagion requiring speaker variation of the primed sentences. Most psycholinguistic research on dialogue has investigated the cognitive mechanisms that underpin language use in dyadic dialogues. Yet, everyday communication dynamically involves dialogic exchanges with different interlocutors. Whether in the workplace or at home, people interact with several others daily. Therefore, it is crucial to understand more complex communicative situations and the cognitive processes involved in multi-party dialogues. In the current experiment, a significant priming effect from baseline to experimental session was observed. Our study contributes to the body of literature on syntactic priming in an online context, highlighting the robust nature of this phenomenon even in settings where experimental conditions are less supervised in comparison to conventional laboratory-based research. Future studies should consider refining task designs to enhance the interactive human dynamics of the experiment. A task structure emphasizing collective group efforts, rather than dyadic dialogues within the game may yield more revealing results. Moreover, while the effect was not evident in syntactic choices, it may be visible in other linguistic behaviors such as learning a new language. Prior research has demonstrated that the presence of others can facilitate the learning of new words (Verga and Kotz 2017), thus providing an avenue for investigating complex contagion in the context of learning new vocabulary. In short, conducting more research is essential for closing the gap between individual language use mechanisms and the social mechanisms of language diffusion within a community.

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Data Availability Statement: Data for this study can be found at https://osf.io/vwpgr/?view_only=104d948f82fe457ea30f71d29f8b08a5 (accessed on 2 April 2024).

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Appendix A

Table A1. Transitive and dative verbs used as cues in the baseline and experimental session. Participants saw a picture of an action scene and were prompted to use a cue verb to describe each scene.

Transitive Verbs	Dative Verbs
sweep	feed
hit	write
frighten	catch
sting	sell
track	bake
scare	buy
splash	tell
bump	hand
annoy	toss
kick	bring
run over	pass
squash	cook
engulf	forward
demolish	fling
attack	throw
scratch	save
punch	give
startle	pour
wake up	get
eat	draw
plant	mail
shoot	teach
scold	issue
chase	reserve
videotape	award
carry	fax
tie	book
break	keep
threat	sew
drag	take
flip	make
rock	purchase
electrocute	steal
lick	paint
grab	show
throw	lend
comfort	read
follow	loan
blow off	promise
ignore	fetch
hear	offer
warm	send
lift	rent
find	prepare

Table A1. *Cont.*

Transitive Verbs	Dative Verbs
bite	knit
strike	cut
sniff	order
approach	organize
destroy	build
swallow	post
outsmart	fix
raise	serve

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