Mental Chronometry of Speaking in Dialogue: Semantic Interference Turns into Facilitation

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Abstract

Numerous studies demonstrate that the production of words is delayed when speakers process in temporal proximity semantically related words. Yet the experimental settings underlying this effect are different from those under which we typically speak. This study demonstrates that semantic interference disappears, and can even turn into facilitation, when semantically related words are embedded in a meaningful communicative exchange. Experiment 1 and 3 (each N=32 university students) implemented a picture-word interference task in a game played between two participants: one named the distractor word and, after a stimulus-onset-asynchrony of -150ms or -650ms, the other named a semantically related or unrelated target picture. Semantic interference reappeared with identical experimental parameters in a single-person picture-word interference setting (Experiment 2, N=32). We conclude that the inhibitory context effects leading to semantic interference in single-subject settings are attenuated whereas facilitatory effects are enhanced in communicative settings.

Keywords: Language production; lexical access; social interaction; semantic context; turn taking

Highlights

- In isolated speakers processing semantically related words interferes with speaking
- Yet we typically speak to communicate with others
- This study transfers picture-word interference to a communicative setting
- Semantically related words produced by a partner do not interfere with speaking

Over the last decades a multitude of experimental studies have demonstrated that semantic context, typically presented in form of words embedded in simple picture naming tasks, can interfere with language production. The present study suggests that semantic interference may be mostly present in settings in which single words are produced devoid of a communicative purpose. When semantic context is embedded in a communicative social interaction interference can turn into facilitation.

A central paradigm for studying semantic context effects is the picture-word interference (PWI) task. In this task speakers name target pictures while trying to ignore visually or auditorily presented distractor words. One very robust finding is semantic interference: pictures are named with a greater latency if they are named in close temporal proximity to a semantically related distractor word (e.g., Damian & Martin, 1999; Glaser & Düngelhoff, 1984; Schriefers et al., 1990). Semantic context effects may arise from a trade-off between semantic facilitation and interference (e.g., Roelofs, 2018). Processing the distractor pre-activates features that are shared with semantically related targets. This facilitates conceptual processing. However, on the lexical level, the target's selection is delayed because target and distractor compete (e.g., Levelt et al., 1999; Roelofs, 2018; Schriefers et al., 1990; but see e.g., Finkbeiner & Caramazza, 2006; Mahon et al., 2007 for an alternative, non-competitive account). Whether overall interference or facilitation is observed depends on whether conceptual (priming) or lexical (competition) processing dominates (Abdel Rahman & Melinger, 2019, 2009).

The picture-word interference task has been very instrumental to insights into the architecture underlying word production. Yet, in day-to-day conversations interlocutors routinely produce words from the same semantic category. For example, at a restaurant, a party of guests might discuss the menu options (e.g., DuBois, John, & Englebretson, 2004, SBC031). One may suggest ordering a classic chef salad, while the

other suggests a pasta salad. Do these interlocutors experience interference from each other's references to different types of dishes? Based on the substantial empirical support from picture-word interference studies, speakers should be experiencing interference when seeking lexical access to semantically related items in close temporal proximity. Yet, under the premise that dialogue is the primary site of language use (e.g., Clark, 1996; Levinson, 1983) a speaker's cognitive system should be optimally equipped to speak in such settings. Experiencing semantic interference from an interlocutor's previous turn would undermine fluent conversation.

In the current study we extended the classic PWI paradigm to a two-person setting embedded in a conversational turn sequence. One person produced the distractor word and the second person named the target picture as part of a simple card game. Distractor and target were either semantically related or unrelated. In half of the trials the distractor preceded the target by 100ms (SOA-100), which typically produces strong semantic interference (e.g., Damian & Martin, 1999; Hantsch et al., 2009; Schriefers et al., 1990). For the other half of trials the distractor preceded the target by 650ms (SOA-650), which typically results in less interference, sometimes even facilitation, presumably because conceptual processing prevails (e.g., Alario et al., 2000; Bloem et al., 2004; Glaser & Düngelhoff, 1984). Experiment 2 implemented the identical experimental parameters in a classic single-subject PWI setting, using audio recordings of the distractors named spontaneously in Experiment 1. Experiment 3 tested a possible mechanism for reducing interference in communicative settings and increased participants' focus on the conceptual relationship between target and distractor.

We hypothesized that semantic interference typically observed in picture-word interference studies can in principle also be observed in communicative settings. Thus, utterances of one speaker may interfere with semantically related utterances of the next

speaker. Furthermore we speculated that the degree of interference depends on the nature of the communicative setting. Specifically, in Experiment 1 and 2, we expected longer naming latencies if distractor word and target picture are semantically related. In contrast, in Experiment 3 we expected less interference, possibly even facilitation. Consistent with past studies, semantic interference may be more pronounced at SOA-100ms, while facilitation may be more pronounced at SOA-650ms. These hypotheses, the experimental procedures, and analyses were pre-registered (Kuhlen & Abdel Rahman, 2019). The raw data of the experiments reported here have been made available (Kuhlen & Abdel Rahman, 2020).

Experiment 1

Methods

Participants. Two native German speakers were recruited to each experimental session, serving consecutively in the role of the partner. Participants were reimbursed, or received credit towards their curriculum requirements, and gave informed consent prior to participating in the study. Four participants had to be excluded and replaced because they had a laughing or coughing spell during the naming task. Furthermore, the audio recordings of twelve participants turned out to be deficient and had to be replaced[1] in order to have a complete set of recorded distractor stimuli for Experiment 2. The final analyses included 32 participants of a mean age of 26 (SD = 4.79), 23 women and 9 men.

Our sample size was determined prior to data collection through a power analysis that simulated the outcome of an LMM model testing for semantic interference at SOA-100ms (simr package, Green et al., 2016). We assumed an interference effect of

[1] An analyses of the data prior to excluding and replacing these participants yielded identical effects.

22.5ms, which corresponds in size to those found in previous PWI studies (e.g., Lorenz et al., 2018). With 32 participants we reached a power estimate of 85.8% chance (95% confidence interval: 83.48, 87.91) for detecting the hypothesized interference effect.

Materials. Our stimulus material consisted of 40 distractor words and 40 to be named color photographs depicting everyday objects. Pictures were scaled to 3.5cm x 3.5cm and presented on a homogenous grey background framed by an orange rectangle, resembling a playing card.

Pictures and words were combined to form semantically related and unrelated target-distractor pairings such that in every condition each picture and each word appeared in the same combination once in every SOA for each participant. All target-distractor pairs were phonologically unrelated. Distractor objects were never target objects. Semantically related target-distractor pairs came from the same superordinate category (e.g., two types of birds, see supplementary materials). These semantically closely related objects have demonstrated strong interference effects in single-subject PWI experiments (Rose et al., 2019). Semantically unrelated target-distractor pairings were formed by re-combining the semantically related target-distractor pairs.

To reduce the predictability with which a particular target followed a given distractor, we created two distinct target-distractor sets within each semantic condition. A participant who was presented a certain set of distractor-target pairs when naming distractors would be presented with a different set when subsequently naming targets. The order in which these sets were presented was counter-balanced across teams. This procedure resulted in 80 related and 80 unrelated target-distractor pairs for each participant in the naming condition.

The presentation order of target-distractor pairs was pseudo-randomized using the software Shuffle_tk (Pallier, 2002) implementing the following constraints: (1) at

least three trials separated the repetitions of a particular distractor word or target picture, (2) at least three trials separated the repetitions of a distractor word's, or target picture's, superordinate category. Under these constraints 64 stimulus lists were created, one for each participant and SOA condition.

Additionally, one semantically unrelated target-distractor pairing served as a first trial of each session and eight unrelated target-distractor pairings served as training trials. These did not enter data analyses.

Procedure. Two participants were invited per experimental session and consecutively served as Player D (naming the distractor) and Player T (naming the target), or vice versa. Upon arrival, participants were introduced to each other as team members. The card sorting task was explained to them using a set of laminated cards created from the training stimuli. The experimenter demonstrated the first round of the game, which begins with Player D asking the question "which card comes on", then taking up a card from the stack and reading out the displayed word (e.g., "eagle"). Next, Player T draws a card and names the displayed picture (e.g., "vulture"). Then Player D places his card to the card corresponding to Player T's picture. Participants played a few rounds among themselves, switching roles in between. To provide an incentive and to strengthen the team spirit the participants were told that the fastest and most accurate team would win a gift certificate of 25 EUR each. Participants were familiarized with the stimulus material, which was presented on paper as unsorted sets of pictures.

For the main experimental session, the two participants were seated in a sound-proof cabin sitting across from each other, each with a monitor and a microphone in front of them, see *Figure 1*. Trials began with a fixation cross. For Player D the fixation cross was replaced after 500ms with the written utterance "which card comes on…", which was read aloud by Player D. After 1750ms the distractor word was presented,

which was also read aloud by Player D. With the onset of the distractor naming, identified by a voice key, the target picture was presented with the given SOA (100 or 650ms later) on Player T's monitor. Player T's task was to name this picture as fast and accurately a possible. The onset of the target naming was recorded by a second voice key and resulted in our main dependent measure, picture naming latency. The onset of the target naming released the presentation of the decision screen on Player D's monitor. The decision screen displayed two pictures side-by-side: the target picture that had been named by Player T and a filler picture that was not part of the stimulus set. Player D indicated by button press where the distractor card should be placed. The target picture disappeared from Player T's screen as soon as Player D gave a response. An Inter-Trial-Interval of 2000ms terminated each trial. Audio recordings were obtained from Player D's reading of the distractor words (for details see Experiment 2).

SOA remained constant for one complete naming of all stimuli and then switched for the second round. The order of SOA condition was counter-balanced across participants. After playing out the entire set of stimuli in both SOA conditions, participants switched seats and roles. With swapped roles they played out all stimuli once more in both SOA conditions, but implementing different sets of distractor-target pairings. After completing both sessions the experimenter handed out a debriefing questionnaire.

Naming response. We analyzed the naming response of Player T, who named the target picture. Responses below 200ms were considered error trials and excluded from the analyses[2] (4.67%). Furthermore excluded were trials during which no

[2] We pre-registered an outlier correction excluding naming latencies above two standard deviations of an individual's overall mean. We now believe this may cut off differences between experimental conditions and the less invasive correction we report here is more truthful to data. Our results stay the same with the pre-registered correction, with the exception of the interference effect at SOA-100 in Experiment 2, which became only marginally significant at $p = .07$.

distractor-naming was registered or distractor naming was disfluent (1.97%) and trials in which target pictures were named wrongly or disfluently (4.14%). In total 91.21% of all trials were analyzed.

Data analyses. Linear mixed effects models (LMM; Baayen et al., 2008) as implemented in the *lmer* function of the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015, Version 1.1-21) for R (R Development Core Team, 2014) were applied to log-transformed naming latencies. Naming latencies were modeled as a function of semantic relatedness (related vs. unrelated) in a nested structure for each SOA level separately. To both predictors we applied sliding difference contrasts that compare mean differences between adjacent factor levels.

Models were initially run with a maximum random effects structure for participants and target pictures. Using singular value decomposition, the initial full random effect structure was simplified, if necessary, by successively removing those random effects for which estimated variance was indistinguishable from zero until the maximal informative model was identified (Bates et al., 2018).

For fixed effects, we report fixed effect estimates, 95% confidence intervals, t-values, and p-values, as well as the square root (standard deviations) of the random effect structure, and goodness-of-fit statistics. P-values were computed using the lmerTest package (Kuznetsova et al., 2017).

Results

Pre-registered analyses. Participants took on average 798.69ms (SD = 237.22) to name target pictures. Naming latencies were not affected by the semantic relationship between target and distractors: independent of whether their partner had just uttered a semantically related or unrelated word participants named target pictures at a comparable speed. This pattern could be observed for both short and long SOA. In both

semantic conditions speakers named pictures faster after a long SOA of -650ms than after a short SOA of -100ms. The results are visualized in raincloud plots (modified from Allen et al., 2019) in *Figure 2*, the output of the LMM model can be found in *Table 1.* The maximal informative model included a random slope for SOA and a random slope for semantic relatedness.

As a control analysis we also implemented a LMM model including as additional predictors whether participants first named distractors (taking the role of Player D) or first named targets (taking the role of Player T) and whether participants named pictures under one or the other target-distractor pairing. Compared to the model without these predictors (described above) this model was not superior in predicting naming responses,$\Delta\chi^2(12) = 18.94$, $p = .09$. We conclude that these factors did not contribute significantly to our data pattern.

Exploratory analyses. Semantic interference in the picture-word interference task has been argued to be modulated by the degree of inhibitory control an individual engages in to suppress a semantically related distractor word (e.g., Shao et al., 2013, 2015). In the presence of another person participants may be particularly motivated to apply inhibitory control (see e.g., Sharma et al., 2010). To look into this possibility we visualized the observed naming latencies in vincentized cumulative distribution curves (e.g., Ratcliff, 1979; Roelofs, 2008a). These rank order naming latencies for each subject and each condition separately and then divide these values into quantiles of 10%. Thus, the first quantile in a given experimental condition reflects the mean value of the 10% of the trials with the fastest naming latency. Since selective inhibition builds up over time (e.g., Forstmann et al., 2008; Ridderinkhof, 2002) semantic interference effects should become increasingly smaller for slower naming latencies. This effect should be strongest in short SOAs, so we extended this investigation to the SOA of -100ms only. As can be

seen in *Figure A.1* of our Appendix, we find no indication for the described data pattern. Instead, semantic interference was slightly more pronounced in the middle of the distribution. This speaks against an incremental build-up of inhibitory control.

Discussion

Based on the extensive literature on picture-word interference naming latencies should increase if the task partner produces a semantically related word in the previous turn. Especially at SOA-100 semantic interference is a well-documented and robust effect. Yet the results of Experiment 1 demonstrate that speakers do not experience semantic interference.

Could this finding be due to unintended deviations from the basic paradigm? Most notably, the SOA was implemented with a voice key and possible inaccuracies of the trigger (e.g., Kessler et al., 2002) could have resulted in irregular SOAs. Also, in the typical picture-word interference experiment auditory distractors are well-articulated and pre-recorded under optimal acoustic conditions. In our experiment, distractors were produced spontaneously and could have been less intelligible, and hence less effective. For these reasons we replicated the experiment with the audio recordings of the distractor naming obtained from Experiment 1 and implemented with identical timing in a single-subject setting devoid of a communicative context.

Experiment 2

Methods

Participants. For each experimental session, one native German speaker was invited to the lab at a time. Participants were reimbursed, or received credit towards their curriculum requirements, and gave informed consent prior to participating in the study. One participant had to be excluded due to non-compliance. The final set of

participants consisted of 32 people of a mean age of 27.84 years (SD = 5.26), 15 men and 17 women. None of the participants had participated in Experiment 1.

Materials. Stimulus materials were identical to those used in Experiment 1 with the exception that the distractor words consisted of all 32 audio recordings obtained from Experiment 1's Player D. Audio recording started at the time point at which the written distractor had been presented to Player D and hence included a period of silence that varied depending on individual reading latency. The recordings ended with the completion of the word. Audio recordings were cleaned of static noise in Adobe Audition. The quality of all stimuli was checked manually. We marked as deficient recordings in which no distractor naming had occurred and recordings that contained speech disfluencies or recording artefacts that could not be corrected, in total 1.48% of all recordings. These deficient recordings were presented as stimuli, but excluded from the analyses. Recordings were presented via headphones to participants. The presentation order was identical to Experiment 1. This resulted in a session-by-session replication of the exact stimuli and their temporal characteristics as implemented in Experiment 1. What differed from Experiment 1 was the absence of a game partner and the lack of a communicative context.

Procedure. Participants were instructed to name the presented pictures as fast and accurately as possible. As is common in picture-word interference experiments, participants were told to ignore the distractor. To provide an incentive for fast and accurate responses comparable to Experiment 1 participants were told that the fastest and most accurate individual would win a gift certificate of 25 EUR. Prior to the main naming session, participants familiarized themselves with the stimulus material.

Each trial proceeded with the identical timing parameters as in Experiment 1: Trials began with a fixation cross presented for 500ms plus and additional 1750ms (the

time period during which, in Experiment 1, Player D read their question). Then the audio recording began, implementing a voice onset of the distractor word identical to the one observed in Experiment 1. With the onset of the distractor word the target picture was presented on the participants' monitor with the given SOA (100 or 650ms later). The onset of participants' target naming was recorded by a voice key. The target picture disappeared from the participants' monitor after a time period that corresponded to Experiment 1 (Player D's decision where to place their card). An Inter-Trial-Interval of 2000ms terminated each trial. All other details of the design, presentation and data analysis were identical to Exp. 1

Naming response. Of all target naming responses 2.07% were excluded from the analyses because naming latency was below 200ms and 5.25% were excluded as error trials. Identical to Experiment 1, 1.97% of all trials were excluded due to missing or deficient distractor-naming. In total, 91.74% of all trials entered the analyses.

Results

Pre-registered analyses.

Participants named target picture at a comparable speed as in Experiment 1, with an average naming latency of 793.22ms (SD = 241.74). At SOA-100 a pronounced interference effect was observed, which resembled in pattern and size those typically reported in PWI studies: participants took on average 23ms longer to name the target picture when a semantically related versus unrelated distractor word had preceded it. Our LMM model confirmed this difference as statistically significant. The maximal informative model modeled variance across participants with a random slope for semantic relatedness and a random slope for SOA and variance across target pictures with a random slope for semantic relatedness.

At SOA-650 participants took on average 7ms longer in the semantically related compared to the unrelated condition. This difference was not statistically significant. As in Experiment 1, participants were numerically faster to name target pictures after a long SOA (-650) than after a short SOA (-100), but this difference was not statistically significant. The results are visualized in *Figure 3*; the output of the LMM model is reported in *Table 2.*

Exploratory analyses. One possible explanation for the strikingly different pattern we observe between Experiment 1 and Experiment 2 could lie in the social convention not to interrupt another speaker. Especially in a social setting, participants may have withheld their response thereby eliminating semantic interference. To look into this, we compared the data of Experiment 1 and 2 to investigate (a) whether a speaker's naming latency depended on the duration of the distractor word (i.e., if the partner took longer completing the distractor word, did the speaker begin naming the target later?), and (b) whether the interturn interval between the end of the distractor word and the beginning of the target word was longer in Experiment 1 than in Experiment 2.

The word duration of each distractor was determined by calculating the root-mean-square of the audio signal's amplitude and identifying the two most prominent change points in power, which typically represent the onset and offset of speech. Recordings for which only one change point could be found (0.8% of all files) and recordings for which the calculated word duration was below 250ms (4.08% of all files) were checked and manually corrected, if necessary. The average distractor word duration was 506.71ms (SD = 148.14). We set up an LMM model which included experiment (1 vs. 2) and word duration (centered and entered as continuous variable) as additional predictors. In both experiments distractor duration made a significant

contribution to predicting naming latency. *Table A* in our Appendix reports the model's output.

The average interturn interval was defined as the time period that elapsed between the offset of the distractor and the onset of the target naming. In Experiment 1 this interturn interval was on average 666.86ms (SD = 344.7), and in Experiment 2 659.97ms (SD = 364.36). This difference was not statistically significant, $t(62) = 0.37$, $p = 0.71$.

To follow up on a possible influence of inhibitory control on the size of semantic interference, we investigated the distributional characteristics of the target naming latencies in vincentized cumulative distribution curves, see *Figure A.2*. These indicate that in Experiment 2 semantic interference seemed to be larger in those trials with longer naming latencies, a pattern that is inconsistent with an influence of inhibitory control.

Discussion

A session-by-session replication of Experiment 1 that did not elicit semantic interference in a social setting did elicit semantic interference when embedded in a single-subject setting. The results at SOA-100 resemble the typical finding in PWI studies. We do not find any effect of semantic relatedness at SOA-650, where semantic effects are considerably less stable. Taken together, we conclude that our specific implementation of the PWI paradigm is not responsible for the disappearance of semantic interference in Experiment 1.

In dialogue it is typically considered inappropriate to begin speaking before the previous speaker has completed their turn (e.g., Sacks et al., 1974). This convention may have occluded semantic effects in Experiment 1. Yet our exploratory analyses suggests that also in a single-subject setting participants may be withholding their response while

the distractor is being articulated. This makes it unlikely that semantic interference vanished because participants delayed their response in a social setting.

Instead we suggest that the game in which the PWI paradigm was embedded in Experiment 1 (but not in Experiment 2) encouraged participants to process the partner's utterances more strongly on a conceptual level. When conceptual processing is emphasized, semantic relatedness has been suggested to alleviate interference, and perhaps even turn to facilitation (e.g., Abdel Rahman & Melinger, 2019). To test this idea, we implemented in Experiment 3 a modified communicative game designed to increase participants' focus on the conceptual commonalities between distractor and target. Resulting facilitatory effects are most likely to be found at SOA-650.

Experiment 3

Methods

Participants. As for Experiment 1 we recruited two native German speakers per session. All participants gave informed consent prior to participating in the study and were reimbursed or received credit towards their curriculum requirements for their participation. Two participants had to be excluded due to laughing spells. The final set of 32 participants had a mean age of 22.91 years (SD = 4.59), 4 men and 28 women.

Materials. The stimulus materials and lists were identical to those employed in the first two experiments.

Procedure. The experiment proceeded as Experiment 1 with the following changes to the communicative game: The game began with Player D asking the question "What matches…" (instead of the semantically less relevant "Which card comes on…") followed by the naming of the distractor word. With a given SOA added to the onset of the distractor word, the target picture appeared on Player T's monitor, who then named

the displayed object as fast and accurately as possible. At the end of each trial Player D indicated whether the picture named by Player T matched the distractor word. If participants were uncertain what counted as a matching card the experimenter gave an example ("Piano and violin match, they are both instruments."). As in the previous experiments, the fastest and most accurate team won a prize. Naming responses and stimulus onset asynchrony were determined as in the previous experiments. All other details of the procedure and data analysis were identical.

Naming response. As in Experiment 1-2 we analyzed the naming response of the participants naming the target picture. 89.9% of all trials entered the analyses. Excluded were 1.23% due to missing distractor naming, 6.41% due to wrong or disfluent target naming, and 3.71% due to naming latencies below 200ms.

Results

Pre-registered analyses.

Participants named target pictures with an average naming latency of 845.66ms (SD= 227.14). The data pattern replicated the pattern observed in Experiment 1 for the SOA-100: the semantic relatedness between distractor and target did not elicit semantic interference. At SOA-650ms we observed a statistically significant facilitatory effect of semantic relatedness: after their partner uttered a semantically related distractor word speakers were on average 31ms faster to name the target picture. The results are visualized in *Figure 4*; the output of the model is reported in *Table 3*. Our data supported a model accounting for variance across participants with a random slope for semantic relatedness and SOA and across target pictures with a random slope for semantic relatedness and SOA. As in the previous experiments, the order in which participants took the role of Player D or Player T, nor the distractor-target set contributed significantly to the data pattern.

Exploratory analyses.

Distributional characteristics. To look into distributional characteristics of our effects, we computed vincentized cumulative distribution curves, see *Figure A.3* in the Appendix. We find no indication that semantic interference is more pronounced in trials with faster naming latency.

Combined analyses Experiments 1-3. We combined the data from all three experiments and set up an LMM analysis contrasting each social setting with the single subject setting (Experiment 1 vs. Experiment 2; Experiment 3 vs. Experiment 2). We were most interested in probing our two main findings, the lack of semantic interference in a social setting at SOA-100 and the presence of semantic facilitation at SOA-650 in Experiment 3. Indeed, the effect of semantic relatedness differed between Experiment 1 and 2 at SOA-100, confirming our observation that semantic interference is significantly reduced in a social setting. Unfortunately, this pattern did not reach significance comparing Experiment 3 with Experiment 2. At SOA-650, semantic relatedness had a distinct effect at SOA-650 in Experiment 3 compared to Experiment 2. This confirms the strong semantic facilitation we observe at this SOA in a social setting. For the full model output please refer to *Table 4*.

Discussion

The communicative game of Experiment 3 was designed to prompt participants to evaluate the conceptual relationship between the partner's and their own utterance. And, indeed, in this setting we observed semantic facilitation at SOA-650, a time window during which conceptual processing, and hence semantic priming, typically dominates.

Experiment 3 replicated our initial finding that semantic interference vanishes in communicative context at SOA-100ms, a time window during which semantic

interference should dominate according to traditional picture-word interference experiments. We will discuss the implications of these findings below.

General Discussion

Traditional accounts of speech production are largely based on tightly controlled experimental settings in which a single subject is instructed to name pictures devoid of a communicative purpose. In these settings it has been demonstrated that speaking is delayed when a semantically related word is processed in close temporal proximity to the target picture (picture-word interference). Yet in dialogue interlocutors often refer to semantically related concepts across speaking turns. We sought out to investigate whether semantic interference can be observed when a word uttered in one task partner's turn semantically relates to a word uttered in the other task partner's turn. For this we implemented a classic picture-word interference paradigm in a communicative setting. In two experiments we did not observe semantic interference. Yet the same experimental design and stimuli, implemented in a single-subject setting, did yield the typical semantic interference effect. We conclude that in dialogue-like settings processing and producing semantically related words in close temporal proximity does not elicit semantic interference.

Our findings are in line with a recent publication that embedded the PWI paradigm in a communicative context (Shao & Rommers, 2019, Experiment 1). In this experiment participants heard a question, pre-recorded on audio, which was either tightly or loosely linked to the target picture. Immediately after the question, the target picture was presented alongside a semantically related or unrelated written distractor. When the question constrained as an answer the target picture, interference by a semantically related distractor was reduced (see e.g., Kleinman et al., 2015 for

comparable findings). Our study differs from this study in decisive ways: In Shao and Rommers' study the distractor word intruded the communicative context by giving additional, misleading context. In our study, the distractor was part of the communicative context established by the task partner's turn. And even when the partner's utterance did not constrain the speaker's naming response (Experiment 1) we found no semantic interference. Hence there may be an additional driving force behind the attenuation of semantic interference in dialogue-like settings.

Our novel findings can be explained by models assuming that semantic context can have both facilitatory and interfering effects on speech production (e.g., Roelofs, 2018). Such models allow for opposing effects of identical semantic relations depending on whether the context or task at hand promotes conceptual processing (eliciting facilitatory priming) or lexical processing (eliciting competition) (Abdel Rahman & Melinger, 2009; 2019). Indeed, our results suggest that the communicative context we established in our modified PWI paradigm promotes conceptual processing of the partner's utterances. This means that the partner naming the distractor strongly primed the target picture and its affiliated lexical representation, but activated to a lesser extent related lexical competitors. Hence, facilitatory priming on a conceptual level and interference on a lexical level canceled each other out (Experiment 1), or even turned towards facilitation when the communicative context emphasized the semantic relation between target and distractor (Experiment 3). A conceptual locus is also in line with the finding that facilitation was found when the word was presented 650ms before the picture.

Alternative accounts of word production that do not assume a trade-off between lexical competition and conceptual priming have been proposed to explain semantic interference effects in picture-word interference paradigms (e.g., Finkbeiner &

Caramazza, 2006; Mahon et al., 2007). According to these accounts interference between target and competitor arises after lexical selection, at the level of articulation. Since only one lexical entry can pass through the so-called articulatory output buffer at a time, distractor and target impede each other during articulation. This clog resolves more quickly if the competing item is not response relevant. According to these original proposals, response relevance is defined by the degree of semantic relatedness between a distractor and a target word. If the definition of response relevance were to be extended to include a higher-level assessment of the contextual or pragmatic relevance at large, one could argue that a distractor word uttered as part of a conversational partner's turn may not be considered response relevant and hence may elicit less interference. However, recent studies speak against a constraining influence of pragmatic context on word selection (Jescheniak et al., 2017; Mädebach et al., 2020).

A second alternative explanation for our findings comes from studies that have investigate interference effects in joint actions (e.g., Sharma et al., 2010; Sellaro et al., 2018). Most notably, a recent conference contribution (Tufft & Richardson, 2020) reports a picture-word interference experiment in which, comparable to our study, the naming of the written distractor word and the naming of the target picture is distributed between two task partners. In this study, the naming of the distractor and target is devoid of a communicative purpose. As in our study, semantic interference disappears. The authors suggest that the shared task setting prompts participants to off-load the processing of the distractor to the partner (interestingly, even if the partner's task does not involve naming the distractor, but instead naming the color of the frame on which the picture-word pair is presented). In our study, as well, the shared task context may have alleviated participants from processing the distractor word deeply. Yet, social off-loading cannot explain why changes to the communicative game, most notably an

increased focus on the conceptual relationship between distractor and target, would facilitate speech production.

Interestingly, in Tufft and Richardson's study the interference effects becomes increasingly smaller with longer reaction times—a pattern of result that is consistent with the exertion of late inhibitory control. In our data we do not find an indication that participants were exerting inhibitory control to suppresses the processing of the distractor. This is a further indicator that there may be different mechanisms at play that can reduce interference in social settings. This will be a fruitful field for future research.

A related question concerns the level of detail at which a task partner's utterance is represented. This is a controversial topic among recent studies that have implemented different joint picture naming paradigms to investigate speech production in shared task setting. Some of these studies demonstrate that pictures that are (presumably or actually) named by a partner contribute to the degree of interference a partner experiences, suggesting that speakers engage in lexical access on behalf of their partner (Baus et al., 2014; Hoedemaker et al., 2017; Kuhlen & Abdel Rahman, 2017). Yet, other studies have reported that speakers may not represent their partner's naming response, or at least not at the lexical level (Brehm et al., 2019; Gambi et al., 2015; Hoedemaker & Meyer, 2019; Tufft & Richardson, 2020). The current study suggests that the partner's utterances are not processed on the lexical level. Given the facilitatory effects observed in Experiment 3, our results however do not support the conclusion that the partner's utterances were not represented at all. While previous studies investigated speech production in settings involving a second speaker, these settings were not, as in the current study was, embedded in a communicative exchange. The divergent findings across different experimental paradigms and social settings highlight

the need for more systematic investigations of the processes underlying speech production in social interaction.

In sum, our results demonstrate that semantic context is processed differently when it is embedded in a communicative exchange compared to when it is embedded in a setting devoid of a social context (i.e., the typical PWI paradigm). Our findings suggest that a communicative setting promotes processing the conceptual relationship between distractor and target and hence enhances semantic priming. Lastly, our findings highlight the relevance of investigating language production in settings in which it typically occurs, namely in social interaction.

Authors' Contribution

Both authors contributed to the study design. Testing and data collection were performed by student assistants. A. K. Kuhlen performed the data analysis and interpretation with significant contributions by R. Abdel Rahman. A. K. Kuhlen drafted the manuscript, and A. Abdel Rahman provided critical revisions. Both authors approved the final version of the manuscript for submission.

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Table 1: Model output for Experiment 1. Fixed-effect estimates, 95% confidence intervals, t-values, and p-values.

	Log-Transformed Target Naming Latencies			
Predictors	*Estimates*	*CI*	*t-value*	*p-value*
(Intercept)	6.65 ***	6.60 – 6.71	229.94	<0.001
SOA	-0.08 ***	-0.13 – -0.04	-3.44	0.002
SOA-100: Semantic Relatedness	-0.00	-0.02 – 0.02	-0.20	0.845
SOA-650: Semantic Relatedness	0.02	-0.00 – 0.04	1.52	0.131
Random Effects				
Residual	0.04			
Subject (intercept)	0.02			
Subject (SOA)	0.02			
Target (intercept)	0.01			
Target (Semantic Relatedness)	0.00			
Corr (Target)	-0.05			
Corr (Subject)	0.11			
Deviance	-1225.926			
log-Likelihood	600.181			

** p<0.05 ** p<0.01 *** p<0.001*

Table 2: Model output for Experiment 2. Fixed-effect estimates, 95% confidence intervals, t-values, and p-values.

	Log-Transformed Target Naming Latencies			
Predictors	*Estimates*	*CI*	*t-value*	*p-value*
(Intercept)	6.64 ***	6.60 – 6.69	291.93	<0.001
SOA	-0.04	-0.09 – 0.02	-1.35	0.186
SOA-100: Semantic Relatedness	-0.03 *	-0.05 – -0.00	-2.24	0.029
SOA-650: Semantic Relatedness	-0.01	-0.03 – 0.02	-0.43	0.667
Random Effects				
Residual	0.05			
Subject (intercept)	0.01			
Subject (Semantic Relatedness)	0.00			
Subject (SOA)	0.02			
Target (intercept)	0.01			
Target (Semantic Relatedness)	0.00			
Corr (Target)	0.01			
Corr (Subject : Semantic Relatedness)	0.47			
Corr (Subject: SOA)	-0.14			
Deviance	-226.582			
log-Likelihood	100.631			

** p<0.05 ** p<0.01 *** p<0.001*

Table 3: Model output for Experiment 3. Fixed-effect estimates, 95% confidence intervals, t-values, and p-values.

	Log-Transformed Target Naming Latencies			
Predictors	*Estimates*	*CI*	*t-value*	*p-value*
(Intercept)	6.72 ***	6.67 – 6.76	291.63	<0.001
SOA2-1	-0.12 ***	-0.16 – -0.07	-5.10	<0.001
SOA-100:bed2-1	-0.01	-0.03 – 0.01	-1.24	0.218
SOA-650:bed2-1	0.05 ***	0.03 – 0.07	4.48	<0.001
Random Effects				
Residual	0.04			
Target (intercept)	0.01			
Subject (intercept)	0.01			
Target (Semantic Relatedness)	0.00			
Target (SOA)	0.00			
Subject (Semantic Relatedness)	0.00			
Subject (SOA)	0.02			
Corr (Target: Semantic Relatedness)	0.03			
Corr (Target: SOA)	0.73			
Corr (Subject: Semantic Relatedness)	0.15			
Corr (SOA)	0.32			
Deviance	-1968.080			
log-Likelihood	970.852			

** p<0.05 ** p<0.01 *** p<0.001*

Table 4: Model output for global LMM pooling data from Experiment 1, 2 & 3. Fixed-effect estimates, 95% confidence intervals, t-values, and p-values.

	Log-Transformed Target Naming Latencies				
Predictors	*Estimates*	*SE*	*CI*	*t-value*	*p-value*
(Intercept)	6.67 ***	0.02	6.63 – 6.71	363.00	<0.001
Exp2-1	-0.01	0.03	-0.07 – 0.05	-0.33	0.744
Exp3-2	0.07 *	0.03	0.02 – 0.13	2.48	0.015
SOA	-0.08 ***	0.01	-0.11 – -0.05	-5.48	<0.001
SOA-100:Semantic Relatedness	-0.01	0.01	-0.03 – 0.00	-1.65	0.103
SOA-650:Semantic Relatedness	0.02 *	0.01	0.00 – 0.03	2.27	0.027
Exp2-1:SOA	0.05	0.04	-0.02 – 0.12	1.39	0.167
Exp3-2:SOA	-0.08 *	0.04	-0.15 – -0.01	-2.36	0.020
Exp2-1:SOA-100:Semantic Relatedness	-0.03 *	0.01	-0.05 – -0.00	-2.01	0.045
Exp3-2:SOA-100:Semantic Relatedness	0.01	0.01	-0.01 – 0.04	1.08	0.282
Exp2-1:SOA-650:Semantic Relatedness	-0.02	0.01	-0.05 – 0.00	-1.62	0.106
Exp3-2:SOA-650:Semantic Relatedness	0.05 ***	0.01	0.02 – 0.07	3.94	<0.001
Random Effects					
Residual	0.04				
Subject (intercept)	0.01				
Subject (SOA)	0.02				
Subject (Semantic Relatedness)	0.00				
Target (intercept)	0.01				
Target (SOA)	0.00				
Target (Semantic Relatedness)	0.00				
Corr (Subject:SOA)	0.09				
Corr(Subject:Semantic Relatedness)	0.37				
Corr (Target:SOA)	0.59				
Corr(Target:Semantic Relatedness)	-0.03				
Deviance	-3377.608				
log-Likelihood	1649.808				

** p<0.05 ** p<0.01 *** p<0.001*

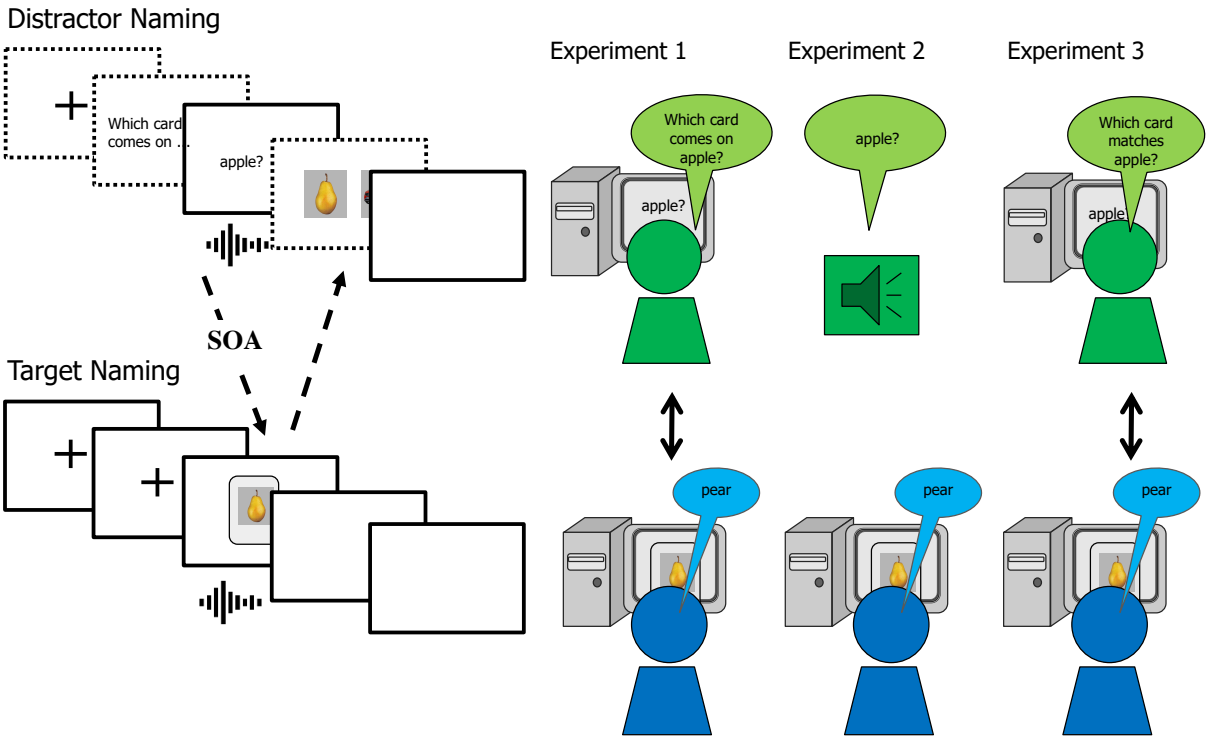

Figure 1. Illustration of trial structure and experimental setting of Experiments 1-3.

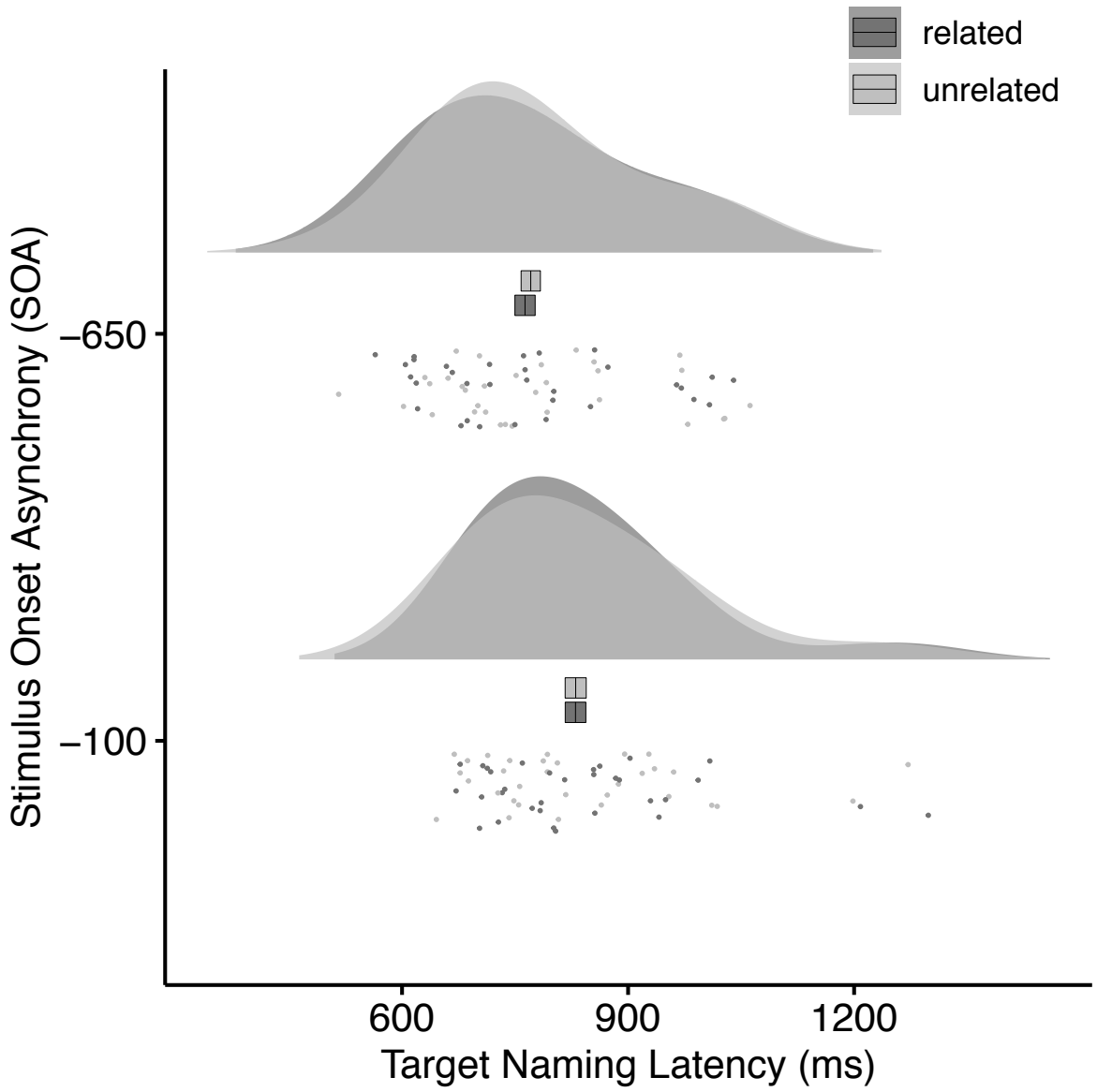

Figure 2. Data distribution of target naming latency (in milliseconds) as probability density function, including boxplots with mean values and 95% confidence intervals and individuals' mean data points for each SOA and semantic relatedness condition separately of Experiment 1.

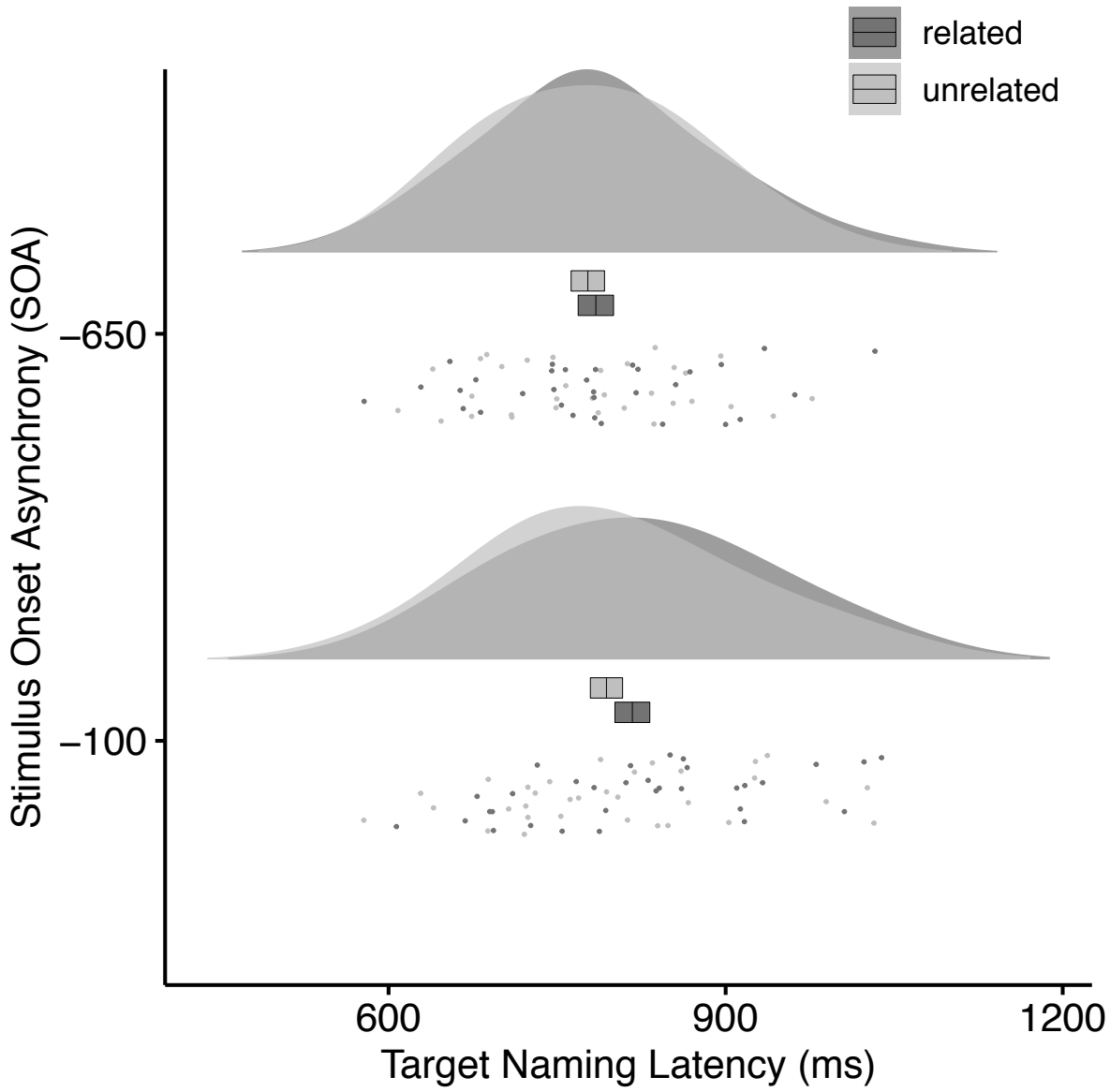

Figure 3. Data distribution of target naming latency (in milliseconds) as probability density function, including boxplots with mean values and 95% confidence intervals and individuals' mean data points for each SOA and semantic relatedness condition separately of Experiment 2.

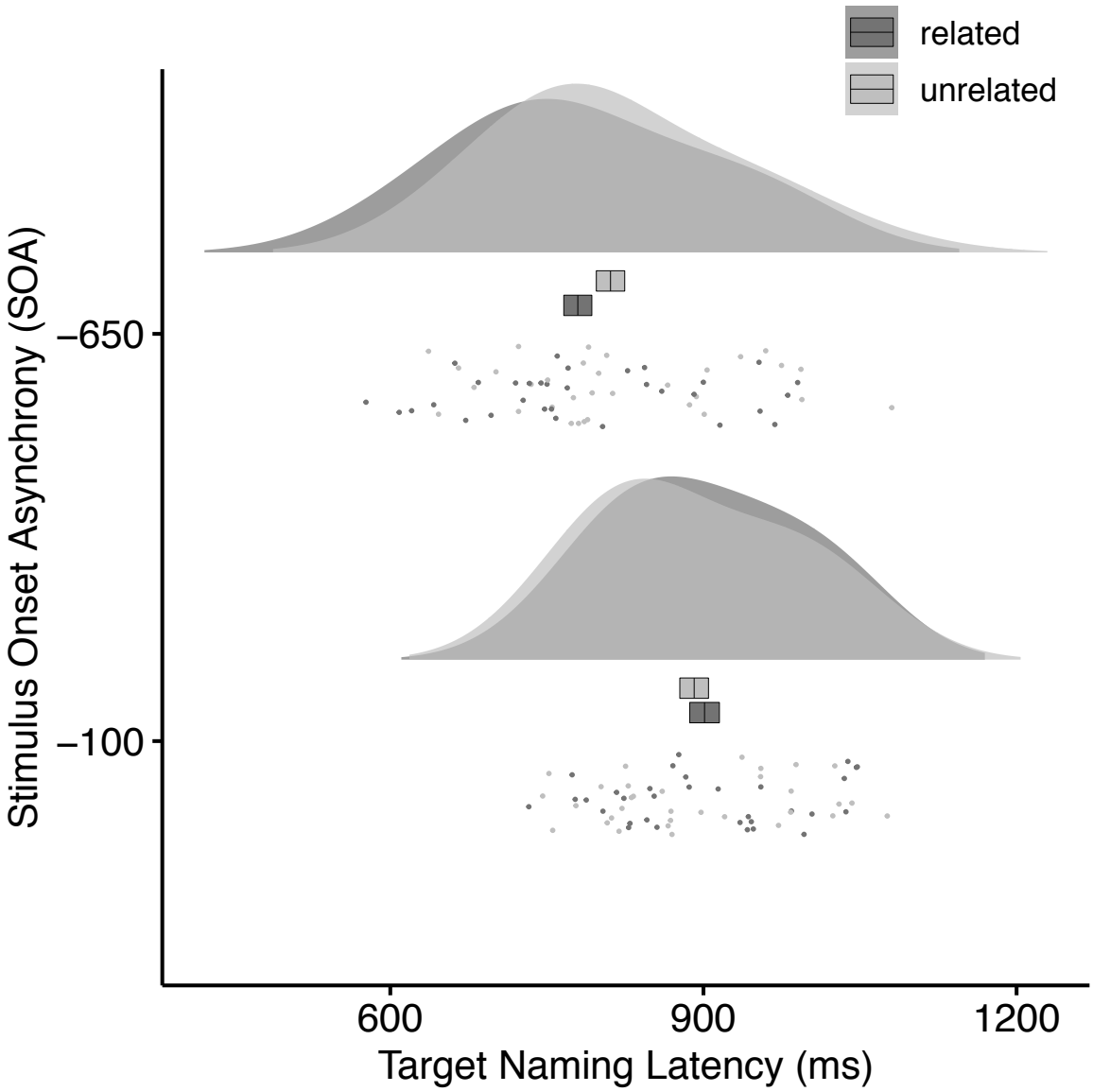

Figure 4. Data distribution of target naming latency (in milliseconds) as probability density function, including boxplots with mean values and 95% confidence intervals and individuals' mean data points for each SOA and semantic relatedness condition separately of Experiment 3.

Appendix A

Table A: Model output for LMM pooling data from Experiment 1 & 2 and entering word duration as predictor. Fixed-effect estimates, 95% confidence intervals, t-values, and p-values.

	Log-Transformed Target Naming Latencies			
Predictors	*Estimates*	*CI*	*t-value*	*p-value*
(Intercept)	6.65 ***	6.61 – 6.69	330.53	<0.001
Exp2-1	-0.01	-0.07 – 0.05	-0.32	0.753
Exp1:SOA	-0.09 ***	-0.14 – -0.04	-3.42	0.001
Exp2:SOA	-0.04	-0.09 – 0.01	-1.54	0.128
Exp1:Duration	0.00 ***	0.00 – 0.00	4.06	<0.001
Exp2:Duration	0.00 ***	0.00 – 0.00	6.25	<0.001
Exp1:SOA-100:Semantic Relatedness	-0.00	-0.02 – 0.02	-0.18	0.857
Exp2:SOA-100:Semantic Relatedness	-0.03 *	-0.05 – -0.01	-2.54	0.011
Exp1:SOA-650:Semantic Relatedness	0.02	-0.01 – 0.04	1.45	0.147
Exp2:SOA-650:Semantic Relatedness	-0.01	-0.03 – 0.02	-0.49	0.624
Random Effects				
Residual	0.05			
Subject (intercept)	0.01			
Subject (SOA)	0.02			
Target (intercept)	0.01			
Target (Semantic Relatedness)	0.00			
Corr (Subject)	0.01			
Corr (Target)	0.08			
Deviance	-1490.827			
log-Likelihood	700.372			

** p<0.05 ** p<0.01 *** p<0.001*

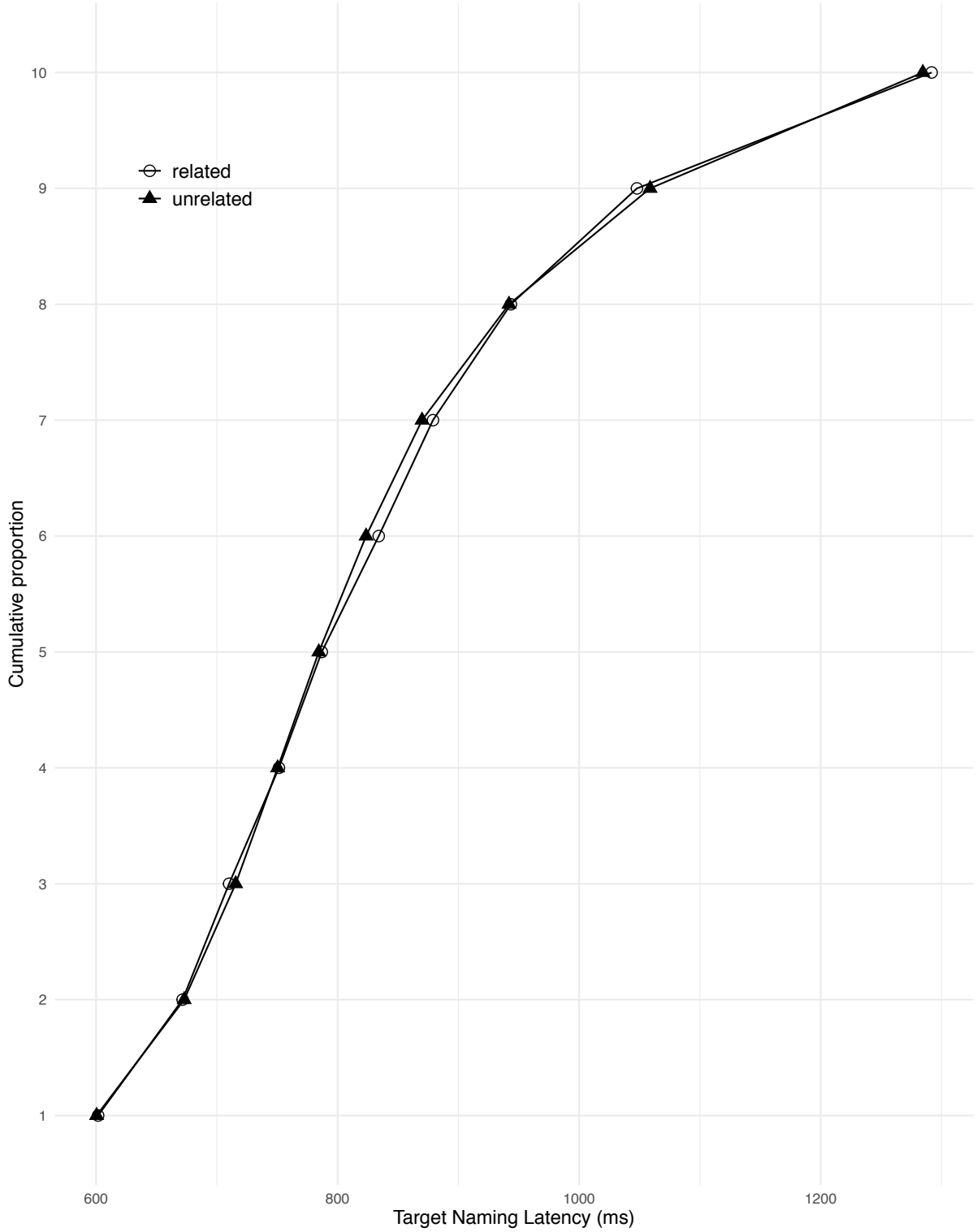

Figure A.1. Vincentized distribution plots for Experiment 1.

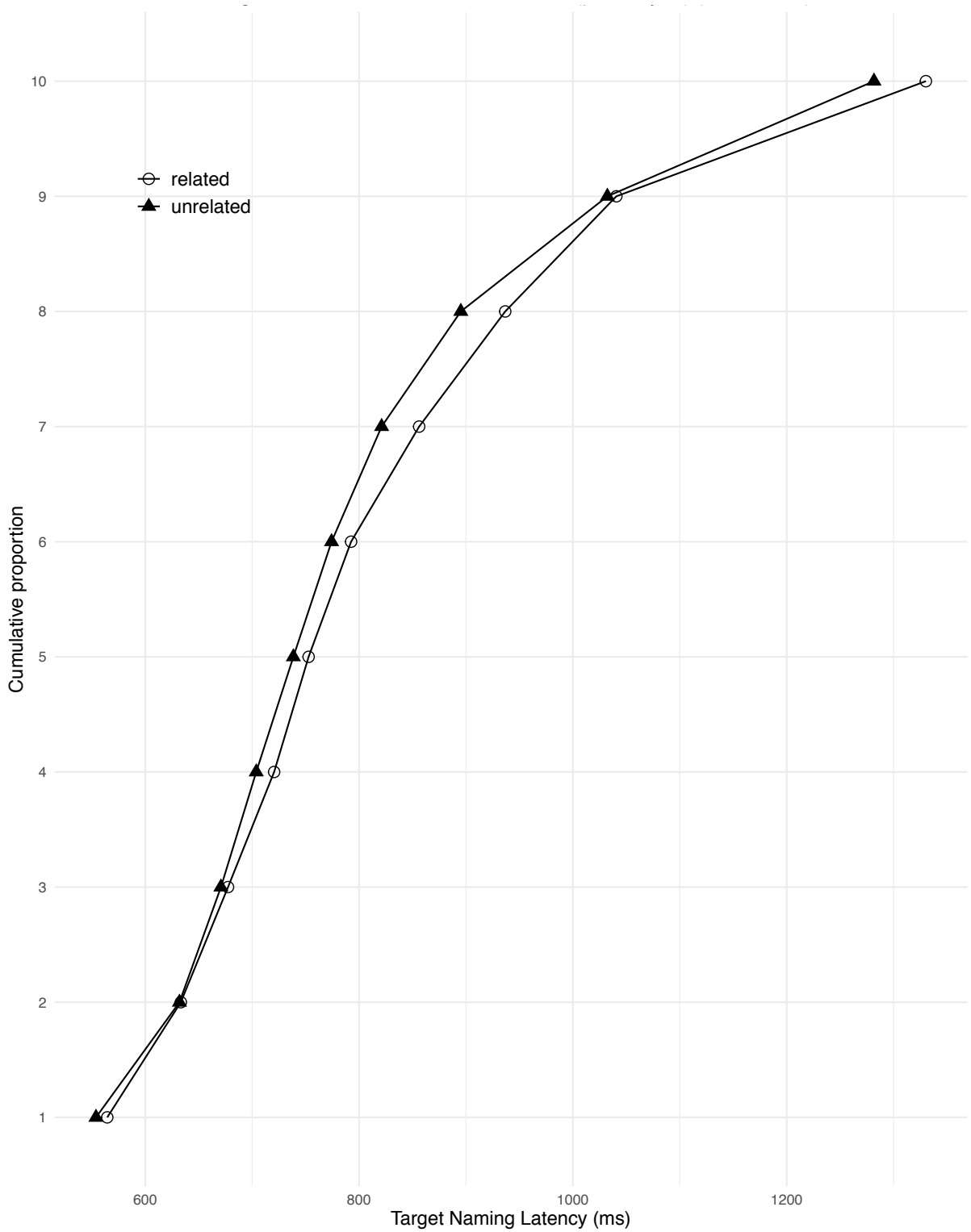

Figure A.2. Vincentized distribution plots for Experiment 2.

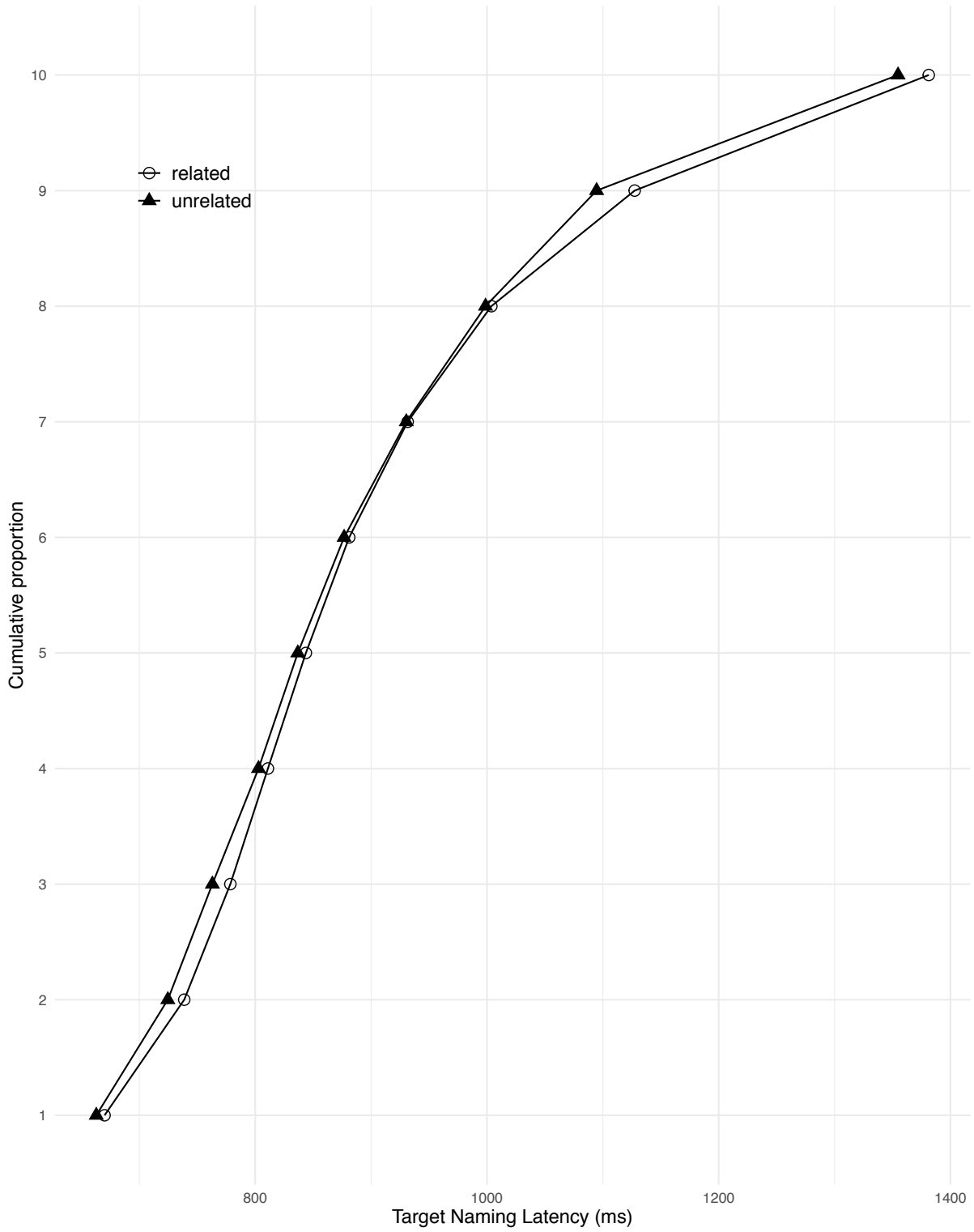

Figure A.3. Vincentized distribution plots for Experiment 3.