Neurocognitive Modulations of Lexical Access during Speech Production in Social and Semantic Context

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Zusammenfassung

Der Sprechakt teilt sich in zwei Vorgänge: Zunächst muss das richtige Wort aus dem mentalen Lexikon abgerufen werden und anschließend wird es in der Kommunikation verwendet. Zur Erforschung des ersteren Vorgangs werden oft Ein-Personen-Studien verwendet, in denen durch Beobachten der Reaktion auf Stimuli (z. B. Bilder) die Mikrostruktur des lexikalisch-semantischen Systems beleuchtet wird. Für die Anwendung von Sprache in der Kommunikation hingegen nutzt man Partnerexperimente, um die Koordination zwischen den Gesprächspartnern zu beobachten und zu ergründen, wie sich gegenseitiges Verstehen und biografisches Wissen darauf auswirken. Wenig erforscht ist aber, wie ein von einem Gesprächspartner eingebrachter Bedeutungskontext die traditionell in Ein-Personen-Studien untersuchten lexikalisch-semantischen Effekte beeinflusst. Im Rahmen meiner Dissertation möchte ich die Lücke zwischen den beiden Forschungsansätzen schließen, indem ich einen kommunikativen Kontext in etablierte Paradigmen der Bildbenennung integriere. Hierzu betrachte ich zunächst klassische semantische Kontexteffekte, die durch nähere oder entferntere kategorische Relationen zwischen Begriffen hervorgerufen werden (Studie 1), um anschließend lose thematische Beziehungen zu untersuchen, die mit alltäglichen Ereignissen verbunden sind (Studie 2 & Studie 3). Um die hochgradig verflochtenen Ebenen der lexikalischen und semantischen Verarbeitung voneinander zu trennen, habe ich ereigniskorrelierte Hirnpotentiale (ERPs) eingesetzt, um die elektrophysiologischen Signaturen des konzeptuellen Primings und der lexikalischen Auswahl zu verfolgen.

Die vorliegende Arbeit liefert sowohl theoretische als auch praktische Beiträge. Erstens stützen unsere Ergebnisse die theoretischen Annahmen, dass sich semantisches Priming und lexikalische Interferenz vorübergehend überschneiden und gemeinsam das Benennungsverhalten in einem Trade-off beeinflussen. Auch die Gegenwart eines Kommunikationspartners kann Auswirkungen auf dieses Zusammenspiel haben. Zweitens ergänzen diese Ergebnisse die aktuelle Literatur zu verschiedenen Arten von semantischen Beziehungen, wie z. B. Nulleffekte für entfernte Beziehungen und Kontexteffekte, die systematisch mit der Stärke der Verwandtschaft zunehmen. Und schließlich bietet unser neuartiges Design eines kommunikativen Kontextes ein praktisches Instrument, um die Lücke zwischen Ein-Personen-Studien und Kommunikationsstudien zu schließen. Alles in allem tragen diese Ergebnisse zu einem besseren Verständnis der neuronalen Mechanismen unseres

Sprachproduktionssystems bei, das in der Lage ist, sich flexibel sowohl an sprachliche als auch an soziale Kontexte anzupassen.

Abstract

Speaking could be divided into two processes: first, the correct word must be retrieved from the mental lexicon, and then it is used in communication. To study the former process, single-person studies are often used, in which the microstructure of the lexical-semantic system is illuminated by observing reaction times to name stimuli (e.g., pictures). For the language use in communication, on the other hand, partner experiments are used to observe coordination between interlocutors and to explore how mutual understanding and biographical knowledge affect it. However, how a meaningful context brought by an interlocutor influences the established lexical-semantic effects from single-person studies remains underexplored. Within the scope of my dissertation, I aim to bridge the gap between these two research approaches by integrating a communicative context into well-established picture naming paradigms. To this end, I first investigate classic semantic context effects induced by close or distant categorical relations (Study 1), and then examine loose thematic relations associated with everyday events (Study 2 & Study 3). To separate the highly intertwined strata of lexical and semantic processing, I used event-related brain potentials (ERPs) to track the electrophysiological signatures of conceptual priming and lexical selection.

The present work makes both theoretical and practical contributions. First, our results support the theoretical assumptions that semantic priming and lexical interference temporarily overlap, and jointly modulate naming behavior in a trade-off. Such interplay may be greatly influenced by the presence of a communicating partner. Second, these findings add to the current literature on different types of semantic relations, such as null effects for distant relations and context effects that systematically increase with the strength of relatedness. Finally, our novel design of a communicative context provides a practical tool to bridge the gap between single-person studies and communication studies. All in all, these findings advance our understanding of the neural mechanisms of our speech production system, which is capable of flexibly adapting to both linguistic and social contexts.

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1 Introduction

Uttering a word to refer to an entity in the world, is a simple yet complex process that involves arousing related semantic concepts and their corresponding lexical representations. Our lexical-semantic system is the foundation of language, a unique ability that human beings are equipped with to communicate with one another efficiently and precisely. Speaking is so natural that, as we talk to each other, we seldom realize how our brain activates the lexical-semantic system to associate concepts with the context, thereby selecting the right utterances. What are the neural mechanisms underlying the lexical selection process? Does our brain respond differentially to naming a nightingale together with a crow, in contrast to naming a nightingale together with a fox? How does a communication partner possibly influence our speech planning process, in comparison with the process when we speak all alone?

In the present dissertation, I start with introducing evidence showing that our lexical-semantic system flexibly adapts to different linguistic contexts (section 1.1). Traces of such adaptations can be observed using three well-established picture naming paradigms to test how various types of semantic relations affect a speaker's naming latencies. Furthermore, I concisely describe the theoretical and computational models that have been proposed to account for the mechanisms underlying these effects. Next, I introduce a psycholinguistic theory of dialogue as a foundation of my research on the flexible adaptations of the lexical-semantic system to social context (section 1.2). As a linkage to conventionally single-person-based picture naming paradigms, I present evidence from communication studies and joint naming studies to highlight how interlocutors or task partners influence speech production. Then, I introduce two electrophysiological signatures of lexical-semantic processing, which I regard as indicators of conceptual-semantic priming and lexical interference, respectively (section 1.3). Lastly, I end the introduction with the aims of my dissertation, along with an outline of the present work (section 1.4).

1.1. Flexible Adaptations of the Lexical-Semantic System to Linguistic Context

1.1.1. Established Semantic Context Effects in Picture-Naming Paradigms

Most often documented in the categorical/taxonomic relations, *semantic context effects* serve as an index of altered activations in the lexical-semantic network. Previous research has proposed that conceptual and lexical processing takes place around 200ms after stimulus onset, and supporting evidence accumulates by examining semantic context effects (e.g., Costa et al., 2009; Levelt, 1992; Levelt et al., 1999; Piai et al., 2014; Strijkers et al., 2010). Measuring semantic context effects provides a practical way to investigate mental chronometry of lexical selection during speech production, because such effects emerge as facilitation or interference depending on the linguistic context in which a target picture is named. By manipulating the naming context, e.g., presenting simultaneously or in rapid succession either categorically related or unrelated items, relatively slower or faster naming responses are observed when contrasting the semantic conditions, respectively. The longer or shorter naming latencies reported for different naming conditions are the so-called semantic context effects.

In this section, I will introduce three well-established picture naming paradigms in the field, which all aim at investigating semantic context effects, albeit they manipulate naming contexts in different ways. By laying out the basic designs and characteristics of the context effects induced in each paradigm, I aim to build a foundation for theoretical explanations, choice of methods and further arguments that are crucial in my dissertation projects.

The first semantic context paradigm to be introduced is the picture-word interference (PWI) paradigm (e.g., Damian & Bowers, 2003; Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Hantsch et al., 2005; Hutson & Damian, 2014; Mahon et al., 2007; Piai et al., 2014; Rose et al., 2019; Schriefers et al., 1990; Vigliocco et al., 2004). In each trial of this task, participants are instructed to name a picture while ignoring a distractor word, which is displayed either visually or auditorily with different stimulus onset asynchrony (SOA). Semantic context effects arise when a distractor word belongs to the same taxonomic category of the to-be-named picture, consistently reported across studies, as interference effects. That is, participants take more time to correctly name the same picture (e.g., *dog*) when presented with a related distractor word (e.g., *cat*) compared to an unrelated distractor word (e.g., *pen*).

Featuring relatively simple naming due to its repetitive nature of a small stimulus set, the blocked-cyclic naming task (sometimes referred to as the semantic blocking task) is another widely applied context paradigm (e.g., Belke, 2008; Belke et al., 2005; Damian & Als, 2005; Damian et al., 2001; Kroll & Stewart, 1994; Navarrete et al., 2012; Schnur et al., 2006; Vigliocco et al., 2002). Participants are instructed to name a set of pictures in close succession in repeated (typically five) cycles. A naming block consists of pictures either taxonomically related or unrelated to one another. Since unrelated picture sets are typically composed of members recombined from the related sets, the former is also referred to as the categorically heterogeneou*s* condition (e.g., fruit: *apple,* fish: *shark,* jewelry: *brooch,* seats: *couch,* farm tool: *plough*) and the latter as the homogeneous condition (e.g., fruit: *apple, pear, cherry, grapes, tangerine*). An intriguing observation is that semantic context effects (also known as semantic blocking effects in this task) arise as interference from the second presentation cycle onward, whereas in the first cycle, findings are less consistent. In contrast to the reliably replicated semantic interference reported in later cycles, either no effects or facilitation has been reported for the first cycle (e.g., Abdel Rahman & Melinger, 2011; Crowther & Martin, 2014; Navarrete et al., 2012; Janssen et al., 2015). Thus, when referring to semantic interference effects in the blocked-cyclic naming task, the first cycles are typically not considered.

Yet another semantic context paradigm that has been increasingly applied in speech production research is the continuous naming task (e.g., Belke, 2013; Belke & Stielow, 2013; Costa et al., 2009; Howard et al., 2006; Navarrete et al., 2010; Rose & Abdel Rahman, 2017). Similar to the blocked-cyclic naming task, participants are instructed to name pictures as quick and accurately as possible in close succession; however, in the continuous naming task, taxonomically related picture sets are not presented in blocks, but interleaved with one another together with unrelated filler items. For instance, when participants name a series of pictures *apple*, ***chain***, *couch, gorilla, pear, ruler,* ***armlet***, *cherry, train,* ***earring***… etc., they are, in fact, naming two sets of pictures in taxonomic relations "fruit" and "jewelry", plus intervening filler pictures that belong to neither taxonomic category. When naming categorically related pictures, participants' naming latencies increase linearly as the number of items in a given category (i.e., ordinal position within a picture set) increases. Such ordinal position effect reported in this paradigm is known as *cumulative semantic interference* (CSI). Cumulative interference effect is robust, unaffected by the number of lags (be it filler items or items from the other taxonomic category) inserted between two members from the same category.

Having described the essential features and characteristic effects of the three semantic context paradigms, I have not yet touched upon possible explanations for this phenomenon occurring in speech production that, at first sight, seems counter-intuitive. Why is our response delayed when naming semantically related items? Should our speech production system not be designed to aid communication, which most often happens under a meaningful – thus semantically related – context? Although these questions might seem too large to answer at this point, in the next section (1.1.2), I will take a small step further to present different theoretical and computational models that have been proposed, in order to account for the cognitive mechanisms of semantic context effects.

1.1.2. Theoretical Explanations for Semantic Context Effects

The mechanisms behind semantic context effects have been explained by the activation spread within the structure of a lexical-semantic network. It is commonly assumed that mental processing of word production proceeds in several stages, with the initial two stages being semantic-conceptual preparation and lexical retrieval (e.g., Dell, 1986; Howard et al., 2006; Indefrey & Levelt, 2004; Levelt et al., 1999; Nozari & Hepner, 2019; Roelofs, 1992, 2018). Take naming a llama for instance. One initiates semantic-conceptual preparation, which involves activating semantic concepts (e.g., llama, horse, camel etc.) and features related to the target word (e.g., MAMMAL, WOOL, HOOVES, FOUR-LEGGED etc.). These semantic representations further activate one another's corresponding lexical representation, resulting in a co-activated lexical cohort (i.e., *llama*, *horse*, *camel*). The target lexical representation *llama* is finally selected among all co-activated lexical candidates for further processing such as morphological and phonological encoding.

Although the large-scale activation spreading from conceptual to lexical level has been commonly accepted across theoretical frameworks, the exact mechanism of selecting the final target lexical representation is still under debate. There are currently two main perspectives in the field attempting to explain semantic context effects (mainly interference): one holds the view that lexical selection is competitive by nature, while the other holds the view that lexical competition is not necessary to elicit the observed interference effects. Below, I will first introduce the competitive view of lexical selection, and describe how the reported semantic facilitation and lexical interference in different naming paradigms is addressed under this framework. I will end this section with the non-competitive view of lexical selection.

A basic assumption of lexical selection, according to the competitive view, is that co-activated lexical candidates compete with the target lexical representation; in the end, the most strongly activated lexical representation is ultimately selected for articulation (e.g., Howard et al., 2006; Levelt et al., 1999; Roelofs, 1992, 2018). In the computational model WEAVER++ implemented by Roelofs (1992; 2018), the activations occurring between any two representations are set as bi-directional, spreading through the whole lexical-semantic network via connections between conceptual and lexical representations. This computational model functions based on an activation equation and a selection ratio. The activation equation takes into account the sum of activations of co-activated lexical cohort to determine the activation level of a given representation. Critically, the selection ratio (referred to as *Luce ratio*) assures that the probability of the target lexical representation being selected depends on the activation state of the co-activated cohort. Originally proposed to account for semantic context effects in the PWI task, the WEAVER++ has been extended to explain the findings also in the continuous and blocked-cyclic naming paradigms, by including a term of conceptual bias (Roelofs, 2018). The inclusion of priming mechanism agrees with another computational model proposed by Howard and colleagues (2006). This model assumes excitatory one-directional feed-forward link from conceptual to lexical level, and inhibitory links between lexical representations. Once the link between the conceptual and lexical representation of a target gets strengthened after a successful selection (priming), the upcoming selection of the next target gets delayed due to the strongly activated, but to-be-suppress previous target. In short, although differ in details, both computational models assume facilitatory conceptual priming, and interfering lexical selection.

Based on empirical and computational evidence, it seems probable that semantic context effects in picture naming paradigms result from combined effects of semantic priming and lexical interference. The Swinging Lexical Network account (SLN; Abdel Rahman & Melinger, 2009, 2019) builds upon this basis and intends to explain not only semantic interference, but also semantic facilitation reported for certain types of semantic relations. This theoretical model assumes, firstly, a cohort of co-activated lexical competitors, and secondly, a trade-off between conceptual facilitation and lexical competition that temporarily overlap in each naming trial. That is, the polarity of the net effects observed in naming latencies results from either facilitatory conceptual priming outweighing interfering lexical competition, or vice versa. Crucially, the size of an activated lexical cohort determines the final polarity of semantic context effects. For instance, in later presentation cycles of the blocked-cyclic naming task, naming a set of categorically related items in the homogeneous blocking condition activates a large cohort of lexical candidates, whereas naming a set of unrelated items in the heterogeneous condition does not. In the related condition, a strongly activated lexical cohort delays the selection process because facilitatory conceptual priming decays fast, while lexical interference persists, leading to an interference-dominant situation. In contrast to the typically reported interference effects in later cycles, the facilitation sometimes observed in the first presentation cycle probably arises due to easier object recognition. Here, the homogeneous semantic context gives conceptual priming an upper hand over lexical competition, creating a facilitation-dominant situation, and thus reveals in the behavioral response as semantic facilitation. The SLN model intends to provide a parsimonious account for the semantic context effects observed for various semantic relations in different context paradigms, on which I will elaborate further in the next section (1.1.3).

Before introducing the context effects elicited by different types of semantic relations, I would like to turn to non-competitive accounts of lexical selection. This view generally does not assume lexical selection to be competitive, but argues that the observed delays in naming responses are due to paradigm-specific effects (e.g., Mahon et al., 2007; Navarrette et al., 2010; Navarrette et al., 2014), or proposes a mechanism of error-based learning to account for semantic interference effects (Oppenheim et al., 2010). Based on findings in the field of memory research, Oppenheim and colleagues (2010) regarded semantic interference effects as a manifestation of *retrieval-induced forgetting* (RIF): A person is impaired in retrieving the episodic memory of a word if she had previously retrieved a memory related to it. Accordingly, they proposed a computational model, the dark side (of incremental learning) model, which implemented lexical selection process with three algorithms: lexical activation, lexical selection, and learning. In a two-layered network without lateral connections, activation spreads from semantic features one-directionally to lexical representations with different weights; such connections can be excitatory or inhibitory depending on relatedness. In the selection stage, a winner-take-all process is applied by a booster that nonlinearly increases network activations, until one lexical representation wins out. Lastly, weights between semantic and lexical layers are adjusted in a way that the connections for the target get strengthened, while connections for all other candidates get weakened. Within this framework, lexical selection does not depend on the activation state of co-activated candidates, and the observed interference effects result from the error-driven incremental learning mechanism that is competitive by nature.

1.1.3. Effects of Semantically Distant and Non-Categorical Relations in Debate

In the previous two sections, I have laid out established semantic context effects reported in three different picture naming paradigms, and elaborated on cognitive and computational models that are proposed to account for such effects. However, there are diverse semantic relations apart from the relatively well-investigated taxonomic/categorical relations. Notably, semantic context effects can be inhibitory or facilitatory, depending on the type of semantic relation in question, and the context paradigm applied for investigation. While categorically related concepts are defined as having overlapping semantic features (e.g., *cow* and *horse* share features such as FOUR-LEGGED and FUR), associative relations are closely linked without sharing semantic features (e.g., *mouse* and *cheese*). Similar to associative relations and often referred to in the literature interchangeably, thematic relations also do not necessarily share semantic features, but very often co-occur in a specific context (e.g., *bee* and *honey* usually appear together in the context of an apiary). How humans process these diverse relations is particularly worth investigating, because the world we live in is composed not only of taxonomic memberships, but also of beings that co-occur under certain event contexts.

To better understand the extent to which semantic context effects are modulated by various types of relations, I will start with investigating different degrees of relatedness within taxonomic relations, i.e., semantic similarity effects. Words which share more semantic features under the same taxonomy, such as *horse* (FOUR-LEGGED, ANIMAL) and *sheep* (FOUR-LEGGED, ANIMAL), are semantically more similar than words that share fewer features, e.g., *horse* and *shark* (NO LEGS, ANIMAL). Previous studies using the PWI paradigm to examine how semantic similarity influences semantic context effects showed inconsistent findings: some studies reported enhanced lexical interference for semantically close versus distant distractor words (e.g., Aristei & Abdel Rahman, 2013; Rose & Abdel Rahman, 2019; Vigliocco et al., 2004), others reported the opposite pattern (e.g., Mahon et al., 2007), and yet others reported an effect of semantic relatedness regardless of similarity (e.g., Hutson & Damian, 2014). Studies using the continuous naming task reported, on the other hand, cumulative interference only for semantically close items (e.g., Rose & Abdel Rahman, 2017). Lastly, studies using the blocked-cyclic naming paradigm reported graded context effects, with close relations inducing enhanced facilitation in the first cycle (e.g., Navarrete et al., 2012, Experiment 1 & 2) and enhanced interference in later cycles (e.g., Vigliocco et al., 2002). In a nutshell, across paradigms, close relations typically elicit context effects, whereas distant relations often do not, or induce weaker/stronger effects. Accumulating evidence suggests that the number of feature overlap among related items influences the strength of the context effects, and a minimal number of overlaps might be required to surpass an arbitrary threshold.

Crossing from semantic similarity within taxonomic relations to semantic relations based on co-occurrence, associative/thematic relations provide us insights into the flexibility of the speech production system. In contrast to the reliably observed interference effects induced by (close) categorical relations, the semantic context effects induced by associative relations remain rather inconsistent. Previous studies either reported no effects, or *facilitation*, on participants' naming responses for associated distractors in the PWI paradigm (e.g., Abdel Rahman & Melinger, 2007, Experiment 3; Alario et al., 2000; Costa et al., 2005; de Zubicaray et al., 2013; Wong et al., 2017). Studies using the blocked-cyclic naming paradigm reported a different pattern: although the associative context effects were sometimes absent (e.g., de Zubicaray et al., 2014; McDonagh et al., 2020), some studies found interference effects (e.g., Abdel Rahman & Melinger, 2007, Experiment 1 & 2; Aristei et al., 2011), which was then comparable to effects elicited by categorical relations. Furthermore, continuous naming paradigm also demonstrated associative context effects which were similar to categorical context effects, i.e., cumulative interference (e.g., Rose & Abdel Rahman, 2016). In short, aside from the PWI task, where facilitation instead of interference was observed, associative relations generally induce, if any, effects that are similar to the ones induced by categorical relations.

The slower naming behavior observed for associates in both continuous naming and blocked-cyclic naming tasks seems to suggest the same underlying mechanisms of lexical access for categorical as well as associative/thematic relations. However, it is an ongoing debate whether associative relations *really* elicit semantic context effects. The doubt on the validity of the effects stemmed from the experimental stimuli that were not well-manipulated: in some cases, stimuli of the studies that found associative interference (e.g., Abdel Rahman & Melinger, 2007; Aristei et al., 2011) actually had overlapping semantic features, and the reported effects could not be replicated after controlling for this covariate (de Zubicaray et al., 2014). Moreover, pursuing a double dissociation between categorical and associative relations, a recent study applied objective measures of semantic similarity to select stimuli, and reported no evidence of associative context effects (McDonagh et al., 2020).

In response to these inconsistent findings in the blocked-cyclic paradigm, a study adopting the continuous naming design reported associative interference reliably with three experiments (Rose & Abdel Rahman, 2016). Specifically, cumulative associative interference was observed when categorical relations were partially involved, and when categorical relations were totally replaced with associative relations. The authors thus argued that the continuous design is particularly well-suited to reveal associative interference, which is weaker than categorical interference, compared to the blocked-cyclic design. In a continuous naming task, two assumptions are made: first, the amount of conceptual-semantic priming induced by each named related item stays the same across members; second, the amount of lexical interference accumulates with each related item. The combined context effects should therefore reveal as increasing net naming times, i.e., the behavioral cumulative interference effects. In contrast, in a blocked-cyclic naming task, the supposedly cumulating lexical interference is cancelled out by the strong conceptual priming coming from the small, repeated cycles, resulting in a stable amount of interference throughout naming cycles. Crucially, the enhanced semantic priming could lead to elimination of weak lexical interference, such as the one elicited by associative relations. To sum up, more evidence is needed to disentangle the cognitive mechanisms of associative relations, especially using different context paradigms.

A special case of non-categorical relations is what I will refer to as *(very) loose event relations* in my thesis. Semantic categories can be spontaneously formed between items that, without situational information or event knowledge, are regarded as unrelated to one another. Such situation-dependent relations can be formed in order to achieve a goal under certain situations (e.g., things to take on a camping trip; Barsalou, 1983), or due to a specific event arousing real-world knowledge provided by a discourse (e.g., playing in a snow; Metusalem et al., 2012). Loose event relations have been shown to induce semantic context effects similar to the ones elicited by categorical and associative relations in a blocked-cyclic naming paradigm (Abdel Rahman & Mellinger, 2011). Crucially, participants showed lexical interference when naming homogeneous blocks (e.g., *ropes, nest, llama, bone*, and *ice cream*) after reading thematically congruent titles (in this case, "zoo"), but not after reading incongruent ones (for instance, "visit to the doctor"). It seems that a situation-related title served as a cue to bind the items into a meaningful context, and thus eliciting *ad-hoc context effects*. Therefore, loose event relations provide evidence that our semantic system is highly flexible, and lexical-semantic activations spread beyond hard-wired storage of relations in long-term memory. Most importantly, the dynamic shifting in strength of relatedness provides a basis for what we see in real-life, enabling us to get involved in social interaction - which is the main focus of the following section.

1.2. Flexible Adaptations of the Lexical-Semantic System to Social Context

1.2.1. The Interactive Alignment Model in Conversational Setting

Speaking is social by nature. Language is a symbol system that human beings developed to better communicate with each other. The social aspect of language use implies a flexible speech production system, with which a person can easily adapt to an interlocutor in order to engage in a conversation. To achieve a successful dialogue, conversational partners work together through verbal exchange to develop a mutually-shared mental representation of the topic being discussed (Clark, 1996; Pickering & Garrod, 2004). Such representations of a described state of affairs are known as *mental models* (Johnson-Laird, 1983), or *situation models* (van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998), which have been investigated substantially in language comprehension and memory studies. Building from a discourse through language comprehension, situation models are semantic constructs that incorporate multi-dimensional representations such as spatial, temporal, causal, motivational and person/object-related information (Johnson-Laird, 1983; Zwaan & Radvansky, 1998). Since a dialogue involves two interlocutors who take turns conveying and receiving messages, the formation of a common situation model, or at least two situation models that are somehow synchronized to be very similar, seems to be crucial for mutual understanding.

A cognitive account of dialogue, the Interactive Alignment Model (Pickering & Garrod, 2004), proposes that alignment occurring at low-level linguistic representations is the building stone for alignment at the highest cognitive level of dialogue, i.e., situation models. A basic assumption underlying this account is similar mental representations of both speech comprehension and production. Importantly, a tight coupling between the two processes leads to an automatic alignment of linguistic representations. Evidence of syntactic alignment in dialogue was reported in a study where participants took turns describing pictures to each other (Branigan et al., 2000). In this study, a confederate played by an experimenter produced scripted responses with different syntactic constructions (e.g., "the cowboy offering the banana to the robber" versus "the cowboy offering the robber the banana"), and participants were observed to be more likely to use the same construction as their interlocutor in the subsequent speech. As another example, alignment happening at the level of articulation was reported in a study where participants shortened expressions (reduced to the extent that the utterance became difficult to recognized if heard in isolation), after hearing repetitions of the same expressions by their interlocutor, but produced the expressions the first time by themselves (Bard et al., 2000). These findings indicated interactively aligned linguistic representations between conversational partners. The successful alignment at one level most likely facilitates alignment on another processing level, until the alignment of situation models is achieved, thereby realizing mutual understanding.

Based on the Interactively Alignment Model, conversational partners should also align in co-activated lexical-semantic representations, corresponding to the common situation model that is shaped throughout the dialogue. Linking back to the loose event relations that are capable of inducing ad-hoc context effects, this type of semantic relation that strongly depends on situational context serves as a practical tool for investigating alignment between interlocutors. Successful alignment of lexical-semantic representations can be clearly demonstrated by ad-hoc semantic context effects elicited due to the shifting from loose to strong relatedness, given a meaningful context provided by an interlocutor. From the observable context effects that indicate alignment at the lexical-semantic level, one can infer an alignment of situation models between conversational partners, which is, by nature not directly assessable.

In my thesis, the Interactive Alignment Model provides a useful framework to examine how the semantic information communicated by a conversational partner comes into play during a speaker's speech planning. Nevertheless, this work does not aim to test the alignment of situation models *per se*, but to shed light on how the lexical-semantic system is influenced by a communicating partner and its implications in real-life scenarios.

1.2.2. Evidence from Communication Studies and Joint Naming Studies

Apart from cognitive-psychological accounts of dialogue, how a social context shapes the behavior of producing language has been studied over decades in communication studies. In fact, the studies of communication build the basis for investigating the cognitive process of speech production in a conversational context. One of the most important concepts in dialogue, mutual/shared knowledge (Grice, 1957; Lewis, 1969; Schiffer, 1972) or *common ground* (Clark, 1996), derives from observing language use in communicative context and analyzing discourse accordingly. This line of research examines how interlocutors build upon previous conversation with the same partner, and collaboratively develop a shared understanding of the topic under discussion (e.g., Clark & Brennan, 1991; Clark, 1996).

In the process of forming a common ground, interlocutors are more likely to re-use the same referring expressions (among other possible choices), which is a phenomenon coined as *lexical entrainment* (Brennan & Clark, 1996). Lexical entrainment is proposed to result from a *conceptual pact* (Metzing & Brennan, 2003) – a temporary, flexible agreement between interlocutors to think about the topic of the conversation in a particular way – which has been shown to be partner-specific. That is, if a new interlocutor steps into the conversation, the conceptual pact is broken and needs to be re-build. The evidence suggests that conversational partners form flexible agreements on single lexical entries. Taking a step further, there is reason to believe, based on the literature on lexical-semantic processing, that common ground or conceptual pacts have consequences not only for a single lexical entry, but also for the entire semantic network, within which a given lexical entry is embedded.

The accumulating evidence from cognitive psychology and communication studies point towards a flexible lexical-semantic system, which enables the formation of ad-hoc relations based on the common topic developed between interlocutors. A crucial factor that emerges from these studies is the presence of a communication partner. By introducing a partner (be it a conversational partner or a task partner) into experimental investigation of language production, we could better understand how speakers produce language in real-life communicative situations.

Recent studies have investigated cognitive processes of language production in social context by using different indexes of lexical processing under a situation that involves a partner. For example, participants were reported to show indication of stronger word frequency effects in a joint-naming task, and most interestingly, co-representation of lexical retrieval when it was their partner's turn to name the pictures (Baus et al., 2014). Besides, joint interference effects in naming were reported, and were proposed to be due to participants' belief whether the partner is going to speak, instead of what they are going to say (Gambi et al., 2015). In a joint continuous naming task, participants not only encountered cumulative interference in the trials where they performed the task (go-trials), but also in the trials where their partner performed the task (partner-go trials; Hoedemaker et al., 2017; Kuhlen & Abdel Rahman, 2017). Nevertheless, such co-representation does not need to be fully incorporated into participants' own planning of speech to achieve effective coordination, when all to-be-named items were shown at once and participants took turn doing the naming task with a partner (Hoedemaker & Meyer, 2019). Still, while participants prioritized their own responses over attending to the partner's task, eye tracking data from the same study suggested that they did fixate more on items to be named by the partner than task-irrelevant items.

All in all, studies involving two task partners to perform joint-naming tasks demonstrate that a speaker takes into account their communication partner's naming behavior, or lexical-semantic representations (at least to some extent), to achieve successful coordination. Co-representing a partner's task as if it were one's own task provides evidence for common ground in dialogue, and an aligned situation model in the framework of Interactive Alignment Model. What remains less explored, however, is how semantic information communicated by a task partner influences a speaker's own lexical-semantic network topic-wise, building a meaningful context that is crucial for dialogue. Before I lay out the aims of the present thesis, I will introduce two electrophysiological indicators that I applied in my studies in pursuit of fine-grained temporal resolution of the semantic context effects, and indications of the functional architecture of lexical-semantic processing.

1.3. Electrophysiological Indicators of Lexical-Semantic Processing

Electroencephalogram (EEG) has been applied by researchers to track the functional architecture and time course of lexical retrieval. Measuring electrical activities on the scalp when participants perform naming tasks, EEG is a non-invasive method that provides precise temporal information of brain responses in milliseconds, which is particularly suitable for capturing impressively rapid cognitive processing such as lexical retrieval. Specifically, event-related potentials (ERPs), namely stereotyped electrophysiological responses to experimental stimuli, are taken as indexes of specific cognitive events. In this section, I will first present a basic assumption of the cognitive framework of lexical retrieval adopted in this thesis. Then, I will turn to a brief introduction of the two electrophysiological indicators that are evidenced to reflect conceptual-semantic priming and lexical interference, respectively.

One of the basic assumptions of the Swinging Lexical Network account (Abdel Rahman & Melinger, 2009, 2019) is that conceptual priming and lexical selection proceed in parallel. Furthermore, the former facilitates naming while the latter makes naming more difficult. Crucially, these two processes are assumed to be in a trade-off, such that the final direction of semantic context effects is determined by the one that dominates. It is important to note that, parallel processing, also referred to as concurrent activation, does not necessarily mean that both processes begin and end at the same time (for similar arguments of parallel processing, see Abdel Rahman & Sommer, 2003; Abdel Rahman et al., 2003; Feng et al., 2021; Strijkers et al., 2017). Instead, this account assumes continuous spread of activation both within and between the levels of conceptual and lexical processing. To be more specific, conceptual activation is initiated before lexical activation, yet does not stop when lexical activation begins. Rather, a period of time exists when both processing levels are co-active and actually interact with each other. It is during this period of overlapping activation and interaction when the assumed trade-off between facilitation and interference takes place.

1.3.1. Indicator of Conceptual-Semantic Priming (N1)

One way to trace the electrophysiological signature of conceptual-semantic priming is to examine an established ERP component that has been taken to reflect at least part of this conceptual process. Take the blocked-cyclic naming paradigm for example. Semantic context effects in the first presentation cycle, if any, typically emerge as initial facilitation. This has been argued to be strategic facilitation due to the application of large-block design instead of alternating design (e.g., AAAABBBB vs. ABABABAB; Belke, 2017), where participants would be aware of the current semantic category and predict upcoming category members. Semantic information from same-category members could have enhanced visual recognition of items from the same category (Abdel Rahman & Melinger, 2007; Aristei et al., 2011). Since semantic priming involves the process of enhanced object identification/recognition, ERP components that are associated with perceptual processing or visual complexity would be suitable indicators of conceptual-semantic activities.

Valente and colleagues (2014) identified an ERP related to visual complexity, from 140 to 180 ms after stimulus presentation, in a study that examined multiple theoretical predictors in an overt picture naming task. The time window of this early ERP falls within the range of the P1/N1 component, which have been conventionally associated with visual-conceptual processing (e.g., Schendan & Kutas, 2003). In fact, object recognition literature suggests a latency range of processing visually complex pictures below 200 ms after stimulus presentation (Thorpe et al., 1996). Moreover, the visual N1 is argued to be an indicator of a discrimination process applied to an attended location (Vogel & Luck, 2000) as well as object recognition learning (Tokudome & Wang, 2012). The regions of interest (ROIs) identified for object recognition process include electrodes at posterior sites, such as TP9/10, P7/8, PO9/10 and O1/2 (e.g., Itier & Taylor, 2004), which I adopted as a priori ROIs for my investigation.

1.3.2. Indicator of Lexical Interference (P2/N2)

Evidence for the precise timing when lexical interference takes place have been provided by studies investigating semantic context effects with the aid of EEG. Competitive accounts of lexical access predict early ERP modulations during this processing stage from 175 to 250 ms (Indefrey & Levelt, 2004; Indefrey, 2011; but see a critical review from Strijkers & Costa, 2011). Costa and colleagues (2009) reported a posterior positivity ranging from 200 to 380 ms after stimulus presentation, which correlated with the behavioral cumulative semantic interference. With accumulating evidence from the continuous naming and PWI paradigms (e.g., Rose & Abdel Rahman, 2016; Rose et al., 2019), such positive-going ERPs at posterior sites has been regarded as an index of lexical interference during overt picture naming.

Although electrophysiological evidence of lexical interference seems to converge for the continuous naming and PWI paradigms, the corresponding signature reported in the blocked-cyclic paradigm remains inconsistent. Critically, ERP modulations reported in this paradigm sometimes diverge from the other two context paradigms regarding the polarity of the effect. Nevertheless, studies using the blocked-cyclic design reported in a similar time period quite consistently enhanced ERP amplitudes at posterior sites for the related compared to unrelated condition, which was associated with the semantic blocking effects (with some exceptions where no related ERPs were found or in a later time window, e.g., Janssen et al., 2011, 2015; Llorens et al., 2014; see de Zubicaray & Piai, 2019 for a comprehensive review).

Aristei and colleagues (2011) incorporated a PWI task into a blocked-cyclic task and found an enhanced negativity for related blocks compared to unrelated blocks, starting between 200 to 300 ms after picture presentation. Since this ERP was modulated by the semantic blocking conditions, this posterior negativity was proposed to reflect the process of lexical interference (cf. an MEG study from Maess et al., 2002 that reported similar results). In contrast, a recent study of Wang and colleagues (2018) reported a posterior positivity for related versus unrelated blocks starting from 200 ms after picture presentation. Despite the inconsistent findings concerning effect polarity, both ERPs look temporally and topographically similar. Thus, following Aristei and colleagues' finding, I selected a priori electrodes at the temporal-parietal sites, TP9 and TP10, as the ROI for my investigation into the mental chronometry of lexical interference during speech planning.

1.4. Aims and Outline of the Present Work

The overarching aim of this doctoral thesis is to explore how a speaker's lexical-semantic system adapts flexibly to social and linguistic context. I started with examining the classic semantic context effects elicited by experimental stimuli with different levels of semantic relatedness, in order to lay the ground for the investigations of loose event relations in a communicative setting. This doctoral thesis consists of three studies, which I will concisely summarize below to draw the outline of my thesis, and elaborate further in the next chapter:

- Using a blocked-cyclic naming design in Study 1, I aimed to investigate whether semantic similarity modulates semantic context effects on a graded basis. This study also aimed to trace the mental chronometry of lexical selection using EEG to address theoretical assumptions of the underlying mechanisms.
- Study 2 introduced a novel design that implements the classic single-person blocked-cyclic naming paradigm in a communicative context. With this, I aimed to investigate whether a speaker incorporates information communicated by their task partner into the lexical-semantic system during speech planning.
- Study 3 originally aimed to validate the communicative naming design of Study 2 in the continuous naming paradigm, and to replicate the reported ad-hoc context effects induced

by a task partner. Unexpectedly, robust cumulative semantic interference was reported even if participants did not receive related event knowledge when naming loosely-related objects. Motivated by this paradigm's high sensitivity to loose event relations, I set out to investigate whether a systematic relationship exists between the strength of semantic relatedness and the strength of cumulative semantic interference.

In the following sections, I will first summarize the three original research articles and highlight the most important findings (section 2.1 – 2.3). Then I will continue with the implications from my three studies, and discuss how they can address issues crucial to the investigation of lexical-semantic processing in different linguistic and communicative contexts (section 3.1 – 3.3). Finally, I will end the doctoral thesis with the conclusions drawn from my own work, and lay out an outlook for future studies in this field (section 3.4).

2 Summary of the Present Studies

2.1. Concurrent Semantic Priming and Lexical Interference for Close Semantic Relations in Blocked-Cyclic Picture Naming: Electrophysiological Signatures (Study 1)

In the first study, we employed event-related brain potentials to investigate effects of semantic similarity on lexical-semantic processing during speech production. The semantic similarity among tested stimuli was manipulated by controlling feature overlap within taxonomical hierarchies: closely-related objects (e.g. “eagle” and “owl”) belong to the same basic category (“birds”), while distantly-related objects (e.g. “eagle” and “shark”) belong to the same superordinate category (“animals”) but different basic categories (“birds” versus “fish”). Here we contrasted the close and distant naming conditions with the unrelated condition, respectively, as a measurement of semantic similarity modulation on categorical context effect in a blocked-cyclic design.

Based on competitive models of lexical access, our first hypothesis was that enhanced semantic similarity would lead to stronger semantic blocking effects, which should reveal as stronger semantic facilitation in the first cycle, and increased lexical interference in later cycles. Relating behavioral responses to brain activations, we expected an enhanced N1 (reflecting facilitated object identification) to accompany facilitation effect in the first cycle, and an enhanced P2/N2 (reflecting concomitant lexical competition) to accompany interference effect in later cycles. Lastly, assuming that conceptual and lexical processing occur in concurrence at each trial with opposite forces, we expected the two ERPs to be present both in the first and in later cycles. Crucially, these two ERPs should jointly modulate naming latency across all cycles – supporting the trade-off assumption between conceptual facilitation and lexical competition.

Behavioral and EEG data were acquired and analyzed from 24 healthy, right-handed, native German speakers with normal or corrected-to-normal visual acuity and normal color vision (18 females, mean age 23.8). During the preparation for EEG set-up, participants were familiarized with the stimuli by reading 125 color print photographs on sheets of paper, presented in random order together with their names. Prior to the experiment, participants were instructed to name pictures as fast and accurately as possible. On a screen with a light grey background, a fixation cross in the center indicated the start of a trial. After 0.5s, a picture was presented for maximally 2s, or disappeared as soon as the voice key was triggered. A blank screen followed and lasted for 1s until the next trial started. Participants named stimulus sets (each exemplar represented by a unique picture) in five repeated cycles, blocked in semantically close (exemplars from the basic categories), distant (an exemplar from each basic category of a superordinate category), or unrelated conditions (an exemplar from each superordinate category). The order of semantic blocking conditions was counterbalanced across participants. The order of the stimulus sets within each condition and the order of the exemplars within a cycle were both randomized. Continuous EEG signals were recorded online during the whole experimental session with 62 Ag/AgCl electrodes, arranged according to the extended 10/20 system.

To study the modulation of semantic similarity on categorical context effect, linear mixed effects models were separately run for the analyses of the first and later cycles due to our specific hypotheses that categorical blocking effects would arise in different directions, i.e., facilitation for the former and interference for the latter. Models were run to predict the dependent variable log-transformed naming latencies and the mean activations of N1 and P2/N2, respectively. We entered into the models as fixed effects the critical factor Semantic Blocking (*close vs. unrelated*; *distant vs. unrelated*), and, for the analyses of later presentation cycles, the control factor Presentation Cycle (*cycles 2-5*), and their interaction term. The random structures were determined following the practice of identifying maximal informative models (cf. Bates et al., 2015). Finally, three additional models (investigating close, distant and unrelated condition separately) were conducted to study the predictive relationship between ERPs and naming responses. To achieve this, we entered the mean ERP amplitudes occurring in both early and late time windows as fixed effects to predict log-transformed naming latencies. Furthermore, to examine whether participants' naming behavior was jointly modulated by concurrent processing of conceptual priming and lexical competition, we entered the interaction term between the two ERPs as another fixed effect into the models.

The outcome of the models showed that only closely-related items, but not distantly-related items, induced semantic blocking effects. In the first cycle, naming was facilitated, and amplitude modulations in the N1 component around 140-180ms post-stimulus onset predicted this behavioral facilitation. In contrast, for cycles 2-5, naming was delayed, and a negative-going posterior amplitude modulation around 250-350ms post-stimulus onset (i.e., P2/N2) predicted this interference. These findings indicate easier object recognition or identification underlying initial facilitation and increased difficulties during lexical selection when naming closely-related items. The finding that N1 modulation persisted in later cycles in which interference dominated, and the posterior negativity was also present in the first cycle in which facilitation dominated, demonstrated concurrent effects of conceptual priming and lexical interference. Moreover, the joint modulation of these two ERPs on naming latency exclusively emerged in the close condition, supporting the trade-off hypothesis that the behavioral context effect results from two opposite forces.

In sum, this study demonstrates that close relations induce stronger semantic blocking effects, and that concurrent electrophysiological signatures reflect the overlap and trade-off between conceptual priming and lexical competition, which together determine the final direction of the behavioral blocking effects.

2.2. Ad-Hoc Thematic Relations Form Through Communication: Effects on Lexical-Semantic Processing During Language Production (Study 2)

While the first study focuses on how semantic similarity modulates semantic context effects within categorical relations, the second study crosses the border to loose event relations (in this study, the term is used interchangeably with thematic relations), aiming to study loosely related objects whose relationships most likely become clear for a speaker if they are provided with relevant event-knowledge from a task partner (e.g., "ice cream", "bone" and "llama" become interrelated once the event "visiting a zoo" is revealed). Specifically, here we embedded the single-person blocked-cyclic naming paradigm in a simulated communicative context, in order to investigate whether a piece of personal experience conveyed by a task partner successfully reveals such ad-hoc relations between objects. To assess the narrative-effects, we let participants watch a task partner narrating a short story about a personal experience, and then name objects that either become meaningful under the given event context or not.

The formation of ad-hoc thematic relations driven by the direct verbal priming suggests a high flexibility of the speech production system (e.g., Abdel Rahman & Melinger, 2011), which may form the basis for successful communication in real-life, e.g., mutual understanding in conversation (cf. Clark, 1996; Pickering & Garrod, 2004). Based on the evidence isolated from social or communicative contexts, we proposed that a speaker integrates a conversational partner's speech dynamically into their own semantic network activation and lexical selection. We hypothesized that the partner's narrative not only establishes thematic relations between entities that were mentioned (e.g., passing by the aviary, going to the petting area, watching the tiger feeding), but crucially, also between entities *not explicitly mentioned* but associated with that particular theme (e.g., nest, llama, bone; corresponding to the mentioned entities).

We predicted that the formation of ad-hoc relations would induce a semantic blocking effect when a set of loosely related objects are named, even if they were not directly mentioned in the narrative.

This study consisted of three experiments, which were all pre-registered under the Open Science Framework (Lin et al., 2018a, b). The goal of Experiment 1 ($N = 32$; 24 females; mean age 24.2) was to establish the novel experimental protocol designed to detect the existence of ad-hoc formation of thematic relations induced in a communicative context. The goal of Experiment 2 ($N = 32$; 20 females; mean age 31.9) was to replicate the novel findings of a semantic blocking effect resulting from the narrative-induced ad-hoc thematic relations. The goal of Experiment 3 ($N = 32$; 23 females; mean age 29) was to control for alternative explanations for the hypothesized narrative-induced semantic blocking effect; here we replaced task partners' narratives with unrelated narratives whose theme was incongruent with the loosely related picture sets.

In all three experiments, participants were asked to name the pictures aloud for their presumably remotely located task partner, so that the partner could supposedly recall these objects later on. Participants were familiarized with the stimulus pictures by naming the objects one by one on a monitor, and were instructed to name the pictures as fast and as accurately as possible later on. The experiment started with participants watching a video of their partner narrating a personal event (e.g., a visit to the zoo). Each trial began with a fixation cross for 0.5s, followed by a stimulus picture that was presented until the participant responded or for a maximum of 2s. Naming latencies were registered with a voice key. A blank screen was presented for 1.5s before the next trial started. Each narrative video was followed by two blocks of pictures, a homogeneous block (e.g., loosely related objects such as "ropes", "nest", "llama", "bone", and "ice cream" can all be associated with a visit to the zoo) and a heterogeneous block (e.g., unrelated objects such as "socks", "flower bouquet", "folding table", "bone", "balloon"; exemplars recombined from loosely related sets). Within each block, five pictures were presented in six cycles with randomized order per cycle. The block order was counterbalanced such that half of the participants first named the loosely related block and then the unrelated block of pictures, whereas the other half of participants did it the other way around. The same procedure was repeated five times, each time with a different task partner and narrative; the order of partner-blocks was counterbalanced.

To study whether a partner's narrative forms ad-hoc thematic relations among objects that were never explicitly mentioned to a participant, linear mixed effects models were run to test naming latencies as a function of thematic blocking condition. In all three experiments, we entered as fixed effects the critical factor Thematic Blocking (*loosely related vs. unrelated*), as well as two control factors Block Order (*related-first vs. unrelated-first*) and Presentation Cycle (*cycles 2-6*) into the models. The random structures were determined following the practice of identifying maximal informative models (cf. Bates et al., 2015). Extra models were set up to test whether covariates (interrelation of the picture sets, participants' belief in online interaction with partner and the realization of the loose relations between objects) interfere with our effects of interest. In all experiments, none of these covariates improved model fit.

Both Experiment 1 and 2 demonstrated semantic blocking effect for objects that were loosely related to the partner's narrative, which seemed to provide a unifying context, i.e., event-knowledge congruent with the underlying theme. Interestingly, the interference effect in later cycles emerged only when unrelated picture blocks were named before the related ones. When loosely related objects were named directly after the partner's narrative, lexical interference was greatly attenuated (Experiment 2), or even turned into facilitation (Experiment 1). Including naming latencies in the first presentation cycle, our exploratory analyses indicated that the block order effect was due to strong conceptual priming elicited by the narrative when participants named related blocks first (likely due to a large number of highly activated associates in the short-term memory, whose one-to-one mapping induced stronger conceptual priming over lexical competition; cf. Swinging Lexical Network, Abdel Rahman & Melinger, 2009; 2019). Such priming effect was stronger in participants with slower naming latencies, which could explain the absence of facilitation effect in Experiment 2, where participants were on average slower. Finally, replacing partners' narratives with incongruent topics, Experiment 3 confirmed that semantic blocking effect disappeared when objects cannot be related to the semantic information conveyed by partners.

To conclude, the present study introduces a novel design that implements a well-established picture naming paradigm from single-person into a communicative context, making a step further towards studying lexical access in social interaction. Furthermore, the results support the proposal that a speaker dynamically integrates the content of their partner's narrative into their own lexical-semantic network, establishing ad-hoc thematic relations. The greatly attenuated difficulties in naming that directly follows a partner's speech encourages further investigation in real-life conversation scenarios. All in all, our examination on a primary form of lexical-semantic alignment in a social-communicative context indicates a flexible speech production system, which enables a speaker to be rapidly tuned in to a conversation.

2.3. Robust Cumulative Semantic Interference for (Very) Loose Semantic Relations in the Continuous Naming Paradigm (Study 3)

Building upon the second study, which brings about implications on a speaker's lexical-semantic adaptation to a communication partner's narrative in a simulated social context, the third study aims to replicate this finding and validate the novel design with the continuous naming paradigm. Proposed to induce semantic context effects related to learning mechanisms, this paradigm has been used to reveal effects of non-categorical relations that may be difficult to observe in other context paradigms. Here, the term *covert condition* refers to the state of ad-hoc relations that were not primed by the common event-knowledge conveyed by a task partner, but could potentially form an ad-hoc semantic category if doing so; the term *overt condition* refers to their enhanced state of relatedness if explicitly primed by the common event-knowledge. A pre-study was conducted to ensure a successful manipulation of ad-hoc relations. Participants ($N = 32$) were asked to rate the semantic relatedness among objects loosely relating to an event, once before and once after reading the event title. Only those objects with significantly increased relatedness after title exposure were selected as picture stimuli.

In order to assess how semantic relatedness increases between objects once they become associated with an event conveyed by the communication partner, we added to the classic continuous naming task the following feature: In a partner-block (e.g. partner narrating a story about "visiting a zoo"), a participant named two picture sets, one associated with the partners' narrative (e.g., "ropes", "nest", "llama", "bone", and "ice cream" shifted from covert condition to overt condition), the other associated with a hidden narrative not revealed to the participant (e.g., "fish sticks", "compass", "lunch box", "blackboard", and "playground" remained in covert condition), plus additional intervening filler trials that were unrelated to both picture sets. We implemented this by randomly assigning participants to two groups that watched different versions of the same narrator's video, such that each narrator was associated with two distinct events ("visiting a zoo" or "elementary school"). We hypothesized that participants would form ad-hoc relations among items whose common event-knowledge was conveyed in the partner's narrative, resulting in cumulative semantic interference. In contrast, we expected no interference if the partner's narrative did not reveal the underlying common event of the items.

Participants ($N = 32$; 15 females; mean age 27.84) were informed prior to the experiment that they would be assigned the role of a teacher for eight learners involved in a virtual teaching program; their task was to name pictures for the remotely located learners for later recall. All picture stimuli were printed on paper and given to the participant for familiarization. Participants were instructed to name the pictures as fast and as accurately as possible in the experiment. At the start of the experiment, participants watched pre-recorded videos from eight task partners one after another. After video introduction of the partners, the naming sessions began. A snapshot of a partner was presented in the center of the screen, to which the participants responded orally the partner's name and the topic they had talked about. Each trial began with a fixation cross in the center of a light gray screen for 0.5s. A picture appeared and was presented until the naming response was registered (naming latency measured with a voice key), or else for maximally for 2s. A blank screen was then presented for 1.5s. The same procedure of the naming session was carried out with each task partner. In the end, participants completed a rating task to evaluate the relatedness among picture sets, carried out in the same way as the pre-study.

To study whether a partner's narrative shifted the semantic relatedness of ad-hoc relations to from low to high by providing a meaningful context, a linear mixed effects model was run to test naming latencies as a function of Event Context (*overt vs. covert*) and Ordinal Position (*position 1 to 5*). The interaction term between the two critical predictors was also entered into the model, along with the control predictor Repetition (*repetition 1 to 5*). The random structure was determined following the practice of identifying maximal informative models (cf. Bates et al., 2015). As a manipulation check, participants' relatedness rating was analysed in another linear mixed effects model as a function of Event Title (*before vs. after title exposure*) and Narrative Group (*matched vs. mismatched*). The former ascertained whether our manipulation of ad-hoc relations worked (confirming the pre-study), whereas the latter ascertained whether participants rated picture sets with matched narratives differentially from those with mismatched narratives.

Rather unexpectedly, we observed semantic interference both among objects with and without the integrating information of the partner's narrative. Crucially, the robust cumulative interference was found with target items regardless of event context, but not with filler items, supporting that the interference effects we observe are indeed semantic in nature. This data pattern suggests that the continuous naming task is sensitive to ad-hoc relations which typically are regarded as unrelated if no context is provided. Moreover, the post-experiment relatedness rating suggests that participants even did not consciously detect the semantic relation for those picture sets whose common event-knowledge was overtly given by their partners. With this surprising finding, we further explored the scope and limits of the cumulative semantic interference effect by relating our findings to other reports (Döring et al., 2021; Döring et al.,under review; Rose & Abdel Rahman, 2016, 2017) with different types of semantic relations, such as categorical and associative/thematic relations. To achieve this, we resorted to a distributional semantic model to estimate semantic relatedness (in cosine similarity) for the stimuli used across studies.

Our mega-analysis demonstrates that the degree of semantic relatedness positively correlates with the strength of semantic interference, indicating a systematic relationship between the two variables. The ad-hoc relations (prior to providing a unifying context) we employed in the present study shows the lowest degree of semantic relatedness among all studies that entered the analyses, whose estimated cosine similarity value was statistically indistinguishable from those of unrelated filler items. This confirms the relatedness rating in the pre-study and in the main study, reassuring that our pre-defined selection criterion of ad-hoc relation sets was valid. Corresponding to the low semantic relatedness, these ad-hoc relations also elicited the smallest cumulative semantic interference compared with associative and categorical relations. Such a systematic relationship supports the claim that the continuous naming paradigm is highly sensitive to the strength of semantic relatedness (Rose & Abdel Rahman, 2016), and is able to detect very weak semantic context effects. Crucially, this high sensitivity might have caused the effects of event context (i.e., partner's narrative) to become undetectable because the amount of cumulative interference elicited by ad-hoc relations was already sufficient even without a unifying context.

To summarize, in contrast to the second study, where we found narrative-elicited semantic interference in a blocked-cyclic paradigm, the present study did not find evidence that a speaker flexibly integrates the semantic information conveyed in their partner's speech into the lexical-semantic system. Instead, we found that cumulative semantic interference is so sensitive that it can even be induced by very loose ad-hoc relations without relevant context information. The present study sheds lights on the ability of the continuous naming paradigm to pick up very weak semantic context effects, which suggests that it is a useful tool to investigate non-categorical relations.

3 General Discussion

The findings from the present dissertation advances our understanding of the neural mechanisms of our speech production system, which is capable of flexibly adapting to both linguistic and social contexts. Evidence found in this work not only provides implications for theories of lexical selection, but also sheds light on important aspects of investigating speech production in communicative context. First, the findings support the theoretical assumption that semantic priming and lexical interference temporarily overlap, lending naming responses facilitatory and interfering effects, respectively, and jointly modulating naming behavior in a trade-off. Second, these findings add to both conclusive and inconclusive reports in the current literature with regard to different types of relations, such as null effects for distant relation and context effects that grow systematically with the strength of relatedness. Lastly, the findings address the gap between psycholinguistic research mostly focusing on single-person word production, and discourse analysis from communication studies that typically involve two interlocutors. In this chapter, I will discuss the above point-by-point, and finally, end this dissertation with an outlook to future research and challenges.

3.1. Concurrent Processing of Semantic Priming and Lexical Interference in Trade-Off

Study 1 empirically tested the theoretical assumption of a competitive model of lexical access, the Swinging Lexical Network account (Abdel Rahman & Melinger, 2009, 2019), that activations at the stages of conceptual-semantic priming and lexical interference temporarily overlap and together modulate naming. Specifically, semantic priming that facilitates naming is first initiated upon picture presentation. This was supported by a posterior N1 that falls in the time window before 200 ms after stimulus onset, which has been proposed to be indicating object identification process (e.g., Itier & Taylor, 2004; Schendan & Kutas, 2003; Thorpe et al., 1996; Tokudome & Wang, 2012; Valente et al.,2014; Vogel & Luck, 2000). Participants showed larger N1 when naming semantically close pictures compared to unrelated ones, and were faster to respond to the stimuli during the first presentation cycle in the blocked-cyclic design. Strijkers and Costa (2011) criticized that, researchers should not explicitly rely on the temporal maps proposed by theoretical accounts, such as Indefrey and Levelt's proposal (2004), to interpret mental chronometry of lexical selection because these maps are still hypothetical. One important concern is that the complexity of cognitive process could allow for alternative interpretations. Addressing this point, this study directly related brain responses to behavioral responses, demonstrating clearly that enhanced N1 predicted faster responses.

Finding that behavioral facilitation was predicted by an enhanced ERP component associated with easier object recognition, provides clear evidence of participants benefiting from semantic priming in the homogeneous closely-related context. When encountering the pictures for the first time, naming should be most difficult for participants because no prior knowledge about the upcoming stimuli is available. Thus, participants benefit more from the related context than unrelated context in a top-down fashion due to co-activated semantic features and concepts (Abdel Rahman & Melinger, 2007; Bar et al., 2006; Scheibel & Indefrey, 2020). Meanwhile, this argument is perfectly compatible with the proposal of a top-down bias owing to strategical response (Belke, 2017): Participants might build a response set, storing named members in the working memory over the course of the first naming cycle. Importantly, retrieving from the temporary response set would only be helpful for related items, because concepts of category members have been semantically primed by the named items. I should emphasize here that I do not distinguish between purely perceptual and purely conceptual identification process in my dissertation, but regard these two processes as a whole that together aid object identification. Particularly, empirical evidence suggests that these two processes interact early on (e.g., Dell'Acqua et al., 2010; Lupyan & Ward, 2013; Proverbio et al., 2007), so it makes sense to discuss them as a whole. For example, how a person consciously perceived the world is determined by their native language (Maier & Abdel Rahman, 2018).

Following the initial spread of activation at the semantic stage, lexical competition that slows down responses starts. This assumption of the SLN account was supported by a later posterior negativity falling in the time range between 250 to 350 ms (N2; e.g., Aristei et al., 2011; Maess et al., 2002). Participants showed larger N2 when naming semantically close pictures compared to unrelated ones, and were slower to respond to the stimuli during later presentation cycles. Most importantly, enhanced N2 predicted slower responses, revealing direct association between the ERP and lexical competition. The time window of this ERP agrees with previous studies investigating semantic context effects (e.g., Costa et al., 2009; Rose & Abdel Rahman, 2016; Rose et al., 2019; Wang et al., 2018) with similar topographical distribution but opposite polarity (P2). Critically, these two ERP modulations both accompany semantic context effects. Therefore, I argue that both posterior effects are essentially the same indicator of lexical competition (P2/N2), whose polarity is subjected to paradigm-specific variables. Although other studies examining semantic blocking effects did report a posterior positivity, they either found no correlation between the ERP and naming latencies (e.g., Janssen et al., 2011), or simply did not report correlation tests (e.g., Wang et al., 2018). Thus, whether a direct link between the positive effects and lexical competition exists remains unclear. In contrast, the predictive relationship reported in Study 1 provides strong evidence for the reverse polarity of an established ERP in this specific naming paradigm.

An essential assumption of the SLN account is concurrent activation at two processing stages – when lexical competition starts, earlier initiated conceptual priming goes on. The parallel activations of these two modulations with opposite effects jointly affect the naming behavior. Crucially, if semantic priming dominates, the semantic context effects emerge as facilitation; in contrast, if lexical competition dominates, the semantic context effects reveal as interference. This assumption of concurrent activations in trade-off is supported by the finding that, first of all, both N1 and P2/N2 were enhanced in all presentation cycles when participants named related compared to unrelated pictures. This finding is in line with evidence on parallel processing at different speech planning stages (e.g., Abdel Rahman & Sommer, 2003; Abdel Rahman et al., 2003; Feng et al., 2021; Strijkers et al., 2017). In addition, the larger N1, which leads to faster naming, and the larger P2/N2, which leads to slower naming, were found for both closely-related and unrelated pictures, revealing general effects of object identification on one hand, and lexical selection on the other. Importantly, while semantic priming and lexical competition modulate behavior responses in parallel, their interplay determines the overall naming latencies: N1 facilitates naming mostly when P2/N2 is weak; when the N1 is weak, even a weak P2/N2 yields strong interference in naming responses. This joint, interactive modulation is exclusively observed for closely-related pictures, but not for unrelated ones. Study 1 thus provides unique evidence for a trade-off between functionally dissociated effects from semantic priming and lexical competition in different semantic contexts.

Additional evidence in favor of the trade-off assumption comes from Study 2, where the interference typically found in later presentation cycles got weakened, even turned into facilitation, when participants named related pictures in close succession after listening to their partner telling a narrative about an event that revealed the relations of loosely related items. The first experiment showed that participants named related pictures faster than unrelated pictures if they first encountered the related ones, while the second experiment showed no difference in naming latencies between both semantic contexts under the same situation. Furthermore, participants that experienced strong facilitation in the first cycle showed less interference in later cycles. Since the SNL account also assumes that the number and strength of the co-activated lexical cohort play a crucial role in net context effects (Abdel Rahman & Melinger, 2009, 2019), I argue that if a speaker named related pictures directly after listening to their partner's narrative, the semantically rich narrative context would provide substantial primes, i.e., associated concepts, aiding initial object identification to win over concurrently active lexical competition (cf. Abdel Rahman & Melinger, 2007; Scheibel, 2020). In this case, massive one-to-one associative mappings would induce relatively strong semantic priming and relatively weak lexical competition. Priming effects gradually fade away when details of the narrative are no longer available in short-term memory. In contrast, initial object identification would not aid semantic processing if related pictures are not immediately named after the narrative context, which results in net effects of lexical interference. To sum up, the dynamic interplay between concurrent priming and competition can be observed when a speaker name pictures in a simulated social situation, on which I will elaborate further in section 3.3.

So far, I argue that the behavioral and electrophysiological evidence provided by two of my studies using the blocked-cyclic naming paradigm supports the theoretical assumptions of the Swinging Lexical Network account (Abdel Rahman & Melinger, 2009, 2019). Still, it cannot be denied that this paradigm may not be able to distinguish between competitive and non-competitive accounts of lexical selection (Oppenheim & Nozari, 2021). For instance, Oppenheim and colleagues' model (2010), which simulated lexical selection with error-based incremental learning mechanisms, may well account for our behavioral findings in later cycles: Selecting a target word strengthens the connections between the categorical concept and target lexical representations, while it weakens the connections between the categorical concept and other competitors in the related blocks. Weight changes are taken into account by a learning algorithm, which lowers initial activations of other competitors, thereby slowing down lexical selection in the upcoming trials. However, our findings of concurrent modulations between N1 and P2/N2 do not speak to Oppenheim's learning-based account. First, the finding of an ERP that is taken to reflect object identification processing provides little insight to this model, because this model does not, to my knowledge, assume early facilitatory semantic priming. Moreover, the posterior negativity by itself cannot explain excitatory/inhibitory connections during lexical activation and selection (which is implemented in this computational model) at the same time, because as its amplitude increases, naming becomes slower. In short, evidence presented in this dissertation is in favor of the competitive Swinging Lexical Network account, but future research is certainly needed to specifically target the electrophysiological signatures that can distinguish between models assuming competitive lexical access, or not.

3.2. Relationship Between Types of Semantic Relations and Semantic Context Effects

As outlined in the introduction, semantic relations of various kind might elicit different semantic context effects, and specifically, with different semantic context paradigms. Already categorical relations with different degrees of semantic similarity induce differential effects, which is revealed in studies reporting graded effects for semantically close and distant relations (e.g., Aristei & Abdel Rahman, 2013; Rose & Abdel Rahman, 2019; Vigliocco et al., 2004), or no effects for distant relations (e.g., Hutson & Damian, 2014; Rose & Abdel Rahman, 2017). Study 1 added to this line of research further evidence of strong categorical context effects for close relations, but no effects for distant relations, using the blocked-cyclic naming task. While closely-related items induced facilitation (as indexed by enhanced object-identification-associated N1) in the first presentation cycle and interference (as indexed by enhanced lexical-competition-related P2/N2) in later cycles, distantly-related items did not induce any observable effects, both in behavioral and brain responses. This indicates that the level of semantic similarity needs to surpass an arbitrary similarity threshold to induce semantic blocking effects.

These findings agree with Rose and Abdel Rahman's study (2017), which used the same picture stimuli in a continuous naming paradigm, and found cumulative semantic interference exclusively for close, but not distant, relations. Interestingly, using the same set of materials in a PWI task, Rose and colleagues (2019) found interference also for distant relations, albeit the effects were weaker than those induced by close relations. Since all the three studies used the same materials, carefully selected by systematically controlling for semantic features under taxonomical hierarchies, Study 1 of this dissertation contributes a missing piece of the puzzle. This way, experimental stimuli, whose visual and semantic similarity could vary across studies, were controlled when comparing effects across semantic context paradigms. An important conclusion that can be drawn here is that across paradigms, close categorical relations reliably elicit semantic context effects, while distant categorical relations do not surpass a threshold of similarity to be observed except for in the PWI task.

Aside from semantic relatedness influencing the strength of semantic context effects within categorical relations, evidence from Study 3 further indicates that different types of semantic relations elicit semantic context effects depending on their strength of relatedness. Critically, the continuous naming paradigm seems to be most sensitive to pick up small context effects; thus, I argue that it is an ideal paradigm to use if one aims to compare effects across various semantic relations. This argument comes most directly from the observation that Study 3, using similar and partially the same materials of loose event relations while changing the design from the blocked-cyclic naming to continuous naming, did not replicate the findings of Study 2. Given that the lexical interference induced by partners' thematically congruent narratives were reliably demonstrated in two experiments (Study 2, Experiment 1 & 2), and the effects were apparently not induced by thematically incongruent narratives (Study 2, Experiment 3), it is very unlikely that the selection of materials with loose event relations was simply not valid. The critical evidence for the continuous naming task picking up semantically meaningful effects is that in Study 3, filler items did not show cumulative interference as target items did, so the effects cannot be due to semantic irrelevant factors such as fatigue. In contrast, robust cumulative semantic interference was found when participants named target items *both* after listening to a thematically congruent and incongruent narrative. Therefore, although the manipulation of partners' narratives was not successful, Study 3 gives an important implication on the inherent quality of the continuous naming paradigm: it captures effects induced by very loose relations.

Based on this implication of the continuous naming task, the mega-analysis of Study 3 further demonstrated that a systematic relationship exists between semantic relatedness and the strength of the induced semantic context effects. The objective measurement of distributional semantic models computed *graded* cosine similarities for materials used in five studies, which tested semantic relations ranging from categorical (Döring et al., 2021; Döring et al., under review; Rose & Abdel Rahman, 2017), associative (Rose & Abdel Rahman, 2016), to loose event relations (Study 3). Because cosine similarities of loose event relations were indistinguishable from those of filler items, the robust cumulative semantic interference observed in Study 3 when participants named pictures without a meaningful narrative context was truly due to semantic relatedness, albeit it was too loose to be assessed as related. Correspondingly, loose semantic relations also elicited the weakest cumulative interference compared with associative and categorical relations, which elicited second strongest and strongest effects, respectively. The positive correlation between semantic relatedness and cumulative interference again provides evidence that continuous naming paradigm is particularly suitable to detect small context effects.

As a comparison, blocked-cyclic naming paradigm has yielded rather mixed evidence for associative or loose event relations: Some studies reported interference effects (e.g., Abdel Rahman & Melinger, 2007; Abdel Rahman & Melinger, 2011; Aristei et al., 2011), while some others reported null effects (e.g., de Zubicaray et al., 2014; McDonagh et al., 2020). Rose and Abdel Rahman (2016) argued that the sensitivity of the continuous design might stem from the accumulating lexical competition outweighing stable semantic priming, while lexical interference could be cancelled out by reinforced priming from the repeated cycles in the blocked-cyclic design. Study 3 provides evidence in favor of this argument by demonstrating that picture materials which may not induce semantic blocking effects can induce cumulative semantic interference. In the continuous naming design, previously named related items induce relatively short-lived activations in the semantic network, resulting in stable priming upon each naming of the category members; meanwhile, interference caused by lexical competition accumulates with each newly named member. The net effects of the trade-off would be the robust cumulative interference for very loose event relations. Counter to this view, the conceptual accumulation hypothesis (Belke et al., 2005; Belke, 2013; Kroll & Stewart, 1994) proposes that semantic facilitation should be cumulative in the continuous paradigm. This hypothesis, however, has only found evidence in the semantic classification task (e.g., participants classify whether an item belongs to natural or mem-made entities), but not in object naming tasks (e.g., Belke, 2013). This could be due to the relevance of semantic features concerning task demands, i.e., facilitation only accumulates via learning if semantic features are actively accessed for responses, but investigations on how loose event relations contribute to this account is required in future studies.

From the observation of a systematic relationship between semantic relatedness and the strength of cumulative semantic interference, I want to raise an important theoretical question: does our lexical-semantic system process different types of semantic relations, i.e., categorical-taxonomic versus associative-thematic relations, with the same mechanisms? Recently, McDonagh and colleagues (2020) argued that these two types of relations are processed differentially during naming. In a blocked-cyclic naming paradigm, they achieved a double dissociation between two relations by selecting pictures with respective quantitative measures such that associative items scored low in categorical measure, and vice versa. The authors reported interference for categorical relations, but no effects for associative relations, and hence concluded that the two relations are processed with different mechanisms. I would argue that there is insufficient evidence to resort to different mechanisms based on the observation that associative relations did not induce semantic blocking effects. As reported at the beginning of this section, Study 1 did not find evidence for semantic blocking effects, either, for distant categorical relations. However, it is unlikely that our lexical-semantic system processes close and distant categorical relations differentially. Null effects reported in McDonagh et al.'s study can also be interpreted as lexical interference not strong enough to surpass the threshold to be observed behaviorally. As I reasoned in the above paragraph, the blocked-cyclic naming paradigm is not as sensitive as the continuous naming paradigm in picking up small semantic context effects. In contrast, Study 3 demonstrates that cumulative semantic interference induced by semantic relations which are defined differently (e.g., categorical relations share features while loose event relations do not) varies systematically with their distributional semantic relatedness. Therefore, I argue that the systematic relationship between semantic relatedness and context effects provides evidence to the advantage of the same mechanisms underlying different types of semantic relations.

3.3. Interactively Aligned Lexical-Semantic Processing in Communicative Contexts

In order to achieve rapid and efficient communication, conversational partners might come to align their situation models of the topic under discussion via alignment at the level of linguistic representations (Pickering & Garrod, 2004). While alignment at other levels of linguistic representations such as lexical alignment (e.g., Brennan & Clark, 1996; Garrod & Anderson, 1987) and syntactic alignment (e.g., Branigan et al., 2000) can be directly observed from utterances, the alignment of situation models can only be tested indirectly. In fact, it has been distinguished from other levels of linguistic representations in terms of the time course of priming. Pickering and Garrod (2004) proposed that the long-lasting priming of situation model which aids communication might depend primarily on memory representations, while the short-lived priming at lower levels depends primarily on temporarily facilitated activation. Pursuing a precise time course of priming effects during speaking while retaining effects brought by a communication partner as much as possible, I came up with a novel experimental design which implemented the classic single-person blocked-cyclic naming paradigm in a simulated communicative context.

Adopting this novel design, Study 2 contributes to the line of research investigating lexical-semantic processing in communication by showing how a meaningful narrative context temporarily shapes the semantic system of a speaker. This study demonstrates that narratives communicated by a task partner greatly enhance the activations of very loose event relations, which in turn elicit ad-hoc semantic context effects. Furthermore, speakers seem to show reduced interference, or even facilitation, when naming related pictures immediately after listening to a partner's narrative about the common theme or event. This data pattern agrees with the trade-off assumption between conceptual priming and lexical competition, which jointly decide the final polarity of the context effects (Abdel Rahman & Melinger, 2009, 2019). To illustrate, here I propose the following mechanisms that might underlie the scenario of this study: A task partner's narrative about a visit to the zoo activates the conceptual representations of entities related to this event (e.g., ropes, nest, llama, bone, ice cream). Since the task partners were instructed not to mention the target items but to narrate storylines that implied those items (e.g., a sentence implying *llama*: "Kids were all eager to go to the petting area."), hypothetically, a speaker updates their situation model which specifically primes entities associated with this scene (cf. activating a context simultaneously activates associates beyond actual linguistic inputs in language comprehension, Metusalem et al., 2010). Meanwhile, co-activated lexical representations compete for selection and generate lexical interference. Because semantic priming facilitates initial object identification most (Abdel Rahman & Melinger, 2007; Scheibel & Indefrey, 2020), naming event related pictures right after the partner's narrative benefits most. That is, semantic priming cancels out or even outweighs lexical competition, resulting in overall reduced interference or facilitation in this case. When the related items show up only after speakers have named unrelated items, semantic priming from the concepts aroused in the situation model might have already faded away, so lexical interference dominates. In short, the systematic pattern of the context effects supports the hypothesis that conversational topics can influence a speaker's speech production system.

One concern that might still be raised at this point is: Why does conceptual priming, typically assumed to be short-lived during lexical-semantic processing, induce a long-lasting effect such that not only the first presentation cycle, but also later cycles, showed reduced interference for naming related pictures immediately after the narrative? My speculation is that participants integrated the details of their partner's narrative into their situation model, kept it in short-term memory, and retained it to a certain degree during the naming task. Short-term memory is assumed to be part the activated permanent knowledge under attentional focus (Cantor & Engle, 1993; Cowan, 1998). Because activation is subject to time-related decay, knowledge needs to be refreshed for its accessibility (Baddeley, 1992; Engle et al., 1999), and numerous studies showed that short-term memory decays as time passes (e.g., Barrouillet et al., 2004; Cowan, 1993, 1998; Towse & Hitch, 1995). Based on this line of research, the time constraints on short-term memory can theoretically account for the reduced interference (or even facilitation) found in Study 2, when participants directly named related pictures after the narrative. This speculation also links back to the Interactive Alignment Account (Pickering &

Garrod, 2004), which posits that the long-lasting priming of situation model depends mostly on memory representations. Suppose a speaker updates the situation model according to their partner's narrative, and then immediately encounters items primed by the storylines, the rich associative relations available in the situation model would facilitate object recognition. Crucially, in this case, strong semantic priming introduced by the situation model could have outweighed lexical competition among loose relations, and thus result in overall net effects of reduced interference during naming.

Findings from Study 2 provide important insights into the processes underlying conversation, because a person listening to a communication partner's narrative would be the one who will take the turn to speak subsequently. Recent research on speech comprehension demonstrates that listeners adapt their expectations to speakers based on world knowledge, e.g., listeners showed ERPs indicating violation of expectations when a speaker associated with working experience on an ox farm instead answered "cow" during an interview (Ryskin et al., 2019). Study 2, on the other hand, shows that semantic knowledge about a communication partner not only shapes comprehension of a person involved in a dialogue-like context, but also has consequences on the speech planning process of this person subsequently. The ad-hoc semantic context effects indicate successful arousal of very loose event relations through the meaningful context provided by the partner, and such alignment at the semantic level could be mechanisms that support mutual understanding between conversational partners (cf. Pickering & Garrod, 2004). A situation model is constantly updated in the mind of the study participants by semantically integrating the partner's narrative. I should note here that I do not propose that these mechanisms of flexibly adapting lexical-semantic network to a meaningful context is exclusive to a conversation-like situation involving a task partner. In fact, similar effects arise outside of social contexts have been reported (e.g., Abdel Rahman and Melinger, 2011). Instead, I argue that the flexible adaptation of the lexical-semantic system to both linguistic or social context forms the basis for what happens during real-life communicative exchanges with an interlocutor.

Study 2 is a preliminary attempt to fill the gap between investigations focusing on linguistic elements in strictly controlled laboratory setting, and those focusing more on social elements, such as involving a real communication partner for more natural interaction. Clark (1996) distinguished between two traditions in language research: While the language-as-action tradition proposes that coordination and shared linguistic representations between interlocutors aid speech planning and thus lead to successful dialogue (e.g., Branigan et al.

2000; Clark & Marshall, 1981; Garrod & Anderson, 1987; Metzing & Brennan, 2003; Pickering & Garrod, 2004), the language-as-product tradition, in contrast, typically predicts interference during naming of semantic related items (e.g., Dell, 1986; Howard et al., 2006; Indefrey & Levelt, 2004; Levelt et al., 1999; Nozari & Hepner, 2019; Roelofs, 1992, 2018). Findings from Study 2 are generally in line with the language-as-product tradition because of the reliable lexical interference induced by a related narrative context. Even more interestingly, speakers seem to be less affected by lexical interference, and in some cases, are facilitated in naming related items if these are presented right after their partner's narrative. The alleviated naming process is, on the other hand, in agreement with the language-as-action tradition. Although the current design is still far from a real dialogue, it has already touched upon an important question in the study of conversation: how a meaningful context provided by a communication partner influences speakers when they need to speak in close temporal proximity - which resembles a real dialogue in the sense of turn-taking.

3.4. Outlook and Conclusions

The current dissertation contributes to a better understanding of the flexible adaptations of our lexical-semantic system to both linguistic and social context. To ultimately illustrate a clearer picture of how language is produced in real-life scenarios, we must first have a solid ground of knowledge about what factors influence the lexical-semantic system independent of social factors, how, and to what extent. To this end, more systematic investigations including various types of semantic relations – from categorical-taxonomic, associative-thematic, to very loose event relations – are needed. Specifically, future research should carefully operationalize these relations and test them using the same semantic context paradigm, which, from the evidence provided in this dissertation, would be the continuous naming paradigm due to its high sensitivity to small effects. Since interlocutors often exchange experience in natural conversations, very loose relations associated with certain events or world knowledge would be crucial for ecologically valid investigations on language production, and thus deserve more attention in the field.

From my attempt to examine lexical-semantic processing in a simulated communicative context, I should note that great challenges need to be overcome when it comes to embedding picture naming paradigms in social context. To strike a balance between well-controlled laboratory experiments and ecological validity, it is crucial to assess post hoc how participants perceived the experimental setting. Whether participants believe the cover story affects the authenticity of the social interaction, which in turn provides a measure of generalization to natural conversation. The findings from this dissertation, for instance, indicate that a speaker's lexical-semantic activation is modulated by a meaningful narrative context provided by a task partner regardless of real interaction. Accordingly, future studies could directly test how authentic social interaction brought by real task partners or confederates affects our lexical-semantic system. The design of simulated social interaction would hopefully become more and more plausible due to the increasing use of online meetings in our time. To conclude, the present dissertation paves the way for more detailed exploration of various semantic relations, and sheds lights on the mechanisms of our flexible speech production system to accommodate natural conversations.

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Original Research Articles

This dissertation is based on the following original research articles:

I. **Lin, H. P.**, Kuhlen, A. K., Melinger, A., Aristei, S., & Abdel Rahman, R. (2021). Concurrent semantic priming and lexical interference for close semantic relations in blocked-cyclic picture naming: Electrophysiological signatures. *Psychophysiology*, e13990. [Study 1] – doi: https://doi.org/10.1111/psyp.13990

II. **Lin, H. P.**, Kuhlen, A. K., & Abdel Rahman, R. (2021). Ad-hoc thematic relations form through communication: effects on lexical-semantic processing during language production. *Language, Cognition and Neuroscience, 36*(9), 1057-1075. [Study 2]

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ORIGINAL ARTICLE

Concurrent semantic priming and lexical interference for close semantic relations in blocked-cyclic picture naming: Electrophysiological signatures

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Abstract

In the present study, we employed event-related brain potentials to investigate the effects of semantic similarity on different planning stages during language production. We manipulated semantic similarity by controlling feature overlap within taxonomical hierarchies. In a blocked-cyclic naming task, participants named pictures in repeated cycles, blocked in semantically close, distant, or unrelated conditions. Only closely related items, but not distantly related items, induced semantic blocking effects. In the first presentation cycle, naming was facilitated, and amplitude modulations in the N1 component around 140–180 ms post-stimulus onset predicted this behavioral facilitation. In contrast, in later cycles, naming was delayed, and a negative-going posterior amplitude modulation around 250–350 ms post-stimulus onset predicted this interference. These findings indicate easier object recognition or identification underlying initial facilitation and increased difficulties during lexical selection. The N1 modulation was reduced but persisted in later cycles in which interference dominated, and the posterior negativity was also present in cycle 1 in which facilitation dominated, demonstrating concurrent effects of conceptual priming and lexical interference in all naming cycles. Our assumptions about the functional role these two opposing forces play in producing semantic context effects are further supported by the finding that the joint modulation of these two ERPs on naming latency exclusively emerged when naming closely related, but not unrelated items. The current findings demonstrate that close relations, but not distant taxonomic relations, induce stronger semantic blocking effects, and that temporally overlapping electrophysiological signatures reflect a trade-off between facilitatory priming and interfering lexical competition.

KEYWORDS
blocked-cyclic picture naming, EEG, lexical selection, semantic facilitation/interference, semantic similarity

1 | INTRODUCTION

Categorization is one of the first things we learn when navigating the environment, constructing knowledge of the world. By categorizing objects and beings according to how similar they are, we form semantic representations and assign them names. Thus, when we speak, we constantly refer to things with different levels of semantic similarity. Semantic similarity denotes the degree of relatedness between two words, for instance, words that share more semantic features under the same taxonomy, such as *horse* (has legs; is an animal) and *sheep* (has legs; is an animal), are more semantically similar than words that share fewer features, for example, *horse* and *shark* (does not have legs; is an animal). Manipulating semantic similarity offers insights into conceptual preparation and lexical selection during speech production and can reveal the micro-structure of our semantic system.

The present study investigated effects of semantic similarity on different planning stages during language production and aimed to provide a fine-grained time frame of the effects. Until now, to our knowledge, there is no electrophysiological evidence directly associated with semantic similarity effects in the blocked-cyclic naming paradigm. To pursue high temporal resolution information, we employed event-related potentials (ERPs) in a blocked-cyclic naming paradigm. To foreshadow the results, we find evidence for semantic facilitation for the first naming cycle that was predicted by an amplitude modulation of the N1 component, followed by semantic interference for later cycles that was predicted by a posterior negativity in the time range of the P2/N2 component. These effects were present only for close, but not for distant, semantic relations, indicating that only semantically close objects induce observable semantic context effects. Furthermore, the N1 modulation was reduced but persisted in later cycles in which interference dominated, and the posterior negativity was also present in the first cycle in which facilitation dominated, providing first evidence for temporally overlapping conceptual and lexical processing in the blocked-cyclic naming paradigm.

1.1 | Investigating semantic similarity in speech production paradigms

Semantic context effects serve as an index of lexical-semantic processing, which has been evidenced to take place around 200 ms after stimulus onset (e.g., Costa et al., 2009; Levelt, 1992; Levelt et al., 1999; Piai et al., 2014; Strijkers et al., 2010). Such effects emerge as facilitation or interference in different language production paradigms. To produce a word (e.g., *horse*), a speaker activates conceptual representations related to that word (e.g., mammal, fur, hooves), and the related concepts further activate one another's corresponding lexical representations. The most strongly activated target lexical representation (*horse*) is then selected from all the co-activated lexical candidates (e.g., *sheep*, *camel*) for articulation (Howard et al., 2006; Levelt et al., 1999; Roelofs, 1992, 2018). Based on models that assume lexical competition, the general mechanisms behind semantic context effects consist of two parts: conceptual priming and lexical competition. While related concepts facilitate the selection of a target lexical representation, co-activated lexical candidates compete with the target and thus disrupt selection (Abdel Rahman & Melinger, 2009, 2019; Belke et al., 2005; Roelofs, 2018). Since semantic context effects are assumed to require sufficient overlapping semantic features to emerge, enhancing semantic similarity should theoretically amplify the context effects. This hypothesis has been tested by studies applying different naming paradigms.

In the picture-word interference (PWI) paradigm (e.g., Damian & Bowers, 2003; Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Hantsch et al., 2005; Hutson & Damian, 2014; Mahon et al., 2007; Piai et al., 2014; Rose et al., 2019; Schriefers et al., 1990; Vigliocco et al., 2004), participants are instructed to name a picture presented together with a superimposed distractor word which they should ignore. When a distractor word is categorically related to the picture, participants typically take more time to respond compared to pictures superimposed with an unrelated distractor word. The role of semantic similarity in lexical-semantic processing has been investigated with the PWI paradigm, but findings are inconsistent. While some studies found stronger interference for semantically close versus distant distractor words (e.g., Aristei & Abdel Rahman, 2013; Rose et al., 2019; Vigliocco et al., 2004), others found the opposite pattern (e.g., Mahon et al., 2007), and yet others found an overall effect of semantic relatedness, but no effect of semantic similarity (Hutson & Damian, 2014). Even when graded effects were observed behaviorally, electrophysiological evidence was only present for the semantically close condition (Rose et al., 2019), revealed as a posterior positivity around 200 ms post-stimulus; no electrophysiological evidence of semantic interference was found for distant distractor words despite the behavioral effects.

In the continuous naming paradigm (e.g., Belke, 2013; Belke & Stielow, 2013; Costa et al., 2009; Howard et al., 2006; Navarrete et al., 2010), participants name pictures in succession. Semantically related picture sets are interleaved with unrelated filler items. A robust effect of ordinal position, that is, a linear increase in naming latency as the number of named exemplars of a given semantic category increases, has been reported for semantically related items, implying increasing difficulty of lexical selection. With regard to the effect of semantic similarity, in the continuous naming paradigm, cumulative interference has been reported for semantically close, but not for semantically distant, items (Rose & Abdel Rahman, 2017). In the same study, the cumulative interference was positively associated with a posterior positivity around 250 ms post-stimulus in the participants' electroencephalogram (EEG) *only* in the semantically close condition—an electrophysiological signature whose time course and scalp distribution agree with previously reported ERPs for lexical selection (Costa et al., 2009).

In order to make results across paradigms more comparable, our study focuses on another commonly used paradigm, the blocked-cyclic naming task (also referred to as the blocking paradigm; e.g., Belke, 2008; Belke et al., 2005; Damian & Als, 2005; Damian et al., 2001; Kroll & Stewart, 1994; Navarrete et al., 2012, 2014; Schnur et al., 2006; Vigliocco et al., 2002) while using the same set of materials as the two studies mentioned above that investigated the semantic similarity effects (Rose & Abdel Rahman, 2017; Rose et al., 2019). In the blocking paradigm, participants name exemplars from a given stimulus set in small repeated cycles; in homogeneous blocks, exemplars are semantically related, whereas in heterogeneous blocks, exemplars are semantically unrelated. From the second cycle onward, longer naming latencies in the homogeneous compared to the heterogeneous condition have been reliably reported, while either no effect or facilitation has been found in the first cycle (e.g., Abdel Rahman & Melinger, 2011; Crowther & Martin, 2014; Janssen et al., 2015; Navarrete et al., 2012). While findings in the first cycle have been less consistent, a review of studies using the blocked-cyclic paradigm found that facilitation is likely to be observed in the first cycle if the semantic conditions are presented in large blocks instead of in alternating order (Belke, 2017). How semantic similarity influences the process of lexical retrieval has also been investigated using the blocked-cyclic naming paradigm (e.g., Navarrete et al., 2012; Vigliocco et al., 2002). Behavioral studies have reported graded effects, with stronger facilitation in the semantically close versus distant condition in the first cycle (e.g., Navarrete et al., 2012, Experiment 1 & 2), and stronger interference in the semantically close versus distant condition (e.g., Vigliocco et al., 2002, collapsing all repetition cycles). However, there is no electrophysiological evidence directly associated with semantic similarity effects in the blocked-cyclic naming paradigm.

In sum, three different naming paradigms have been applied to test the effect of semantic similarity on lexical retrieval. While close relations usually produce context effects, such effects induced by distant relations are often absent or significantly weaker. One of our goals is thus to provide more evidence with regard to the extent to which semantic similarity modulates context effects. Moreover, even though EEG has been recorded in the PWI and continuous naming paradigms to examine the modulation of semantic similarity, the electrophysiological evidence for such modulation is absent in the blocked-cyclic paradigm.

1.2 | Theoretical explanations for semantic blocking effects

The semantic context effects in the blocked-cyclic paradigm, specifically referred to as *semantic blocking effects*, have been alternatively related to perceptual, conceptual, lexical, or post-lexical planning stages. The view that underpins the current investigation holds that semantic blocking effects, and indeed all semantic context effects, reveal a trade-off between conceptual and lexical processes, which temporally overlap. Specifically, the slower naming times observed in later homogeneous naming cycles result from the competitive nature of the lexical selection process[1] (cf. Levelt et al., 1999; Roelofs, 1992, 2018). A Swinging Lexical Network account argues that, in contrast to a heterogeneous blocking context, the repeated naming of a set of semantically related items in the homogeneous blocking condition results in a cohort of strongly co-activated candidates striving to be selected (Abdel Rahman & Melinger, 2009, 2019). The presence of this active cohort slows down lexical selection because all active candidates enter into a competition for selection, much like a tug of war.

Within the Swinging Lexical Network model, the facilitation observed in the first cycle arises due to easier object recognition: Object recognition is most difficult in the first cycle, and participants may profit from the semantic contexts (Abdel Rahman & Melinger, 2007). This gives conceptual priming an upper hand over lexical competition, following the aforementioned assumption that blocking effects reflect a trade-off between conceptual facilitation and lexical competition, two processes that temporally overlap and unfold in parallel (Abdel Rahman & Melinger, 2009, 2019; Rabovsky et al., 2021). Supporting this explanation, a recent study manipulating visual and semantic similarity using a non-repeated semantic priming paradigm found evidence for a perceptually related top-down

[1]There are other models that do not assume a competitive lexical selection process (e.g., Oppenheim et al., 2010), but we focus on competitive models in this study.

bias underlying initial facilitation (Scheibel & Indefrey, 2020). In this study, participants named pictures in three conditions: semantic/lexical knowledge (primed by a category word), perceptual/conceptual knowledge (primed by a picture of the category's mean shape, generated by overlaying all exemplars within the given category) and no a priori knowledge (no prime preceding the picture). Naming visually consistent categories (e.g., birds) benefitted from both types of a priori knowledge more than visually variable categories (e.g., buildings). Furthermore, the facilitation based on a priori perceptual/conceptual knowledge was consistently larger than that based on a priori semantic/lexical knowledge. The authors argue that a priori perceptual/conceptual knowledge presented a top-down mechanism that limited the number of target-shape candidates and accelerated the feature matching procedure, thus facilitating the naming response.

1.3 | Tracking the functional architecture and time course of lexical selection

The basic assumption about the functional architecture of the just described model is that conceptual processing (typically reflected in facilitatory effects) and lexical selection (typically reflected in effects of interference) proceed in parallel (concurrent activation; for similar arguments of parallel processing, see Abdel Rahman & Sommer, 2003; Abdel Rahman et al., 2003; Feng et al., 2021; Strijkers et al., 2017). Note, this does not necessarily mean that both processes begin and end at the same time. Specifically, we assume continuous spread of activation within and between conceptual and lexical processing levels (cf. Roelofs, 1992, 2018). As a result, conceptual activation is initiated in an initial sweep before lexical activation, but conceptual activation does not stop when lexical activation begins. Rather, there is a period of time when both levels of processing are active and can in fact interact with each other. The period of overlapping conceptual and lexical activation and interaction results in the trade-off between facilitation and interference. The outcome of the trade-off depends on the situation and context in which pictures are named. For instance, in the blocking paradigm, when the semantic context is most helpful in the first cycles, semantic priming (facilitatory effects) dominates, whereas lexical interference dominates if many competitors are fully active at the lexical level, and the influence of conceptual priming should be reduced.

These aspects of the functional architecture of the language production system and the time course of conceptual and lexical processing can be investigated by employing the temporal precision of the EEG, as we will describe below (for EEG evidence in the blocking paradigm, e.g., Aristei et al., 2011; Janssen et al., 2011, 2015; Llorens et al., 2014; Wang et al., 2018; see de Zubicaray & Piai, 2019 for a comprehensive review). Across studies, a common finding of a larger ERP at posterior sites for the related compared to unrelated condition has been associated with the semantic blocking effect, although the polarity of the amplitude seems to differ. Aristei and colleagues (2011) incorporated the PWI task into the blocked-cyclic paradigm and found a larger negativity for homogeneous blocks starting at around 200–250 ms post-stimulus. This ERP was associated with the blocking effect based on the significantly different amplitudes when contrasting homogenous and heterogeneous blocks (see also an MEG study from Maess et al., 2002, which reports similar results), suggesting that the posterior negativity reflects lexical selection. A more recent study by Wang and colleagues (2018) reported a relative positivity at posterior sites for homogeneous blocks from 200 ms after stimulus onset. In sum, the evidence for the polarity of the electrophysiological signature of lexical selection remains inconsistent for the blocking paradigm.

1.4 | The present study

The first goal of the present study is to examine whether enhanced semantic similarity leads to stronger blocking effects. We frame our study within the context of competitive models of lexical selection because they provide clear and tractable predictions. Specifically, enhancing semantic similarity should theoretically lead to (a) stronger conceptual priming, thus stronger semantic facilitation in the first cycle, and (b) more intense lexical competition, thus increased semantic interference in later cycles.

In the first presentation cycle, we expect semantic facilitation to emerge. Furthermore, the strength of this effect should be influenced by semantic similarity, that is, stronger blocking effects in the semantically close condition than in the semantically distant condition. The expectation is based on the current large-block design, where initial facilitation has been reliably reported (Belke, 2017). To trace the electrophysiological signature of such facilitation induced by higher semantic similarity, we focused on relatively early ERP modulations within a latency range below 200 ms at posterior sites that should reflect object recognition, including perceptual and conceptual aspects (e.g., Itier & Taylor, 2004; Thorpe et al., 1996; Tokudome & Wang, 2012; Valente et al., 2014; Vogel & Luck, 2000).

For cycles 2–5, we predict that increasing semantic similarity results in stronger interference during lexical selection when naming semantically closely related pictures compared to naming distantly related ones. In addition, we expect a larger posterior negativity at temporal-parietal sites starting in the time range of the P2/N2 component at around 250 ms post-stimulus (cf. Aristei et al., 2011), which has been linked to the process of lexical selection, in the semantically close condition compared to the distant condition. While prior investigations using other naming paradigms reported converging evidence of a positive-going ERP for the semantic context effects (as reviewed in Section 1.1), in the blocked-cyclic naming paradigm, negative-going ERPs have also been reported (e.g., Aristei et al., 2011; Maess et al., 2002). Except for the polarity, both ERP look temporally and topographically similar.

The second goal of this study is to relate behavioral facilitation and interference in the first and later cycles to different planning stages and their relative time courses reflected by ERPs. We assume that conceptual priming and lexical interference start at different points in time relative to picture onset. As proposed above, we expected conceptual facilitation to start first, and be indexed by an earlier ERP modulation. While this process is still ongoing, lexical selection starts and will be indexed by a later ERP modulation (parallel/concurrent activation). Assuming that conceptual and lexical processing occur concurrently with opposite forces, regardless of the behavioral blocking effects, their respective ERP modulations should be present both in the first and in later cycles, modulating naming latency in opposite directions. The two ERPs should interactively be related to naming latency such that an enhanced N1 (related to facilitated object identification) would induce facilitation, while an enhanced P2/N2 (related to concomitant lexical competition) would induce interfering effects. Naming latencies are a result of the relative contributions of both effects. Crucially, these two ERP modulations should interactively influence naming behavior, indicating a joint modulation by both cognitive processes on naming latency across all cycles - in support of the trade-off assumption between conceptual facilitation and lexical competition.

In sum, our basic expectations were graded blocking effects depending on semantic similarity on both naming latencies and ERP amplitudes: Behaviorally, semantic blocking effects emerge as facilitation in the first cycle but turn into interference in later cycles, whereas cycle 1 facilitation should be accompanied by a relatively early ERP modulation and cycles 2–5 interference should be accompanied by a relatively late ERP modulation. In addition, based on the theoretical trade-off assumption, these two ERPs should modulate naming latencies in opposite directions and interact with each other, indicating a joint modulation on naming latencies, but only when semantic similarity is high.

2 | METHOD

The experiment was approved by the local ethics committee and was based on ethical principles put forward by the Declaration of Helsinki for research involving human subjects (Version 2013). The data that support the findings of this study are available in OSF at https://osf.io/jkzn9/?view_only=fcd144715c854731904736288dbd48ba.

2.1 | Participants

We collected data from 25 healthy, right-handed, native German speakers with normal or corrected-to-normal visual acuity and normal color vision. Participants were compensated with expense allowance or received credit towards their curriculum requirements. All participants gave informed consent prior to participation. The data from one participant had to be excluded due to excessive EEG artifacts, resulting in a total number of 24 participants (18 females, mean age 23.8) for data analyses. The sample size was determined based on previous work investigating semantic interference effects in different naming paradigms (e.g., Rose & Abdel Rahman, 2017; Rose et al., 2019), which are comparable to the blocking effects starting from the second presentation cycle.

2.2 | Materials

A total number of 125 colored photographs of objects were selected as picture stimuli. Stimuli and semantic relations were identical to Rose and Abdel Rahman (2017) and Rose and colleagues (2019), which manipulated the degree of semantic similarity in a systematic way. We manipulated semantic similarity by the semantic features that items share with closely related members in a sub-category, or with more distantly related members in an overarching category. For instance, an eagle shares more features with an owl and a parrot, but less with other animals such as a shark or a camel. In short, we varied the semantic feature overlap while keeping the overarching taxonomic category membership constant. Manual classification resulted in five broad categories (animals, clothes, tools, groceries, and furniture), each of which contained five sub-categories (e.g., animals: birds, fish, insects, ungulates, and monkeys; see Appendix A for the full stimulus list). Each sub-category consisted of five exemplars (e.g., birds: eagle, hummingbird, parrot, vulture, and owl). Each item was represented by a unique exemplar (i.e., we only included one image for "eagle"), and the same exemplar (image) was repeatedly named in a block.

The stimulus sets within each sub-category represented the *semantically close* blocking condition (hereafter the close condition). For the *semantically distant* blocking condition (hereafter the distant condition), we assigned one exemplar from each sub-category of a given broad category to form the stimulus sets (cf. Rose & Abdel Rahman, 2017; Rose et al., 2019). Finally, for the *semantically unrelated* blocking condition (hereafter the unrelated condition) we took one exemplar from each broad category. With this, all stimuli appeared in the close, distant, and unrelated stimulus sets. Visually, the selected pictures were typically not confused with other category members and were easy to identify. To avoid higher visual similarities between members in closely related sets influencing the expected effects, we selected our materials following two criteria: (1) pictures of objects are taken from different perspectives, without unnecessary similarities; (2) members in the closely related sets look visually different (e.g., eagle vs. owl). Using a computational similarity measure for images, the Haar wavelet-based perceptual similarity index (HaarPSI; Reisenhofer et al., 2018), we generated perceptual similarity indexes for all possible combinations between stimulus pictures. With the coefficients obtained from a Haar wavelet decomposition, local similarities between two images were assessed, including the relative importance of image areas. The average visual similarity is numerically relatively balanced across conditions (group means for close = .193; distant = .187; unrelated = .180), while an ANOVA test showed a significant difference between condition means, $F_{(2,678)} = 6.59$, $p = .001$. However, since the HaarPSI ranges from 0 to 1, differences less than 0.7% have little practical significance on visual similarity. All photographs were edited for a homogenous background color and scaled to the size of 3.5 cm × 3.5 cm. Stimuli were presented on a 4/3 17″ BenQ monitor with a resolution of 1,280 × 1,024 using Presentation® software (Version 18.0, Neurobehavioral Systems, Inc., Berkeley, CA) at a viewing distance of 60 cm, producing an equal stimulus size of 2.7° visual angle for each object stimulus.

2.3 | Procedure

Participants were familiarized with the stimuli prior to the main experiment as follows: Color print photographs were presented together with their names in random order on sheets of paper. Participants were asked to study the pictures and the corresponding names carefully. For the main experiment, participants were instructed to name pictures as fast and accurately as possible. On a screen with a light grey background, a fixation cross in the center indicated the start of a trial. After 0.5 s, a picture was presented for maximally 2 s, or disappeared as soon as the voice key was triggered. A blank screen followed and lasted for 1 s until the next trial started.

The experimental session consisted of three sections that corresponded to the three semantic blocking condition (close, distant, and unrelated). The ordering of conditions was counterbalanced across participants. The order of the stimulus sets within each condition was randomized. Each stimulus set was presented five times (five presentation cycles), and an online randomization was performed for each cycle separately. This resulted in 625 trials per semantic blocking condition (125 per presentation cycle) and a total trial number of 1,875.

2.4 | Acquisition and analyses

2.4.1 | Accuracy

In general, participants showed very high accuracy in naming pictures, and deviations were fairly low ($M = 99.88\%$, $SD = 0.12\%$). We ran a generalized linear mixed-effects model (GLMM) using the function *glmer* in the *lme4* package (Bates, Maechler, et al., 2015, version 1.1-21) in R (R Core Team, 2018) to test the accuracy as a function of block order to control for possible covariate. The random structure consisted of random intercepts of subject and item, and a random slope of block order for subject.

2.4.2 | Naming latencies

Naming latencies were measured with a voice key starting from stimulus onset to participants' response. Only those trials were analyzed in which participants named the picture correctly and without speech disfluency. According to these criteria, around 3.8% of the data had to be excluded. Naming latencies shorter than 200 ms (0.87%) were removed. We log-transformed the naming latencies based on the outcome of a Box-Cox Test in order to meet the normality assumption of linear mixed-effect models.

Of all trials, 91.76% entered data analyses. Aside from the pre-defined exclusion criteria, further trials were excluded due to EEG data loss. Since we aimed to predict naming latencies by ERP modulations on a trial-by-trial basis, we analyzed only those trials in which both behavioral and EEG data points survived the exclusion criteria, that is, correct naming within 200 ms and clean EEG signal. This resulted in a total of 8.11% of trials being excluded. While the sum of trials per participant was 1875, the number of trials removed was on average 152 (*SD* = 132) per participant. One participant's data in a whole condition block (one-third of all trials) was removed due to EEG recording issues.

Linear mixed-effects models (LMMs; Baayen et al., 2008) tested the relationship between log-transformed naming latencies and the predictors using R (R Core Team, 2018) and the *lme4* package (Bates, Maechler, et al., 2015, version 1.1-21). Separate analyses were conducted for cycle 1 and cycles 2–5. We entered into the model as fixed effects the critical factor Semantic Blocking, and, for the analyses of presentation cycles 2–5, the control factor Presentation Cycle, and their interaction terms. The predictor Semantic Blocking was contrast coded to compare the semantically close to the unrelated condition (*close* vs. *unrelated*) and the semantically distant to the unrelated condition (*distant* vs. *unrelated*)[2]. The predictor Presentation Cycle was centered and entered as a continuous variable.

To account for random effects, our model included intercepts for participants and items and random slopes for the fixed effect terms. Models were initially run with a maximum random effects structure. Since the maximal model failed to converge, we set all correlation parameters to zero by using the double-bar syntax (cf. Kliegl, 2014). Applying singular value decomposition, this initial random effect structure was simplified by successively removing those random effects whose estimated variance was zero until the maximal informative model was identified (cf. Bates, Kliegl, et al., 2015).

For fixed effects, we report fixed effect estimates, 95% confidence intervals, and *t* values. Fixed effects are considered significant if $|t| \geq 1.96$ (cf. Baayen et al., 2008), but we also computed *p*-values by Satterthwaite approximation (using the *summary* function in the *lmerTest* package, version 3.1-1; Kuznetsova et al., 2017). For random effects, we report estimates of variance as well as the standard deviations. Goodness-of-fit statistics are also reported.

2.4.3 | Event-related potentials

The continuous EEG was recorded with 62 Ag/AgCl electrodes, arranged according to the extended 10/20 system, online referenced to an electrode at the left mastoid. The sampling rate was 500 Hz. To register eye movements and blinks, electrodes were placed near the left and right corner of both eyes and above and beneath the left eye. Electrode impedance was kept below 5 kOhm.

Eye movements and blink artifacts in the EEG signals were identified by employing the Multiple Source Eye Correction (MSEC) method implemented in the BESA Research software (Version 6.0, BESA GmbH, Gräfelfing, Germany; Berg & Scherg, 1994). After identifying eye-movements artifacts, the raw EEG data were submitted to BrainVision Analyzer (Version 2.1.2, Brain Products GmbH, Gilching, Germany) for preprocessing. Offline EEG was re-referenced using the common average reference. The identified spatiotemporal patterns reflecting eye-movements artifacts were corrected by a linear derivative. To reduce noise, a low-pass filter was applied (high cutoff = 30 Hz, 24 dB/oct). The data was then segmented based on the reference marker, including all necessary markers. An interval starting from 100 ms before the stimulus onset was used for baseline correction to exclude stimulus-independent activity at the beginning of the segment. Remaining artifacts were eliminated with an automatic artifact rejection procedure, which excluded segments with potentials exceeding 50 μV voltage steps per sampling point and a threshold of 200 μV. The EEG data were then segmented again in epochs of 1,300 ms, starting 100 ms before the onset of the stimulus, to specify conditions for single-trial analysis. The resulting segments arranged according to experimental conditions were exported to MATLAB (Version 2019b, The MathWorks Inc., Natick, Massachusetts) for speech artifact correction.

Speech artifact correction

To tackle the severe artifacts induced by speaking in the EEG signals (e.g., Brooker & Donald, 1980; Grözinger et al., 1975; Wohlert, 1993), we implemented a MATLAB toolbox capable of correcting articulation-related artifacts: residue iteration decomposition (RIDE; Ouyang et al., 2016). This toolbox decomposes ERPs into separate component clusters with different trial-to-trial variabilities (e.g., stimulus-locked, response-locked, and latency-variable component clusters). Articulation artifacts can be identified from the EEG signal based on their large amplitudes and highly variable trial-to-trial latencies. By implementing RIDE, we decomposed the ERPs into the stimulus-locked S-component (search time window 0 to 600 ms after stimulus onset) and the response-locked R-component (i.e., articulation-related artifacts; search time window ±300 ms from response time, see Figure 1). The R-component (per participant and per condition) was then subtracted from the original ERPs for every single trial. The resulting cleaned ERPs were then matched to

[2]We chose to set the unrelated condition to the baseline to keep our results comparable to other studies in the field. Yet where appropriate we also ran analyses with the distant condition as baseline. This did not change the general pattern of our findings. We report the central outcome of these analyses alongside our main results and give the full model outputs in the Supporting Information.

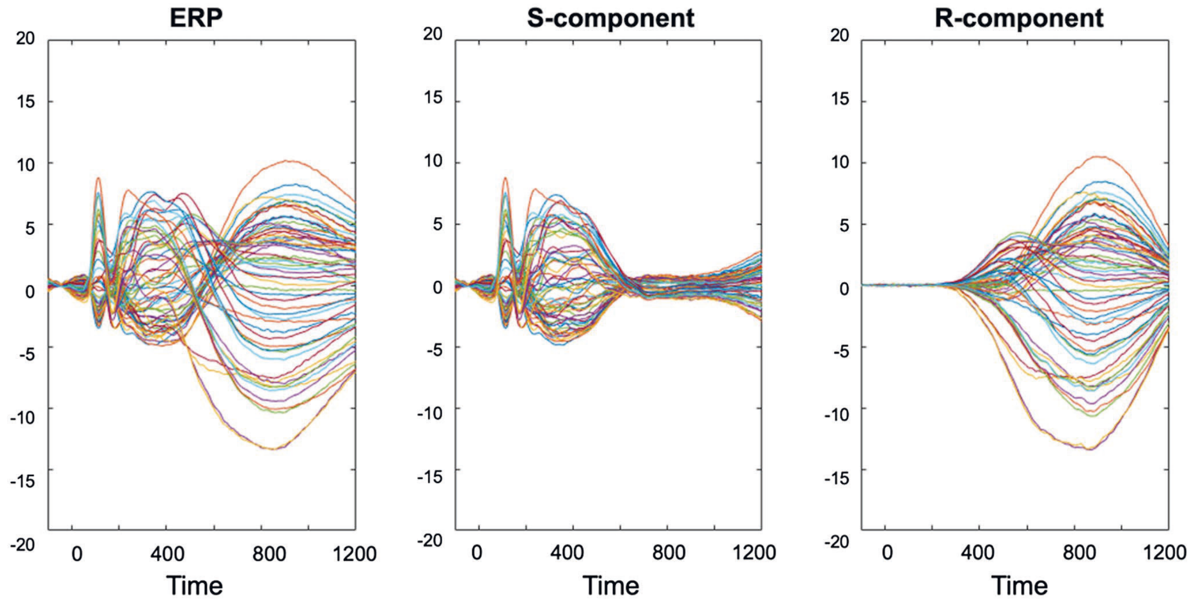

FIGURE 1 Component separation for artifact corrections with RIDE. The left plot shows the original ERPs prior to speech artifacts correction. The middle plot shows the S-component free of articulation-related noise, which was submitted to data analyses. The right plot shows the R-component, which was removed from the original ERPs

naming latencies on a trial-by-trial basis and exported to R for statistical analysis.

Analysis procedure

The general parameters and analysis procedure for models predicting ERP amplitudes were the same as the LMMs testing naming latencies, except that the predicted variable was replaced with the averaged EEG activities at the pre-defined ROIs and time windows.

Based on the hypothesis that conceptual priming should be strongest when participants name pictures for the first time in the semantically related contexts, likely restricted to the close context (cf. Abdel Rahman & Melinger, 2007; Scheibel & Indefrey, 2020), for cycle 1, we examined an ERP component reflecting the mechanism of object recognition and identification. Therefore, we analyzed EEG signals from the posterior sites, including electrodes TP9/10, P7/8, PO9/10, O1/2 (ROI for object recognition; Itier & Taylor, 2004) ranging from 140 to 180 ms after stimulus onset (the stage of visual complexity during picture naming; cf. Valente et al., 2014; see also other object recognition studies, e.g., Thorpe et al., 1996; Vogel & Luck, 2000).

For cycles 2–5, we hypothesized that lexical competition should be strongest when participants name pictures in semantically related contexts, particularly pictures with close relations. Here we examined the ERP amplitudes at the ROI and during the time window found in Aristei and colleagues' study (2011), in which brain activities were proposed to reflect changes during lexical retrieval in the blocked-cyclic naming paradigm. We selected two electrodes at the temporal-parietal sites, TP9 and TP10, as the ROI, and analyzed the EEG activities from 250 to 350 ms after stimulus onset.

In addition to our basic hypotheses and predictions that semantic facilitation in cycle 1 should be accompanied by a relatively early ERP modulation, and that lexical interference in cycles 2–5 should be accompanied by a relatively late ERP modulation, we took a step further to examine whether these two ERP modulations are active in parallel. This was based on the theoretical assumption that the concurrent processing of conceptual priming and lexical competition together contribute to the behavioral facilitatory or interfering blocking effects (cf. Swinging Lexical Network, Abdel Rahman & Melinger, 2009, 2019). In support of the trade-off hypothesis proposed in this framework, we should find concurrent traces of the early and late modulation in the selected ROIs across all cycles, with relative strengths. For this purpose, we separately ran a model testing the early modulation in cycles 2–5, as well as a model testing the late modulation in cycle 1.

2.4.4 | Relating behavior to brain activities

Assuming that ERPs reflect the underlying cognitive sources, whose changes can be observed behaviorally, the amplitude of ERPs relevant to lexical-semantic processing should serve as a good predictor for naming latencies. Another reason for conducting this brain-behavior analysis was to examine whether participants' naming behavior was really modulated by concurrent processing of conceptual priming and lexical competition across all cycles, and whether their naming behavior was modulated *together* by these two cognitive processes at the same time. To examine the first question, we entered the mean ERP amplitudes occurring in both early and late time windows as two fixed effects into a single LMM to predict log-transformed naming latencies. To examine the second question, we entered the interaction term between these two ERPs as another fixed effect on the naming latencies. Moreover, we recoded the predictor presentation cycle as a two-level categorical variable (*first* vs. *later*) to more precisely capture our research interest, that is, conceptual facilitation in the first cycle versus lexical interference in later cycles.

The random structure was selected following the same procedure as the other models described above. In order to reduce the complexity of the model so that the results could be more interpretable, we split the dataset according to the blocking condition. Since the results of both the naming latency and ERP models indicated that naming latencies in the distant condition did not vary much from the unrelated condition, here we only analyzed data from the close and unrelated conditions.

3 | RESULTS

3.1 | Accuracy

The overall accuracy was 99.82% in the first block, 99.95% in the second block, and 99.89% in the third block. The GLMM showed a slight trend of significance of the contrast Order 2 versus Order 1 ($\beta = 2.83$, $SE = 1.68$, $z = 1.68$, $p = .09$), and a null result for the contrast Order 3 versus Order 2 ($\beta = -1.66$, $SE = 1.75$, $z = -0.94$, $p = .34$). The finding indicates that participants' naming accuracy was not influenced by the order in which items were named in the close, distant or unrelated blocks.

3.2 | Naming latencies

3.2.1 | Cycle 1

In cycle 1, the mean naming latency in the close condition was 39 ms shorter than in the unrelated condition (semantic facilitation), while the naming latency in the distant condition was only 5 ms longer than in the unrelated condition (close: $M = 732$, $SD = 189$; distant: $M = 777$, $SD = 179$; unrelated: $M = 771$, $SD = 175$; see Figure 2). The descriptive statistics were confirmed by the identified LMM testing the semantic blocking effects

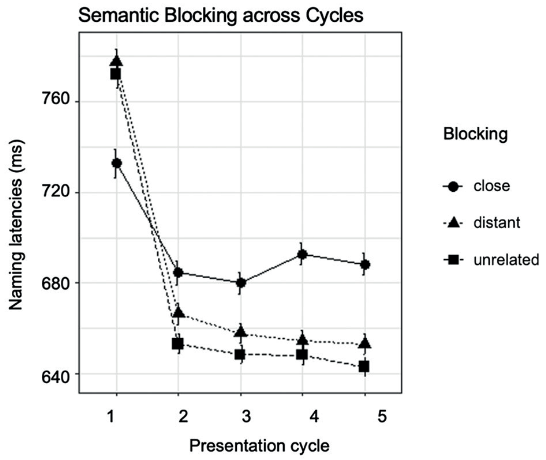

FIGURE 2 Naming latencies plotted against presentation cycles, grouped by semantic blocking condition. The figure shows that in the first cycle, participants named semantically closely related objects faster compared with naming distantly related or unrelated objects (semantic facilitation). From the second cycle onwards, the data pattern was reversed (semantic interference). The error bars refer to the 95% confidence intervals

in cycle 1. The model showed that the hypothesis-based fixed effect contrast close versus unrelated was statistically significant, whereas the contrast distant versus unrelated did not reach significance (see Table 1). Thus, supporting our hypothesis, we found semantic facilitation for semantically close items in cycle 1. Although there was no semantic context effect for semantically distant items, the unexpected finding is still consistent with our hypothesis that semantically distant items induce weaker effects—in this case, too weak to be detected.

3.2.2 | Cycles 2–5

From cycles 2 to 5, the mean naming latency in the close condition was 38 ms longer than in the unrelated condition, whereas in the distant condition, naming latency was only 9 ms longer than in the unrelated condition (semantic interference; close: $M = 686$, $SD = 156$; distant: $M = 658$, $SD = 140$; unrelated: $M = 648$, $SD = 135$; see Figure 2). The observed data patterns were confirmed by the identified LMM testing the semantic blocking effects in cycles 2–5. The model demonstrated that the fixed effect contrast close versus unrelated was statistically significant, whereas the contrast distant versus unrelated did not reach significance (see Table 2). This suggests that, as hypothesized, semantic interference arises in the semantically close condition; unexpectedly, no blocking effect was found in the semantically distant condition, possibly because the effect is too weak to be seen.

TABLE 1 Linear mixed-effects model of cycle 1 on log-transformed naming latencies, with the semantic blocking contrasts close versus unrelated and distant versus unrelated as predictors

Log-transformed naming latencies (cycle 1)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		0.014	−0.02 to 0.05	0.862	.393
Close versus unrelated		−0.064	−0.10 to −0.03	−3.376	.002**
Distant versus unrelated		0.006	−0.02 to 0.03	0.452	.655
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		0.005	0.070		
Close versus unrelated		0.007	0.085		
Distant versus unrelated		0.004	0.066		
Picture					
(Intercept)		0.008	0.094		
Close versus unrelated		0.005	0.076		
Residual		0.027	0.166		
Observations	7,536	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
		X^2	*df*	*p*	
Close versus unrelated		9.643	1	.0019**	
Coding formula in R					

```
Log RT in cycle 1 ~ Semantic Blocking + (1 + Semantic Blocking ||participant) + (1 + close
  versus unrelated || picture)
```

Abbreviations: *CI*, confidence interval; *SD*, standard deviation.

** $p < .01$.

Interestingly, the above model also revealed a main effect of the presentation cycle, reflecting an incremental speed up of naming latencies across cycles (numerically, there was a total decrease of 6 ms from cycles 2 to 5). However, inspection of the naming latencies across presentation cycles distinguished by blocking condition reveals a more complex picture. Specifically, naming latencies increased from cycles 2 to 5 by 3 ms in the semantically close condition but decreased over cycles by 13 ms in the semantically distant condition, and by 9 ms in the unrelated condition.

3.3 | Event-related potentials

3.3.1 | Testing the basic hypotheses: Electrophysiological traces of facilitation and interference

Posterior N1 in cycle 1

The mean amplitude at posterior sites in the close condition was 0.85 μV more negative than in the unrelated condition, while the amplitude in the distant condition was only 0.03 μV more negative than in the unrelated condition (close: $M = -0.33$, $SD = 6.17$; distant: $M = 0.49$, $SD = 6.21$; unrelated: $M = 0.52$, $SD = 6.15$).

The LMM testing for traces of facilitation in cycle 1 demonstrated a statistically significant effect of the a priori contrast close versus unrelated (see Table 3, Figure 3a[upper],e). Similar to the behavioral LMM, the contrast distant versus unrelated did not reach significance (see Figure 3a[lower],e). The direction of the effect indicates a stronger negativity during the close condition compared to the unrelated condition. This posterior negativity during 140–180 ms is analogous to the typical visual N1 activities (e.g., Itier & Taylor, 2004; Thorpe et al., 1996; Tokudome & Wang, 2012; Vogel & Luck, 2000) and is in line with the visual complexity stage during picture naming (cf. Valente et al., 2014). These results supported our hypothesis that closely related pictures induced larger ERP modulations compared to unrelated pictures; there were no modulations of the ERPs in the distant condition. This finding is unexpected but consistent with our hypothesis that semantically distant items yield weaker effects; in this case too weak to be detected.

TABLE 2 Linear mixed-effects model of cycles 2–5 on log-transformed naming latencies, with the semantic blocking contrasts, presentation cycle, and their interaction as predictors

Log-transformed naming latencies (cycles 2–5)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		0.001	−0.03 to 0.03	0.073	.942
Close versus unrelated		0.056	0.04 to 0.08	5.476	<.001***
Distant versus unrelated		0.012	−0.00 to 0.03	1.407	.170
Presentation cycle		−0.002	−0.00 to −0.00	−2.719	.006**
Close versus unrelated: cycle		0.008	0.00 to 0.01	4.272	<.001***
Distant versus unrelated: cycle		−0.001	−0.01 to 0.00	−0.929	.352
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		0.006	0.079		
Close versus unrelated		0.001	0.043		
Distant versus unrelated		0.001	0.040		
Picture					
(Intercept)		0.002	0.050		
Close versus unrelated		0.002	0.052		
Distant versus unrelated		0.001	0.032		
Residual		0.025	0.160		
Observations	33,757	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
		X^2		*df*	*p*
Close versus unrelated		21.23		1	<.001***
Presentation cycle		7.096		1	.007**
Close versus unrelated: cycle		18.241		1	<.001***
Coding formula in R					
`Log RT in cycles 2-5 ~ Semantic Blocking * Presentation Cycle + (1 + Semantic Blocking || participant) + (1 + Semantic Blocking || picture)`					

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

** $p < .01$; *** $p < .001$.

Posterior negativity in the P2/N2 time range in cycles 2–5

The mean amplitude at temporal-parietal sites in the close condition was 0.6 μV more negative than in the unrelated condition, while the amplitude in the distant condition was only 0.34 μV more negative than in the unrelated condition (close: $M = -1.99$, $SD = 7.25$; distant: $M = -1.7$, $SD = 7.25$; unrelated: $M = -1.38$, $SD = 7.47$).

The LMM testing for electrophysiological signatures of semantic interference in cycles 2–5 demonstrated a statistically significant effect of the a priori contrast close versus unrelated (see Table 4). The effect direction indicates a larger negativity in the close versus unrelated condition from cycles 2 to 5 (see Figure 3d[upper],h). The contrast distant versus unrelated was marginally significant (see Figure 3d[lower],h). The posterior negativity in the semantically close condition replicates the finding in Aristei and colleagues' study (2011), in which the negative modulation reflects the semantic interference during lexical retrieval induced by the blocked-cyclic naming paradigm. Additionally, the LMM also showed a significant main effect of presentation cycle, indicating a positive-going activity over the course of the cycles. Finally, the interaction between the contrast close versus unrelated and presentation cycle was not significant. These results support our hypothesis that closely related pictures induced larger ERP modulations compared to unrelated pictures. Although distantly related pictures seem to yield little effects, this is still consistent with our hypothesis that

TABLE 3 Linear mixed-effects model of cycle 1 on the ERP component N1, with the semantic blocking contrasts close versus unrelated and distant versus unrelated as predictors

N1 (cycle 1)					
Fixed effects					
Predictors		Estimates	95% CI	*t*	*p*
(Intercept)		0.294	−0.88 to 1.47	0.493	.627
Close versus unrelated		−1.043	−1.48 to −0.61	−4.695	<.001***
Distant versus unrelated		−0.183	−0.52 to 0.16	−1.057	.300
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		8.313	2.883		
Close versus unrelated		0.672	0.820		
Distant versus unrelated		0.230	0.480		
Picture					
(Intercept)		0.930	0.964		
Close versus unrelated		0.245	0.495		
Residual		24.354	4.935		
Observations	7,536	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
		X^2	*df*	*p*	
Close versus unrelated		16.322	1	<.001***	
Coding formula in R					

```
N1 in cycle 1 ~ Semantic Blocking + (1 + Semantic Blocking +Presentation Cycle || participant) +
   (1 + close versus unrelated || picture)
```

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

***$p < .001$.

semantically distant pictures induce weaker effects than the close pictures.

3.3.2 | Testing the theoretical assumption: Concurrent processing of conceptual priming and lexical competition across all cycles

Posterior negativity in the P2/N2 time range in cycle 1

The mean amplitude at temporal-parietal sites in the close condition was 1.49 µV more negative than in the unrelated condition, while the amplitude in the distant condition was only 0.45 µV more negative than in the unrelated condition (close: $M = -2.44$, $SD = 7.88$; distant: $M = -1.4$, $SD = 7.25$; unrelated: $M = -0.95$, $SD = 7.68$).

To test for traces of semantic interference in cycle 1, we ran an LMM predicting the posterior negativity in the P2/N2 time range for cycle 1. This model demonstrated a statistically significant effect of the contrast close versus unrelated (see Table 5), indicating a larger negativity in the close versus unrelated condition in cycle 1 (see Figure 3b[upper],f). The contrast distant versus unrelated was not significant (see Figure 3b[lower],f). These results supported our hypothesis that even in the first presentation cycle, where participants showed facilitated naming behavior (associated with N1), traces of lexical competition can still be found, as indexed by the presence of the P2/N2 component.

Posterior N1 in cycles 2–5

The mean amplitude at posterior sites in the close condition was 0.47 µV more negative than in the unrelated condition, while the amplitude in the distant condition was 0.26 µV more negative than in the unrelated condition (close: $M = -0.54$, $SD = 6.17$; distant: $M = -0.33$, $SD = 6.08$; unrelated: $M = -0.07$, $SD = 6.14$).

To test for traces of facilitation in cycles 2–5, we report the LMM predicting the N1 component for cycles 2–5. The model demonstrated a statistically significant effect of the close versus unrelated contrast (see Table 6, Figure 3c[upper],g). In contrast to the behavioral LMM, the distant versus unrelated contrast was also significant (see Figure

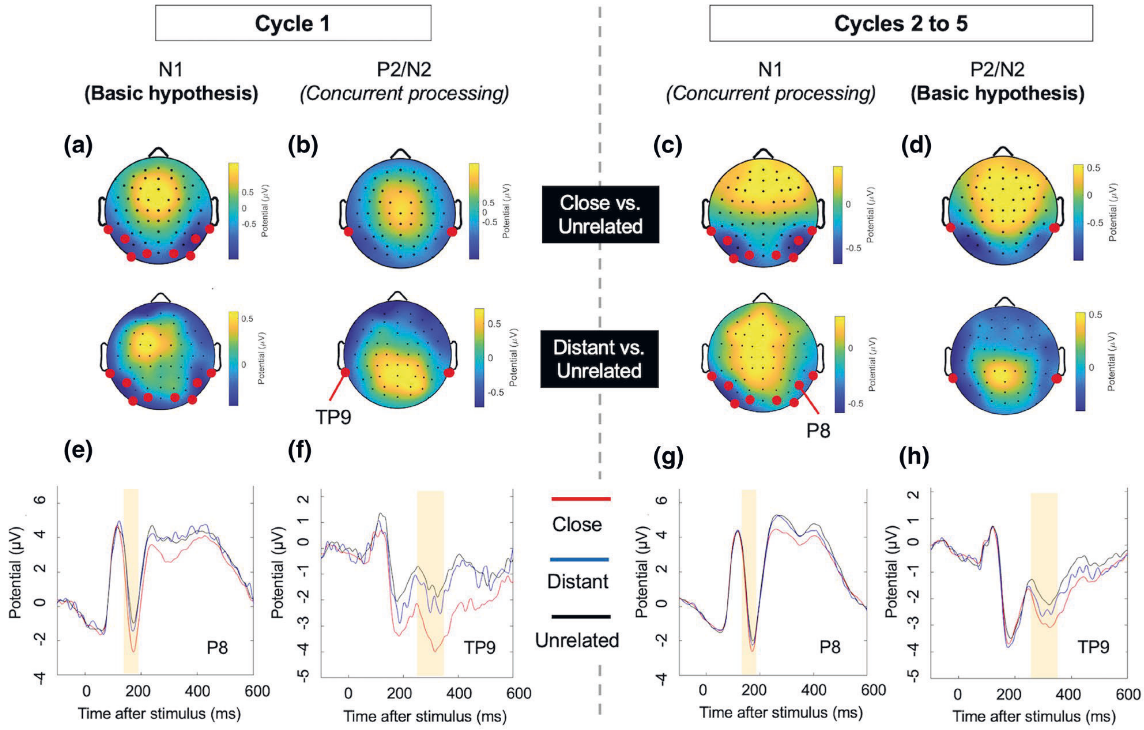

FIGURE 3 Electrophysiological results of cycle 1 and cycles 2–5. ROI for N1: TP9/10, P7/8, PO9/10, O1/2; ROI for the posterior negativity in the P2/N2 time range: TP9/10; both are highlighted with red dots in the topographies. (a) Posterior negativities from 140 to 180 ms in cycle 1; (b) temporal-parietal negativities from 250 to 350 ms in cycle 1; (c) posterior negativities from 140 to 180 ms in cycles 2–5; (d) temporal-parietal negativities from 250 to 350 ms in cycles 2–5; upper topographies illustrate the close versus unrelated contrast, and lower topographies illustrate the distant versus unrelated contrast. (e–h) illustrate the averaged brain activities in each semantic blocking condition at specific channels within the ROIs pre-defined for cycle 1 and cycles 2–5; the selected time windows of the ERP modulations are highlighted with yellow color

3c[lower],g), but the effect size was smaller than the close versus unrelated contrast. The direction of the effect indicates a stronger negativity during both the close and distant condition compared to the unrelated condition. Finding traces of N1 in later presentation cycles supports our hypothesis that even when participants show interference in their naming behavior, they experience easier object recognition in parallel.

3.3.3 | Predicting naming latencies by N1 and P2/N2

Until this step, the above LMMs testing the effect of semantic blocking condition on naming latencies and ERP amplitudes have demonstrated that both participants' behavioral and brain responses were indeed modulated by the semantic blocking condition, and to be more precise, by naming objects that are semantically close but not by semantically distant objects. Furthermore, we found indications that facilitatory processes, as indexed by N1, and interfering processes, as indexed by P2/N2 are concurrently active in both the first and later cycles. This provides first evidence for the trade-off between these processes as predicted by the Swinging Lexical Network model (cf. Abdel Rahman & Melinger, 2009, 2019).

To explore the predictive relationship between brain activities and naming responses across cycles, particularly when naming semantically closely related objects, we set up an LMM including presentation cycle, N1, P2/N2, as well as their interaction terms as fixed effects to predict log-transformed naming latencies in the close condition (see Table 7). This model showed significant effects of both N1 and P2/N2. The effect directions indicate that the stronger (more negative) the N1, the quicker the participants name the closely related pictures. In contrast, the stronger (more negative) the P2/N2, the slower the participants name the closely related pictures. The results support our hypotheses that N1 reflects the process of object recognition/identification, while P2/N2 reflects the process of lexical selection; furthermore, the two processes modulate naming latencies in parallel across all cycles.

TABLE 4 Linear mixed-effects model of cycles 2–5 on the posterior negativity in the P2/N2 time range, with the semantic blocking contrasts, presentation cycle, and their interaction as predictors

Posterior negativity in the P2/N2 time range (cycles 2–5)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		−1.708	−2.62 to −0.80	−3.678	.001**
Close versus unrelated		−0.601	−0.93 to −0.27	−3.591	.001**
Distant versus unrelated		−0.264	−0.54 to 0.01	−1.890	.070
Presentation cycle		0.182	0.08 to 0.29	3.457	.002**
Close versus unrelated: cycle		0.051	−0.09 to 0.19	0.730	.465
Distant versus unrelated: cycle		0.095	−0.04 to 0.23	1.355	.175
Random effects					
Groups		*Variance*	*SD*		
Participant					
(Intercept)		4.987	2.233		
Close versus unrelated		0.501	0.708		
Distant versus unrelated		0.308	0.555		
Presentation cycle		0.046	0.216		
Picture					
(Intercept)		0.825	0.908		
Close versus unrelated		0.126	0.355		
Residual		34.713	5.891		
Observations	33,757	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
		X^2	*df*	*p*	
Close versus unrelated	10.397	1		.001**	
Presentation cycle	9.6422	1		.001**	
Close versus unrelated: cycle	0.533	1		.465	
Coding formula in R					
`P2/N2 in cycles 2-5 ~ Semantic Blocking * Presentation Cycle + (1 + Semantic Blocking + Presentation Cycle || participant) + (1 + close versus unrelated || picture)`					

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

** $p < .01$.

In addition, there was a significant effect of presentation cycle, which indicates a general drop of naming latencies in later cycles compared to the first one, likely due to repetition priming.

Furthermore, we found a significant interaction between N1 and P2/N2. Judging from the effect pattern (see Figure 4), this result indicates that the N1 modulation on naming latencies is most salient when P2/N2 is weak, while the P2/N2 modulation on naming latencies is most salient when N1 is strong. This supports the theoretical hypothesis that there is a trade-off between concurrent processing of conceptual priming and lexical competition, respectively represented by N1 and P2/N2, affecting naming latencies with facilitatory and interfering modulations.

As a control analysis, we conducted a similar LMM for the unrelated condition including the same fixed effects to predict log-transformed naming latencies (see Table 8)[3]. Similar to the model testing data in the close condition,

[3]Since we had unbalanced numbers of ROIs selected for the two ERPs (8 for N1 and 2 for P2/N2), we split the ROIs of N1 into all possible combinations of electrodes from each hemisphere, and iterated the analysis across all combinations such that we entered the same amount of data into the N1 and N2/P2 analyses. This resulted in a total of 16 sub-analyses. In the end, 15 out of all sub-analyses identified a significant interaction between N1 and P2/N2, similar to the effects reported in Tables 7 and 8, with the only exception being marginally significant (sub-ROI of N1: O1 and P8). We thus concluded that unbalanced numbers of ROIs did not affect our findings. We would like to thank an anonymous reviewer for recommending this analysis.

TABLE 5 Linear mixed-effects model of cycle 1 on the posterior negativity in the P2/N2 time range, with the semantic blocking contrasts, presentation cycle, and their interaction as predictors

Posterior negativity in the P2/N2 time range (cycle 1)						
Fixed effects						
Predictors		Estimates	95% *CI*		*t*	*p*
(Intercept)		−1.656	−2.80 to −0.51		−2.829	<.001***
Close versus unrelated		−1.505	−1.94 to −1.07		−6.755	<.001***
Distant versus unrelated		−0.342	−0.74 to 0.05		−1.708	.097
Random effects						
Groups		Variance	*SD*			
Participant						
(Intercept)		7.856	2.804			
Close versus unrelated		0.328	0.573			
Distant versus unrelated		0.221	0.471			
Picture						
(Intercept)		1.235	1.111			
Close versus unrelated		0.796	0.892			
Residual		37.245	6.102			
Observations	7,536	$N_{participant}$	24		$N_{picture}$	125
Likelihood ratio test						
		X^2	*df*		*p*	
Close versus unrelated	27.892	1			<.001***	
Coding formula in R						

```
P2/N2 in cycle 1 ~ Semantic Blocking + (1 + Semantic Blocking ||
   participant) + (1 + close versus unrelated || picture)
```

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

***$p < .001$.

this model also showed significant effects of both N1 and P2/N2. The effect directions again demonstrated that the stronger the N1, the shorter the naming latencies; the stronger the P2/N2, the longer the naming latencies. The results here indicate that N1 is associated with a general recognition/identification process of objects, and that P2/N2 is associated with a general lexical selection process - both processing stages modulate naming behavior regardless of semantic blocking condition. Crucially, the model did not show a significant interaction between N1 and P2/N2.

To directly compare the effect sizes of this interaction term across two LMMs, we refit both models with a standardized version of the data (using the *standardized_parameters* function in the R-package *effectsize*, Version 0.4.4, Ben-Shachar et al., 2020). The standardized coefficient of the interaction between two ERPs was .02 in the close model, while the coefficient of the interaction was only .006 in the unrelated model. The absence of the interactive modulation of the two ERP components together on naming latencies is the only difference from the close model: It indicates that in the unrelated condition, naming behavior is not affected by a trade-off between conceptual priming and lexical competition, which occurs exclusively in the close condition.

Considering that close and distantly related items may share associative relations (co-existing in the same space, e.g., live in the forest) while unrelated items do not, we also ran an LMM predicting naming latency by N1 and P2/N2 amplitudes for the distant condition. The aim of this analysis was for direct comparison between close and distant relations. Critically, we found no interaction between both ERPs, as in the model for the unrelated condition reported above. The absence of any influence of the joint modulation of the two ERPs on naming latencies, which was exclusively observed in the close condition, supports our hypothesis that the behavioral semantic blocking effect was determined by a trade-off between priming and lexical competition. The supplemental analyses and results can be found in OSF via the link provided in the Method section.

4 | DISCUSSION

The present study tested the impact of semantic similarity on different planning stages during overt picture naming

TABLE 6 Linear mixed-effects model of cycles 2–5 on the ERP component N1, with the semantic blocking contrasts close versus unrelated and distant versus unrelated as predictors

N1 (cycles 2–5)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		−0.313	−1.41 to 0.79	−0.557	.582
Close versus unrelated		−0.471	−0.68 to −0.27	−4.482	<.001***
Distant versus unrelated		−0.337	−0.59 to −0.08	−2.611	.015*
Presentation cycle		−0.010	−0.10 to 0.08	−0.227	.822
Close versus unrelated: cycle		0.073	−0.04 to 0.19	1.272	.203
Distant versus unrelated: cycle		0.053	−0.06 to 0.17	0.905	.365
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		7.362	2.713		
Close versus unrelated		0.164	0.405		
Distant versus unrelated		0.287	0.536		
Presentation cycle		0.034	0.185		
Picture					
(Intercept)		1.028	1.014		
Residual		23.946	4.893		
Observations	33,757	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
		X^2	*df*	*p*	
Close versus unrelated	14.626	1		<.001***	
Distant versus unrelated	5.841	1		.015*	
Coding formula in R					

```
N1 in cycles 2–5 ~ Semantic Blocking * Presentation Cycle + (1 + Semantic Blocking +
   Presentation Cycle || participant) + (1 | picture)
```

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

* $p < .05$; ***$p < .001$.

in the blocked cyclic naming paradigm with behavioral and electrophysiological indexes. Furthermore, this study tested the trade-off assumption between concurrently active processes of conceptual priming and lexical competition that may underlie the observable behavioral blocking effects when naming semantically related pictures. In the following, we start with the discussion separately for cycle 1 and cycles 2–5, for which we predicted semantic facilitation and interference, respectively. We then turn to discuss evidence of concurrent modulations of the two planning stages that appear to highly interact with each other, causing opposite effects on naming latencies across all cycles.

4.1 | Semantic facilitation and N1 in cycle 1

In cycle 1, we observed semantic facilitation in the semantically close condition. This confirms Navarrete and colleagues' previous report (2012, Experiment 1) of initial facilitation when named objects were semantically close to each other. In contrast, we found no facilitation in the semantically distant condition, which indicates that the level of semantic similarity needs to surpass some similarity threshold to induce semantic facilitation in the blocked-cyclic naming paradigm. Our findings, therefore, add to the accumulating evidence that high semantic similarity enhances semantic context effects.

Object recognition may involve perceptual as well as conceptual processes, and thus can be assumed to take place before 200 ms after stimulus onset (e.g., Thorpe et al., 1996; Tokudome & Wang, 2012; Valente et al., 2014; Vogel & Luck, 2000). We examined this early object identification process in cycle 1 by looking at the N1 component that falls in this time range (e.g., Itier & Taylor, 2004). An example of integrated processing of

TABLE 7 Linear mixed-effects model on log-transformed naming latencies in the close condition, with presentation cycle, N1, P2/N2 and their interaction as predictors

Log-transformed naming latencies (close condition)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		0.030	0.00 to 0.07	2.163	.038*
Presentation cycle		−0.061	−0.08 to −0.04	−5.431	<.001***
N1		0.002	0.00 to 0.00	4.710	<.001***
P2/N2		−0.002	−0.00 to −0.00	−6.129	<.001***
N1 × P2/N2		< 0.001	0.00 to 0.00	2.795	.005**
Cycle × N1		< −0.001	−0.00 to 0.00	−0.578	.563
Cycle × P2/N2		< −0.001	−0.00 to 0.00	−0.220	.825
N1 × P2/N2 × Cycle		< −0.001	−0.00 to 0.00	−1.678	.093
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		0.006	0.082		
Presentation cycle		0.001	0.041		
Picture					
(Intercept)		0.005	0.072		
Presentation cycle		0.005	0.070		
Residual		0.029	0.172		
Observations	13,943	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
	X^2	*df*	*p*		
Presentation cycle	23.679	1	<.001***		
N1	30.430	1	<.001***		
P2/N2	59.247	1	<.001***		
N1 × P2/N2	5.006	1	.025*		
Coding formula in R					
`Log RT in close condition ~ Presentation Cycle * N1 * P2/N2 + (1 + Presentation Cycle | participant) + (1 + Presentation Cycle | picture)`					

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

* $p < .05$; ** $p < .01$; *** $p < .001$.

perceptual and conceptual priming is a study demonstrating that one's native language determines what one consciously perceives: Maier and Abdel Rahman (2018) found that participants distinguished better between verbally marked color contrasts than unmarked color contrasts, while participants whose native language does not distinguish between the same color contrasts did not show such boosted perception during categorization. Since perceptual and conceptual processing interact early on (e.g., Dell'Acqua et al., 2010; Lupyan & Ward, 2013; Maier & Abdel Rahman, 2018; Proverbio et al., 2007), in the present study, we do not distinguish between purely perceptual and purely conceptual identification, but instead, regard perceptual or conceptual effects as a whole that may aid identification.

The behavioral pattern of semantic facilitation was in line with the electrophysiological modulations as a larger posterior N1 was present only for the semantically close but not for the distant condition when compared to the unrelated condition. Moreover, enhanced N1 amplitudes predicted shorter naming latencies, confirming that participants benefited from conceptual priming in cycle 1. In cycle 1, participants encounter the stimuli for the first time within the main naming task and hence recognition is likely to be most difficult in

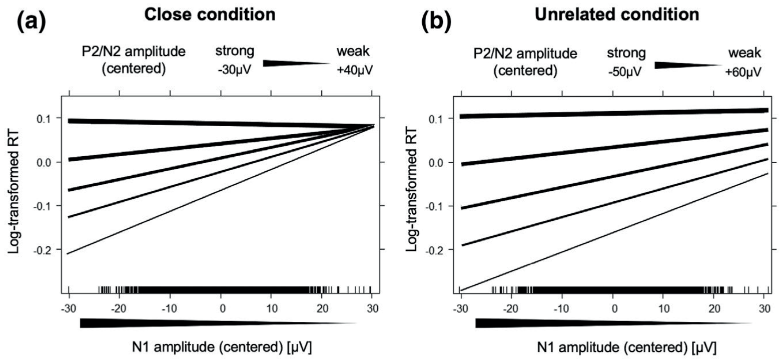

FIGURE 4 Estimated interactive modulation of N1 and P2/N2 on log-transformed naming latencies. This figure demonstrates a trade-off between the estimated N1 and P2/N2 modulations on naming latencies across all cycles in the semantically close naming condition, which is absent in the unrelated naming condition. Panel A shows the interactive modulation of N1 and P2/N2 on naming latencies in the close condition: On the one hand, the facilitatory N1 modulation is most salient when P2/N2 is weak (less negative). On the other hand, when the N1 is weak (more positive) even a weak P2/N2 yields strong inhibitory effects. Panel B shows the estimated interactive modulation of the two ERPs on naming latencies in the control analysis (unrelated condition); this interaction does not improve model fit. Both plots were initially generated using the *effect* function in the *effects* package (version 4.1-4, Fox & Weisberg, 2018) implemented in R based on the estimated effects of the LMM, and modified for better illustration of the findings

this cycle[4]. Accordingly, participants benefit from the semantic context in a top-down fashion (Abdel Rahman & Melinger, 2007; Bar et al., 2006; Scheibel & Indefrey, 2020). Furthermore, enhanced N1 amplitude is associated with objects of high inter-object similarity during object recognition learning (Tokudome & Wang, 2012). In the context of our study, larger N1 may imply reduced object recognition efforts, supporting our proposal that co-activated conceptual features from the semantically close condition facilitate object recognition, leading to facilitated naming responses in cycle 1.

4.2 | Lexical interference and P2/N2 in cycles 2–5

In cycles 2–5, a semantic interference effect emerged only for objects that were semantically close to each other. Similar to the absence of facilitation in cycle 1 in the distant condition, the absence of interference in later cycles for the distant relations again indicates a similarity threshold for the context effect to emerge. This is in line with a continuous naming study using the same pictures which demonstrated cumulative interference over ordinal naming positions exclusively with close, but not distant, relations (Rose & Abdel Rahman, 2017). Interestingly, a study using the picture-word interference paradigm to manipulate semantic similarity, again using the same pictures and relations, found significant interference in the distant condition, although they were weaker than in the close condition (Rose et al., 2019). Thus, using the same materials and semantic relations, significant interference effects in naming latencies were only found for semantically close relations in the continuous and blocked cyclic task, and interference effects were stronger for close relative to distant relations in the PWI task.

Similarly, in all picture-naming paradigms, there is converging evidence from ERPs reflecting the presence of semantic interference for semantically close but not for distant relations. Interestingly, however, the polarity of these ERPs appears to vary between paradigms. In studies using the continuous naming and PWI paradigms to test the traces of lexical interference effects, a posterior positivity is reported, starting around 200–250 ms (e.g., Costa et al., 2009; Rose & Abdel Rahman, 2017; Rose et al., 2019). In contrast, in the blocked naming paradigm used here, we find a posterior *negativity* around the same time window that is likely to reflect the lexical selection process. Indeed, a similar posterior negativity has been previously reported in other studies using this same naming paradigm (e.g., Aristei et al., 2011; Maess et al., 2002). We propose that these two posterior effects with opposite polarities in the 200–250 ms time window are analogs of one another, both reflecting lexical selection in their respective naming paradigms. This proposal is supported by the fact that the strength of the present negativity predicts naming latencies and because the time course and the posterior topographical distribution are similar in both ERP modulations.

[4]We are aware that participants might build up a response set, storing it in working memory during the first cycle. The retrieval of the temporarily stored response set might be most helpful for closely related items, leading to the observed facilitation. This view can be well integrated with our proposal of a more beneficial semantic context aiding object recognition when naming semantically closely related pictures. However, the investigation of working memory is beyond the range of the present study.

TABLE 8 Linear mixed-effects model on log-transformed naming latencies in the unrelated condition, with presentation cycle, N1, P2/N2 and their interaction as predictors

Log-transformed naming latencies (unrelated condition)					
Fixed effects					
Predictors		Estimates	95% *CI*	*t*	*p*
(Intercept)		0.045	0.01 to 0.08	2.566	.015*
Presentation cycle		−0.185	−0.21 to −0.16	−15.027	<.001***
N1		0.001	0.00 to 0.00	4.780	<.001***
P2/N2		−0.002	−0.00 to −0.00	−6.489	<.001***
N1 × P2/N2		<0.001	−0.00 to 0.00	1.013	.311
Cycle × N1		<0.001	−0.00 to 0.00	0.644	.519
Cycle × P2/N2		−0.001	−0.00 to 0.00	−1.926	.054
N1 × P2/N2 × Cycle		<0.001	−0.00 to 0.00	0.257	.797
Random effects					
Groups		Variance	*SD*		
Participant					
(Intercept)		0.006	0.081		
Presentation cycle		0.002	0.046		
Picture					
(Intercept)		0.004	0.070		
Presentation cycle		0.006	0.077		
Residual		0.023	0.152		
Observations	13,925	$N_{participant}$	24	$N_{picture}$	125
Likelihood ratio test					
	X^2	*df*	*p*		
Presentation cycle	63.914	1	<.001***		
N1	48.154	1	<.001***		
P2/N2	101.440	1	<.001***		
N1 × P2/N2	1.848	1	.174		
Coding formula in R					
`Log RT in unrelated condition ~ Presentation Cycle * N1 * P2/N2 + (1 + Presentation Cycle | participant) + (1 + Presentation Cycle | picture)`					

Abbreviations: *CI*, confidence intervals; *SD*, standard deviation.

* $p < .05$; *** $p < .001$.

We are aware that other blocked-cyclic studies investigating the interference effects have reported a posterior positivity during the same time window, but these studies either found no correlation between the observed ERP and the blocking effects (Janssen et al., 2011) or did not report correlation tests (Wang et al., 2018). Thus, the relationship between the reported posterior positivity and the behavioral effects in these studies remains unclear. In the present study, we provide evidence for a predictive relationship between the posterior negativity and the behavioral responses in this specific paradigm. We demonstrated that stronger P2/N2 predicts longer RTs, and importantly, this posterior negativity ERP is modulated by N1 amplitude exclusively in semantically close condition. We take this as evidence of the trade-off between conceptual priming (N1 facilitatory effect) and lexical competition (P2/N2 interfering effect), whose context effects take place in parallel and become behaviorally observable when participants name categorically closely related objects. Our results therefore support the claim that the negativity found in the blocked-cyclic paradigm and the positivity found in other picture-naming paradigms essentially reflect the same underlying processes and are, quite literally, two sides of the same coin.

Although semantic interference in the blocked-cyclic paradigm typically does not accumulate over cycles, we replicate the increasing interference that has been reported before (e.g., Belke, 2008; Schnur et al., 2006, 2009). Although gradually increased semantic interference in the close condition was observed behaviorally, evidence for a correspondingly increasing N2 amplitude in the close condition was missing. A potential explanation may be that the detected effect was too weak to be captured with EEG measurement due to a noisier signal than naming latency, since the behavioral estimates of the effect of Presentation Cycle on Semantic Blocking were small (yet statistically significant). A similar speculation has been made in a PWI paradigm to explain the absence of ERP underlying the weaker yet statistically significant semantic interference in the distant condition compared with the close condition, where the ERP was significant (Rose et al., 2019).

4.3 | Concurrent conceptual priming and lexical competition

Overall, we find a pattern of initial semantic facilitation associated with an enhanced N1 amplitude in cycle 1, followed by interference, associated with a posterior negativity in the P2/N2 time range, in cycles 2–5 for the semantically close relations. Based on the theoretical assumption that semantic contexts should induce conceptual priming and lexical competition within each trial, we should find traces of lexical competition also in cycle 1 (despite overall facilitation), and we should find traces of conceptual priming also in cycles 2–5 (despite overall interference). As argued in the Swinging Lexical Network account (cf. Abdel Rahman & Melinger, 2009, 2019), net effects of semantic contexts are always composed of a trade-off between conceptual priming and lexical competition, with overall facilitation if priming dominates and overall interference if competition dominates. Indeed, for the close condition, we find an enhanced N1 amplitude (related to easier object recognition/identification) not only in cycle 1 but also in cycles 2–5. Similarly, we find an enhanced P2/N2 (taken to reflect lexical selection) not only in cycles 2–5 but also in cycle 1.[5]

[5]Based on the estimated coefficients, however, the effect of P2/N2 is larger in the first presentation cycle compared to the effect in cycles 2–5. We have two explanations for this: (1) Due to the nature of EEG, there might be a physiological carry-over effect; that is, a large N1 in an earlier time window in cycle 1 contributes to an enhanced amplitude of P2/N2 in a later time window. We entered N1 as a covariate into the LMMs predicting P2/N2, and vice versa, to address the concern whether these two ERPs are dependent on each other. Across all cycles, N1 and P2/N2 predicted each other to a large degree. This implies that the larger P2/N2 in the first presentation cycle seems to result from the strong activation of N1. (2) Neural-physiological response tends to be stronger at the first encounter with the stimuli and becomes weaker later on (repetition suppression). To address this concern, block order was also included as an extra covariate in the above-mentioned LMMs. Since block order does not change the semantic blocking effects, this finding indicates that the stronger amplitude of P2/N2 observed in the first presentation cycle is less likely to result from repetition suppression.

Predicting naming behavior with the two ERP components, we find that stronger N1 leads to faster naming and stronger P2/N2 leads to slower naming. This holds for the related (close relation) and unrelated condition in all presentation cycles, revealing general effects of object identification/conceptualization on one hand, and lexical selection on the other. While the conceptual facilitation-related N1 and the lexical competition-related P2/N2 modulate naming latencies in parallel, crucially, their interplay determines the overall naming latencies: N1, related to object recognition, facilitates naming the most when the interfering P2/N2 is weak; when the facilitatory N1 is weak, even a weak P2/N2 yields strong interfering effects. Such a joint, interactive modulation on naming latency is exclusively observed for semantically closely related condition, but not for unrelated condition. This functionally related effect of related contexts nicely captures the trade-off assumption posited by the Swinging Lexical Network account, allowing us to dissociate how conceptual priming and lexical competition jointly affect naming behavior in different semantic contexts.

Taken together, these findings provide supporting evidence for concurrent conceptual priming (as evidenced by N1) and lexical competition (as reflected in the posterior negativity in the P2/N2 time range), in line with previous evidence on parallel processing at different speech planning stages (e.g., Abdel Rahman & Sommer, 2003; Abdel Rahman et al., 2003; Feng et al., 2021; Strijkers et al., 2017). In cycle 1, parallel to the facilitated object recognition, speakers also experience lexical competition. Presumably, the conceptual priming wins out over the lexical competition, producing a net effect that is observed as semantic facilitation. In later cycles, speakers may still profit from the context brought by the semantically close objects, while experiencing lexical competition at the same time. In these cycles, conceptual priming is less strong while lexical competition persists, which results in overall lexical interference. Although no interference was observed in later presentation cycles for the distant blocks, the N1 amplitude was still associated with naming latencies. This is another indication of the trade-off between conceptual priming and lexical competition, with the two effects canceling each other out. All in all, conceptual facilitation brought by semantic features in the distant condition does not seem to surpass the threshold for the blocking effect to emerge.

To further address the differences between close and distantly related items we applied, as an additional manipulation check, a distributional semantic model as a measure of semantic relatedness. This model computes cosine similarity between exemplars within stimuli sets and measures the frequency of the exemplars co-occurring under similar linguistic contexts based on a selected semantic space (cf. Günther et al., 2015). Confirming our manipulation, the selected closely related items are assessed as more inter-related, compared with the distantly related items. A Pearson's correlation test showed an overall positive correlation between naming latencies and cosine similarity values in naming cycles 2–5 ($R^2 = .19$, $p < .001$). Critically, the correlation was found only in the close condition ($R^2 = .18$, $p < .001$) but not in the distant condition ($R^2 = .01$, $p = .12$). Moreover, entering cosine similarity values into the LMMs to predict naming latencies, the output shows that this predictor was only significant in the close condition (close: $\beta = 0.27$, $p < .001$; distant: $\beta = 0.11$, $p = .11$). This confirms our earlier analyses and conclusions that the influence of semantic similarity arises with sufficient semantic feature overlap. The more similar items are the stronger is the induced lexical interference.

In our design, the order of the semantic blocking conditions was counterbalanced across participants. However, due to the block-wise feature, participants might have been tacitly aware that some items were related while some were not. To ensure that the semantic blocking effects were not modulated by the order of blocking condition assignment, we entered block order as a co-variate into the original LMMs as well as its interaction with semantic blocking (the output of the analyses can be found online at OSF, link provided in the Method section). These control analyses showed that the reported effects remained robust when including block order as a co-variate. Only in the first presentation cycle, ERP effects in the distant condition seemed to be influenced by block order; since no corresponding behavioral effects were observed, we refrain from further speculation on this interaction.

4.4 | Implications on theories of lexical selection

As proposed by Oppenheim and Nozari (2021), one probably cannot distinguish between competitive and non-competitive accounts of lexical selection with the blocked-cyclic design, and we do not intend to do so in the present study. From the point of view of Oppenheim and colleagues' Dak Side model (Oppenheim et al., 2010), which does not assume direct competitive lexical selection process, their error-based incremental learning mechanism may also account for our findings in later cycles, at least behaviorally. In the case of naming related objects, the connections between concept and target lexical representation get strengthened once the target word is selected, while connections between the categorical concept and the to-be-named competitors get weakened. The learning algorithm takes into account the weight changes and operates in the upcoming trials, lowering initial activations of lexical representation of the competitors, thereby slowing down lexical selection. All in all, the lexical interference in later cycles reported here can be explained by the Dark Side model.

Nonetheless, our findings of concurrent modulations of N1 and P2/N2, do not speak to Oppenheim's learning-based account. The limitation is that we based our hypotheses on the competitive Swinging Lexical Network account, and therefore chose regions and time window of interests accordingly. Since the Dark Side model does not, to our knowledge, assume facilitatory conceptual processing, the finding of N1 in an early time window provides little insight to the model. On top of that, it is difficult to argue that the reported posterior negativity reflects both the excitatory/inhibitory connections during lexical activation and selection processes because as its amplitude grows, naming latencies clearly get slower. In short, future studies are needed to specifically target the electrophysiological traces relevant to the proposal of the Dark Side model.

To conclude, the present study demonstrates that in a blocked-cyclic naming task, speakers initially identify semantically closely related objects quicker, but are hampered in later object naming. Such effects require sufficient overlapping semantic features to emerge because semantically distantly related objects induce no behavioral differences. That is, high semantic similarity induces strong semantic context effects, with facilitated processing during first presentation and lexical interference in later presentations. The electrophysiological evidence indicates easier object recognition underlying the initial facilitation around 140–180 ms after stimulus onset, and interfering effects in the time range between 250 and 350 ms. Moreover, the N1 component and the posterior negativity in the P2/N2 time range jointly modulate behavioral responses and affect each other's strength, whether or not the context effect eventually emerges as semantic facilitation or lexical interference. These functionally related effects support the idea that there is always a trade-off between concurrent conceptual priming and lexical competition upon naming closely related objects. The current findings contribute to the accumulating literature on the influence of semantic similarity on context effects during language production, and relate the behavioral facilitatory and interfering blocking effects to ERP components that reflect different but interacting planning stages during naming in the blocked cyclic paradigm.

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CONFLICT OF INTEREST

We have no conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

Hsin-Pei Lin: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Software; Visualization; Writing – original draft. **Anna Katharina Kuhlen:** Conceptualization; Formal analysis; Investigation; Methodology; Project administration; Supervision; Writing – original draft. **Alissa Melinger:** Conceptualization; Investigation; Methodology; Writing – review & editing. **Sabrina Aristei:** Conceptualization; Investigation; Methodology; Writing – review & editing. **Rasha Abdel Rahman:** Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Supervision; Writing – original draft.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.
Supplemental analyses & results

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APPENDIX A.

COMPLETE LIST OF STIMULI

Tiere (animals)				
Vögel (birds)	**Fische (fish)**	**Insekten (insects)**	**Huftiere (ungulates)**	**Affen (apes)**
Adler (eagle)	Hai (shark)	Fliege (fly)	Kamel (camel)	Schimpanse (chimpanzee)
Kolibri (hummingbird)	Aal (eel)	Biene (bee)	Reh (roe deer)	Pavian (baboon)
Papagei (parrot)	Forelle (trout)	Schmetterling (butterfly)	Pferd (horse)	Gorilla (gorilla)
Geier (volture)	Rochen (ray)	Hirschkäfer (stag beetles)	Esel (donkey)	Orang-Utan (orangutan)
Eule (owl)	Lachs (salmon)	Ameise (ant)	Schaf (sheep)	Mandrill (mandrill)
Kleidung (cloth)				
Kopfbedeckung (headwear)	**Mäntel (coats)**	**Schmuck (jewelry)**	**Schuhe (shoes)**	**Unterwäsche (underwear)**
Turban (turban)	Mantel (coat)	Armreif (bracelet)	Stiefel (boot)	BH (bra)
Hut (hat)	Jacke (jacket)	Kette (chain)	Pumps (court shoe)	Tanga (thong)
Mütze (wooly hat)	Poncho (poncho)	Ohrring (earring)	Turnschuhe (gym shoe)	Socke (socks)
Cappy (cap)	Anorak (anorak)	Brosche (brooch)	Clogs (clogs)	Korsett (corset)
Zylinder (top hat)	Sakko (suit jacket)	Diadem (diadem)	Mokassins (moccasins)	Unterhemd (vest)
Lebensmittel (food)				
Obst (fruits)	**Getränke (drinks)**	**Pilze (mushrooms)**	**Kräuter (herbs)**	**Süßigkeiten (sweets)**
Apfel (apple)	Tee (tea)	Pfifferling (chanterelle)	Basilikum (basil)	Kuchen (cake)
Birne (pear)	Milch (milk)	Steinpilz (cep)	Petersilie (parsley)	Eis (ice cream)
Kirsche (cherry)	Bier (beer)	Morchel (morel)	Dill (dill)	Praline (praline)
Trauben (grapes)	Wein (wine)	Champignon (mushroom)	Schnittlauch (chives)	Bonbon (candy)
Mandarine (tangerine)	Cocktail (cocktail)	Bovist (puffball)	Rosmarin (rosemary)	Lakritze (licorice)
Möbel (furniture)				
Sitzen (sit)	**Liegemöbel (reclining furniture)**	**Aufbewahrungs möbel (storage furniture)**	**Sanitär (sanitary)**	**Textil (textile)**
Couch (couch)	Bett (bed)	Regal (shelf)	Badewanne (bathtub)	Perserteppich (Persian carpet)
Hocker (stool)	Futon (futon)	Kleiderschrank (wardrobe)	Pissoir (urinal)	Vorhang (curtain)
Ohrensessel (wing chair)	Liege (day bed)	Vitrine (showcase)	Waschbecken (sink)	Rollo (blind)

Tiere (animals)				
Vögel (birds)	**Fische (fish)**	**Insekten (insects)**	**Huftiere (ungulates)**	**Affen (apes)**
Eckbank (corner seat)	Hängematte (hammock)	Truhe (chest)	Dusche (shower)	Badvorleger (mat)
Bürostuhl (office chair)	Schlafsofa (sofa bed)	Sideboard (sideboard)	Bidet (bidet)	Tischdecke (tablecloth)
Werkzeug (tool)				
Küche (kitchen)	**Bauernhof (farm)**	**Friseur (hairdresser)**	**Arzt (doctor)**	**Büro (office)**
Schneebesen (whisk)	Pflug (plough)	Kamm (comb)	Reflexhammer (reflex hammer)	Edding (Edding pen)
Kochlöffel (spoon)	Rechen (rake)	Lockenstab (curling iron)	Spritze (syringe)	Tacker (stapler)
Nudelholz (rolling pin)	Heugabel (hay fork)	Schere (scissors)	Pinzette (tweezers)	Bleistift (pencil)
Messer (knife)	Sense (scythe)	Bürste (brush)	Akupunkturnadel (acupuncture needle)	Lineal (ruler)
Dosenöffner (can-opener)	Axt (axe)	Haarnadel (hair pin)	Thermometer (thermometer)	Klammer (staple)
Unrelated 1	**Unrelated 2**	**Unrelated 3**	**Unrelated 4**	**Unrelated 5**
Eule (owl)	Fliege (fly)	Gorilla (gorilla)	Schaf (sheep)	Lachs (salmon)
Sakko (suit jacket)	Clogs (clogs)	Hut (hat)	Jacke (jacket)	Kette (chain)
Praline (praline)	Dill (dill)	Kirsche (cherry)	Tee (tea)	Bovist (puffball)
Bett (bed)	Bidet (bidet)	Truhe (chest)	Dusche (shower)	Rollo (blind)
Kamm (comb)	Spritze (syringe)	Bürste (brush)	Bleistift (pencil)	Sense (scythe)
Unrelated 6	**Unrelated 7**	**Unrelated 8**	**Unrelated 9**	**Unrelated 10**
Adler (eagle)	Mandrill (mandrill)	Hai (shark)	Pferd (horse)	Biene (bee)
Tanga (thong)	Socke (socks)	Brosche (brooch)	Mütze (wooly hat)	Stiefel (boot)
Bonbon (candy)	Rosmarin (rosemary)	Apfel (apple)	Steinpilz (cep)	Cocktail (cocktail)
Eckbank (corner seat)	Badvorleger (mat)	Couch (couch)	Futon (futon)	Liege (day bed)
Kochlöffel (spoon)	Edding (Edding pen)	Pflug (plough)	Thermometer (thermometer)	Nudelholz (rolling pin)
Unrelated 11	**Unrelated 12**	**Unrelated 13**	**Unrelated 14**	**Unrelated 15**
Schimpanse (chimpanzee)	Ameise (ant)	Kolibri (hummingbird)	Rochen (ray)	Esel (donkey)
Ohrring (earring)	Cappy (cap)	Poncho (poncho)	Korsett (corset)	Turban (turban)
Wein (wine)	Eis (ice cream)	Morchel (morel)	Trauben (grapes)	Schnittlauch (chives)
Badewanne (bathtub)	Ohrensessel (wing chair)	Sideboard (sideboard)	Perserteppich (Persian carpet)	Vitrine (showcase)
Rechen (rake)	Pinzette (tweezers)	Dosenöffner (can-opener)	Schere (scissors)	Lineal (ruler)
Unrelated 16	**Unrelated 17**	**Unrelated 18**	**Unrelated 19**	**Unrelated 20**
Forelle (trout)	Orang-Utan (orangutan)	Geier (volture)	Hirschkäfer (stag beetles)	Kamel (camel)
Anorak (anorak)	BH (bra)	Armreif (bracelet)	Mokassins (moccasins)	Pumps (court shoe)
Lakritze (licorice)	Milch (milk)	Pfifferling (chanterelle)	Petersilie (parsley)	Mandarine (tangerine)
Pissoir (urinal)	Tischdecke (tablecloth)	Hängematte (hammock)	Regal (shelf)	Bürostuhl (office chair)
Heugabel (hay fork)	Lockenstab (curling iron)	Messer (knife)	Tacker (stapler)	Akupunkturnadel (acupuncture needle)

Tiere (animals)				
Vögel (birds)	**Fische (fish)**	**Insekten (insects)**	**Huftiere (ungulates)**	**Affen (apes)**
Unrelated 21	**Unrelated 22**	**Unrelated 23**	**Unrelated 24**	**Unrelated 25**
Reh (roe deer)	Papagei (parrot)	Pavian (baboon)	Schmetterling (butterfly)	Aal (eel)
Unterhemd (vest)	Diadem (diadem)	Turnschuhe (gym shoe)	Zylinder (top hat)	Mantel (coat)
Bier (beer)	Birne (pear)	Basilikum (basil)	Kuchen (cake)	Champignon (mushroom)
Vorhang (curtain)	Kleiderschrank (wardrobe)	Schlafsofa (sofa bed)	Hocker (stool)	Waschbecken (washbasin)
Haarnadel (hair pin)	Schneebesen (whisk)	Reflexhammer (reflex hammer)	Axt (axe)	Klammer (staple)

Ad-hoc thematic relations form through communication: effects on lexical-semantic processing during language production

Language, Cognition and Neuroscience

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Ad-hoc thematic relations form through communication: effects on lexical-semantic processing during language production

In this preregistered study, we investigate whether themes conveyed by task partners' narratives reveal semantic relationships between objects that would otherwise be perceived as unrelated. Such ad-hoc formation of thematic relations should result in semantic interference when naming objects related to the theme in a blocked-cyclic naming paradigm. Participants watch pre-recorded videos of presumed partners narrating real-life events, and then name pictures either thematically related or unrelated to the narrative. Experiment 1 and 2 (N=32 each) demonstrate semantic interference between objects related to the partner's narrative. Interestingly, this effect emerges only when unrelated pictures are named first. Interference is greatly attenuated, or even turns into facilitation, when related pictures are named directly after the partner's narrative. Experiment 3 (*N*=32) confirms that semantic context effects disappear when the objects cannot be related to the narrative. Our results demonstrate how flexible semantic processing adapts to context communicated by a task partner.

Keywords: alignment, ad-hoc thematic relations, lexical selection, semantic facilitation/interference, blocked cyclic picture naming

Imagine you are at a party. You come across two friends who have been chatting for a while and you find it rather tricky to take the turn. Weird enough, at some point one of them mentions "ice cream", "bone" and "llama". What you do not know at this point is: The two friends are talking about their recent visit to the Berlin Zoo. Just as you are wondering whether you should share your food preference, the other person mentions passing by the public feeding of tigers – and now you understand. You join the conversation by sharing your memories of visiting the zoo last year. This example demonstrates how through conversation seemingly unrelated concepts can be associated and become part of a meaningful representation of the topic under discussion. Recent evidence has shown that direct verbal priming of themes with visually presented cue words results in the flexible formation of ad-hoc relations, suggesting a high degree of flexibility of lexical-semantic processing (Abdel Rahman & Melinger, 2011). This property of the lexical-semantic system may form the basis for successful communication. Specifically, we propose that processing a conversational partner's speech results in the formation of ad-hoc thematic relations, binding lexical entries related to the conversational topic together. The present study investigates how language production is shaped by this ad-hoc lexical-semantic processing. Specifically, we test whether speakers experience semantic interference between objects that have been tied together via ad-hoc formation of thematic relations through prior communication with a task partner.

Semantic interference reflects lexical-semantic processing during word production, which has been investigated by semantic context paradigms. In the blocked-cyclic naming paradigm, participants are asked to repeatedly name pictures that are grouped in either semantically homogeneous blocks (e.g., different types of hoofed mammals) or heterogeneous ones (unrelated pictures). In this type of setting, participants typically experience interference between semantically related pictures, reflected in longer naming latencies in homogeneous compared to heterogeneous blocks (e.g., Belke et al., 2005; Belke, 2017; Kroll & Stewart, 1994; Damian et al., 2001). This interference effect typically arises from the second presentation cycle onward. As for the first cycle, naming latencies in homogeneous blocks are typically either equal or shorter than those in heterogeneous blocks (i.e., semantic facilitation; e.g., Abdel Rahman & Melinger, 2007).

There are several accounts to explain these effects. Speaking proceeds in several stages (e.g., Dell, 1986; Howard et al., 2006; Indefrey & Levelt, 2004; Levelt et al., 1999; Nozari & Hepner, 2018; Roelofs, 1992): To produce a word (e.g., llama), a speaker initiates conceptual preparation, which involves activating semantic concepts related to the target word (e.g., "mammal", "wool", "hooves"). These semantically related concepts further activate each concept's corresponding lexical representation, leading to the activation of a lexical cohort (Abdel Rahman & Melinger, 2009, 2019). The target lexical representation ("llama") is then selected from this lexical cohort. According to competitive accounts of lexical models, co-activated lexical candidates compete with the target entry for selection. The lexical entry most strongly activated is ultimately selected for articulation (Dell, 1986; Howard et al., 2006; Levelt et al., 1999; Roelofs, 1992, 2018). Based on this assumption, semantic interference has been proposed to result from lexical competition outweighing conceptual priming: while a given concept primes and facilitates the selection of a target lexical entry, co-activated lexical candidates compete with the target and thus hinders selection (Abdel Rahman & Melinger, 2009, 2019; Belke et al., 2005; Roelofs, 2018). An alternative account that does not assume lexical competition instead proposes an incremental learning mechanism, which strengthens the connections between concepts and lexical entries of named items, and weakens the connections between the concepts and co-activated but unselected lexical entries, resulting in hampered subsequent naming (Navarrete et al., 2012; Navarrete et al., 2014; Oppenheim et al., 2010).

Semantic categories can be spontaneously formed even between seemingly unrelated objects (Barsalou, 1983; Metusalem et al., 2012; Vallée-Tourangeau et al., 1998; Yeh & Barsalou, 2006). This also affects language production and has been demonstrated with the cyclic naming paradigm. Abdel Rahman and Melinger (2011) conducted a series of experiments, where seemingly unrelated pictures sharing an underlying theme were named in homogeneous or heterogeneous blocks, either preceded by a thematically congruent or incongruent block title (e.g., ropes, nest, llama, bone, ice cream can all be related to the theme “zoo”, but not “visit to the doctor”). Participants showed semantic interference when naming homogeneous blocks after reading thematically congruent titles, but not after reading incongruent ones. The authors proposed that the observed semantic interference was elicited by the congruent title, which served as a cue to bind the items into a meaningful context, forming an ad-hoc category. The formation of ad-hoc categories supports the idea that semantic processing is highly flexible and spreads beyond hard-wired storage of semantic relations in long term memory.

This flexibility may be one of the mechanisms supporting mutual understanding in conversation. In successful conversations, conversational partners build up shared representations of the topic under discussion (Clark, 1996; Pickering & Garrod, 2004), which are known as *situation models* (e.g., Johnson-Laird, 1983; Zwaan & Radvansky, 1988). One prominent account of dialogue, the Interactive Alignment Model (Garrod & Pickering, 2004; Pickering & Garrod, 2004), proposes that shared situation models can be achieved by aligning low level linguistic representations. This model assumes that speech comprehension and speech production depend on similar mental representations, and the tight coupling between both leads to an automatic alignment of linguistic representations. For example, after hearing a confederate speaker produce a certain syntactic construction, participants are more likely to use the same construction in their own subsequent speech (Branigan et al., 2000). An alignment on one level facilitates alignment on other linguistic levels and thus enables mutual understanding. In analogy to this proposal, we speculate that conversational partners also align in the activation of their semantic network corresponding to the communicated situation model. By processing another speaker's speech, loosely-related semantic concepts that potentially share thematic associations become parts of the same underlying situation model. This can result in the flexible formation of ad-hoc thematic relations elicited by the specific conversational context and can subsequently affect own speech production. Please note that while the Interactive Alignment Model provides us a framework how the narration of a conversational partner could come into play during a speaker's language production, we do not claim to test the alignment of situation models *per se*. Instead, we intend to shed light on the covert processing of the situation model (which, is by nature not directly assessable) by testing how a speaker's lexical-semantic processing flexibly adapts to a given conversational context.

The idea that language production within a conversational context is shaped by the temporary network activations also connects to other theories of dialogue, which describe how conversational partners build upon what previously has been said and collaboratively develop a shared understanding of the conversational topic (e.g., Clark & Brennan, 1991; Clark, 1996). This shared understanding has been shown to affect subsequent lexical choices, by making it more likely that the same terms are re-used between conversational partners, a phenomenon known as *lexical entrainment* (e.g., Brennan & Clark, 1996). Lexical entrainment is described as a temporary, flexible agreement between conversational partners to think about the topic under conversation in a particular way (Metzing & Brennan, 2003). We propose that such temporary flexible agreements not only concern single lexical entries, but have consequences for the entire semantic network within which a given lexical entry is embedded.

The accumulating evidence mentioned above points towards a flexible semantic system that enables the formation of associations, based on the topic developed with conversational partners. By introducing a partner into experimental investigation of language production, we may better understand how speakers produce language in real-life communicative situations. Recently, the cognitive processes underlying language production in social interaction have gained interest (e.g., Baus et al., 2014; Gambi et al., 2015; Hoedemaker & Meyer, 2019; Hoedemaker et al., 2017). For instance, semantic interference has been investigated in a social setting, in which two task partners take turns naming pictures (Kuhlen & Abdel Rahman, 2017). Embedded in the continuous stream of pictures were pictures that are semantically related to each other (in this case by predefined categorical relations stored in long term memory). With each additional picture they named within a given semantic category, speakers experienced more semantic interference. This is in line with the assumption of lexical competition or with the assumption that naming a picture strengthens the link between a concept and its lexical entry, which strongly interferes when shortly thereafter seeking lexical access to a semantically related picture. Crucially, this study demonstrated that semantic interference increases not only when speakers name pictures themselves, but also when their task partner names the pictures. Thus, a task partner's picture naming may trigger lexical processes, which subsequently can interfere with a speaker's own lexical retrieval. This supports the idea that a task partner's speech production affects one's own lexical-semantic processing by contributing to the activation of a semantic network.

The Present Study

We aim to provide first evidence of how semantic content communicated by a task partner is integrated into and shapes a speaker's semantic network activation and lexical selection. Specifically, we test whether an ad-hoc semantic blocking effect, which has been previously demonstrated isolated from social or communicative contexts, can be elicited by a task partner.

In our study, participants were exposed to narratives of presumed task partners on personal events (e.g., a recent visit to a zoo). We hypothesize that these narratives establish thematic relations between entities mentioned within the narrative (e.g., passing by the aviary; going to the petting area; watching the tiger feeding), as well as, crucially, between entities *not* mentioned explicitly but associated with that particular theme (e.g., nest; llama; bone). We predict that such formation of ad-hoc thematic relations will induce a semantic blocking effect when these entities are named in the blocked-cyclic naming paradigm, even if they were not directly mentioned in the narrative (Abdel Rahman & Melinger, 2007, 2011). To summarize, we assume that a speaker's semantic network activation is shaped by semantic content communicated by a task partner. This content modulates the activation pattern of semantic and lexical representations, resulting in the formation of ad-hoc thematic relations, which leads to a semantic blocking effect in a blocked cyclic naming task.

In three experiments, participants first listened to their presumably remotely located task partner narrating a personal event (e.g., a visit to the zoo). Subsequently, participants were asked to instruct their partner by naming the pictures aloud so that the partner could supposedly recall these objects later on. The pictures were presented in short cyclic repetitions in homogeneous blocks consisting of objects related to the theme of the partner's narrative (e.g., ropes, nest, llama, bone, ice cream relate to a zoo visit), or in heterogeneous blocks consisting of unrelated objects (e.g., socks, flower bouquet, folding table, bone, balloon). Crucially, while some of the presented objects were thematically related to the partner's narrative, none were explicitly mentioned during the narration. Experiment 1 established this novel experimental procedure, which integrates, to our knowledge for the first time, a blocked-cyclic naming paradigm in a communicative setting. Experiment 2 replicated the novel findings of a semantic blocking effect resulting from the narrative-induced ad-hoc formation of thematic relations. Finally, in Experiment 3, the partner's narrative was unrelated to the same group of pictures presented in homogeneous blocks, thus discouraging the formation of thematic relations.

Experiment 1

The goal of Experiment 1 was to establish the experimental protocol designed to detect the existence of ad-hoc formation of thematic relations induced by the conversational context. We hypothesized that participants would experience semantic interference when naming pictures related to the partner's narrative (even though the specific objects had not been mentioned) because the narration serves as a prime to activate the underlying thematic relations. Thus, we expected participants to show a semantic blocking effect. Note that in the blocked-cyclic naming paradigm, semantic interference typically emerges starting from the second presentation cycle onward (e.g., Abdel Rahman & Melinger, 2011; Belke et al., 2005; Navarrete et al., 2012). Hence, we did not have specific hypotheses about the first presentation cycle.

This experiment was preregistered under the Open Science Framework (Lin et al., 2018a). Pre-registered parts include hypotheses, materials, design, procedures, statistical models, data exclusion criteria, and sample size. The experiment was approved by the local ethics committee and was based on ethical principles put forward by the Declaration of Helsinki for research involving human subjects (Version 2013). The same holds for all experiments.

Methods

Participants

Thirty-two native German speakers (24 female), aged 18 to 45 (M = 24.2, SD = 5.25), were recruited and gave informed consent. They were either paid for participation or received partial fulfillment of a curriculum requirement. All participants gave consent prior to participation, and were fully-informed of the true purpose of the study after the experiment.

For sample size estimation a statistical power analysis was performed based on data from the study of Abdel Rahman and Melinger (2011, Experiment 3, N = 32). The thematic blocking effect in this study was, according to Cohen (1988), of medium size (f = 0.3; converted from partial eta squared, $\eta^2_p = 0.086$). In the present study, the manipulation of thematic blocking was realized between-subjects. With an alpha level of 0.05 and an aspired power of 0.85, the projected sample size is approximately 64 subjects (N=32 in Experiment 1/2: experimental group, N = 32 in Experiment 3: control group) in order to detect the hypothesized thematic blocking effect ($\eta^2_p = 0.099$; estimated with G*Power 3.1). Hence, this resulted in 32 participants at each factor level (N=32 in Experiment 1 & 2: experimental group, N = 32 in Experiment 3: control group).

Materials

The materials consisted of video recordings of the partners' narratives presented prior to the naming task, and the object pictures presented during the naming task. All the materials were in German.

Task partners' narratives. Five native German college students (two female) were invited to record a one-minute-long video. Narrators introduced their name, age and study major, and then narrated the assigned event ("funeral", "flea market", "hiking", "zoo", "campaign") as if it had been their personal experience (see Appendix A for an example of video transcription). Narrators were provided with storylines in bullet points, each implying a specific target concept. While the narratives were otherwise produced spontaneously, narrators were instructed not to mention explicitly the objects which were later presented as stimulus pictures. The topic of the event was always mentioned.

Object pictures. We adopted the identical stimuli from Abdel Rahman and Melinger's study (2011). Twenty-five coloured photographs of common objects formed the five homogeneous picture groups[1,2]. These seemingly semantically unrelated and visually dissimilar pictures were drawn from different categories, but could potentially be related to a theme (e.g., suit, coffee, shovel, flower, handkerchiefs can all be related to the event "funeral", see Appendix B for a complete list of objects). None of the objects was a prototypical member of the narrative theme, and none of the objects was mentioned in the narrative. The homogeneous (related) groups were recombined to form five heterogeneous (unrelated) groups. All photographs were scaled to 3.5 x 3.5 cm and presented with grey background. Stimuli were presented on a 4/3 17″ BenQ monitor with a resolution of 1280 x 1024 using Presentation® software (Version 18.0,

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[1] To test whether grammatical gender affects our results (see e.g., Jacobson, 1999), we set up an extra LMM, including grammatical gender of the items as a new predictor (3-level factor: feminine, masculine, neuter nouns; coded as sliding difference contrast). In neither of our three experiments did the factor improve model fit (Experiment 1: $\chi^2 = 0.40$, $p = .81$; Experiment 2: $\chi^2 = 0.63$, $p = .72$; Experiment 3: $\chi^2 = 0.27$, $p = .87$). We thus concluded that grammatical gender did not influence our result, and dropped it from the model.

[2] The items were controlled for phonological overlap, but word length and frequency were not specifically controlled. This is because in the blocked-cyclic design the same item was named in both related and unrelated conditions, so the potential variance introduced by differences between words, e.g., length and frequency, cannot explain the relatedness effects and could be accounted for with the random effects of item set up in the LMMs.

Neurobehavioral Systems, Inc., Berkeley, CA) at a viewing distance of 60 cm, producing an equal stimulus size of 2.7° visual angle for each object stimulus.

Procedure

To create the impression of an authentic social interaction, participants were informed prior to the experiment that they would take part in a study investigating memory performance in a virtual learning environment. Participants were instructed to teach the other (presumably) remotely located partner by naming the materials that the partner later needed to recall. Participants were told that they would be provided with percentages regarding how well the partner correctly recalled the items, which were in fact randomly selected numbers.

Prior to the main experiment, participants were asked to record a short introduction of themselves including a short autobiographical event on a pre-defined topic, a recent visit to a restaurant. This was done for the sake of the cover story, which implied that all participants of the virtual learning environment should introduce themselves to one another. Afterward, participants were asked to fill out the German version of the Autism Quotient test (AQ-test, Baron-Cohen et al., 2001), which was referred to as a "questionnaire on social communication skills" to conceal the true study purpose. The collected AQ-scores will be used in future studies and will not be discussed further in the present study (the same holds for all three experiments)[3]. To familiarize participants with the stimulus pictures, we presented them in random order before

[3] The collected AQ-scores were entered as an additional predictor in the LMMs for all three experiments; since none of the model performance was improved by this covariate (Experiment 1: $\chi^2 = 0.09$, $p = .75$; Experiment 2: $\chi^2 = 0.01$, $p = .90$; Experiment 3: $\chi^2 = 0.28$, $p = .59$), we dropped this predictor.

the experiment began. The experimenter corrected the participants if they named the picture falsely. Picture names were provided if necessary.

In the main experiment, participants watched a partner's narrative video. After a slight delay, the picture naming task began. Each trial began with a fixation cross in the centre of a light grey screen for 0.5s, followed by a stimulus picture. The picture was presented until the participant responded, or for a maximum of 2s. An inter-stimulus interval of 1.5s consisting of a blank screen was presented before the next trial started. Naming latencies were registered with a voice key during picture presentation, which gets triggered with proper volume received through a microphone (with the experimenter monitored online whether the voice key was erroneously triggered, e.g., by coughing). Participants were instructed to name the pictures as fast and as accurately as possible. There was a break of 15s in between the homogeneous and the heterogeneous block. After both naming blocks, the screen displayed a 30-second countdown (in this time, the remote partner was presumably recalling the objects that had just been named by the participant). On the following screen, participants received feedback about the partner's performance (performance percentage was selected offline, randomly varied between 60, 80 and 100%). The same procedure was repeated five times, each time with a different task partner and narrative (see Figure 1).

[Figure 1 near here]

After the main part of the experiment, participants completed three measures that were later entered as covariates in the LMM analyses. (a) Inter-object relatedness: All homogeneous and heterogeneous blocks were presented to participants with names printed below the pictures (order of the themes was counterbalanced across participants). Participants were asked to rate how related the objects were within each homogeneous and heterogeneous block on a scale from -5 (not related) to 5 (highly related). (b) Picture-story association: Participants were questioned on whether they had noticed any relation between the pictures and the narrative. (c) Real-time interaction: Participants were asked whether they believed the task had really been based on online interaction with their task partner. To ascertain that participants correctly associated a given task partner with their respective narrative, we asked participants to recall in bullet points the content of the autobiographical story each partner had told after presenting the face. Lastly, participants were fully informed about the true nature of the setting and the research purpose of the experiment.

Counter-Balancing of Stimulus Presentation

The order of the narratives was shuffled through a Balanced Latin Square Design (Kim & Stein, 2009) so that narratives were presented in different order across participants. Each narrative was followed by two blocks of pictures, a homogeneous block and a heterogeneous block. Within each block, five pictures were presented in six cycles with randomized order per cycle. A constraint was implemented so that the last object in the preceding cycle could not be the first object in the subsequent cycle. The block order was counterbalanced across participants such that half of the participants first named the homogeneous and then the heterogeneous blocks of pictures, whereas the other half of participants first named the heterogeneous and then the homogeneous blocks.

Data Analyses

We analysed naming latencies excluding trials in which pictures were named incorrectly or disfluently (0.31%), or trials in which the voice-key was erroneously triggered (2.26%). Of all target trials, 97.42% were analysed.

Based on the result of a Box-Cox Test which identified the most suitable transformation for our data to achieve normal distribution, we performed all analyses on inverse naming latencies. A linear mixed effects model (LMM; Baayen et al., 2008) testing the relationship between inverse-transformed naming latencies and thematic blocking was run using R (R Core Team, 2018) and the *lme4* package (Bates et al., 2015, version 1.1-21). As preregistered, we entered as fixed effects the critical predictor thematic blocking (homogeneous vs. heterogeneous, with heterogeneous being the reference level), and the control predictor repetition (cycles 2 to 6) into the model. The predictor thematic blocking was modelled as sliding difference contrasts that compare the means of factor levels to the respective reference level. The predictor repetition was centered and coded as a continuous variable. Our pre-registered model did not include the interaction between blocking and repetition because the latter was a control variable. Yet we also tested a possible contribution of this interaction term during the model selection process via the likelihood ratio test (cf. Luke, 2017) to assure that the interaction term could be dropped.

All models were initially run with a maximum random effects structure including intercepts for subjects and items, as well as by-subject and by-item random slopes for the effects of blocking. 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). All models converged after the random structure reduction process.

To assess the effect of participants' individual perception of the experimental setting, we set up extra LMMs with the three measures that participants completed in the end of the experiment entered as fixed effects. Inter-object relatedness was a 10-point scale, centered and entered as a continuous variable, used to assess the relatedness among items within a given block. Picture-story association (noticed, not noticed), used to assess whether participants noticed the items' relation to the story during the experiment, and real-time interaction (believed, not believed), used to access whether participants genuinely believed that they were interacting with a task partner, were both coded as dummy variables with a two-level contrast.

In the results section below, we report estimates, standard errors, 95% confidence intervals and *t*-values for fixed effects. We considered fixed effects as significant if $|t| \geq 1.96$ (cf. Baayen et al., 2008), but also computed *p*-values by Satterthwaite approximation (using the *summary* function in the *lmerTest* package, version 3.1-1, Kuznetsova et al., 2017). For random effects, we report estimates of variance as well as the standard deviations. Goodness-of-fit statistics are also reported. We report the most relevant LMM outputs in tables, and only highlight significant findings in text. To reduce the number of tables in the manuscript, we report the descriptive statistics in text.

Results

Pre-Registered Analyses

Other than hypothesized, participants did not show any semantic blocking effect. In fact, numerically, participants were on average 5ms faster when naming pictures related to the story compared to the unrelated ones (related: $M = 643.02$, $SD = 125.32$; unrelated: $M = 647.89$, $SD = 138.20$). Participants' naming latencies stayed consistent over the course of repetitions, see

Figure 2. The LMM analyses showed no significant main effects of blocking and repetition, see Appendix C, Table C.1. Thus, statistically, naming latencies did not differ across semantic conditions, which did not support our hypothesis that a related narrative context would induce ad-hoc thematic relations.

[Figure 2 near here]

Exploratory Analyses

In a similar blocked-cyclic naming paradigm, Abdel Rahman and Melinger (2007) discuss how participants' naming latencies might shift depending on whether they name all the homogeneous blocks before naming all the heterogeneous blocks, or the reverse order. This alerted us the possibility that participants may be susceptible to the order in which they underwent the two blocking conditions. To test for such a block order effect, we split the data into two subgroups based on block order: Half of the participants named pictures that could be thematically associated with the narrative directly after hearing the narrative and half of the participants first named pictures unrelated to the narrative.

Those participants who named unrelated pictures before naming related pictures showed on average 14ms longer naming latency in related compared to unrelated blocks (related: M = 641.40, SD = 131.04; unrelated: M = 627.73, SD = 132.69), see Figure 2. That is, these participants showed the expected semantic blocking effect. In contrast, those who first named related pictures were on average 23ms quicker to name pictures related to the story compared to the unrelated ones (related: M = 644.63, SD = 151.33; unrelated: M = 667.84, SD = 169.70). An additional LMM included this new predictor, block order (related-unrelated vs. unrelated-related), and its interaction with thematic blocking. This LMM confirmed the significant interaction between thematic blocking and block order, see Table 1. The model did not show any main effects of thematic blocking, block order, or repetition, respectively.

To investigate this interaction further, we set up a nested model, which allows to test the effect of thematic blocking and repetition separately for each block order. This analysis revealed a significant effect of thematic blocking in both block orders, indicating that the order in which participants named the related and unrelated blocks affected the polarity of the semantic blocking effect, see Table 2. Specifically, when participants named related after unrelated pictures, they experienced semantic interference. In contrast, when participants named related before unrelated pictures, they experienced semantic facilitation. In short, these findings supported our hypothesis that participants might be differentially affected by the ad-hoc thematic relations depending on the time elapse between picture naming and a related narrative context.

[Table 1 near here]

[Table 2 near here]

Around one third of the participants reported that they noticed the relations between the narrative and the pictures ($\chi^2 = 0.01$, $p = .90$); half of the participants reported that they genuinely believed they were interacting with their task partner via a live video link (see Appendix C, Table C.2). The inter-object relatedness of the picture blocks scored on average 0.9 for homogeneous and -2 for heterogeneous condition ($\chi^2 = 0.12$, $p = .72$). All three measures were entered as covariates into the LMM separately, but were dropped during model selection because they did not improve the model performance.

Discussion

We had hypothesized that a task partner's narrative evokes the formation of ad-hoc thematic relations, which bind lexical entries related to the narrative together. Indeed, speakers' naming latencies when naming objects related to the narrative revealed that the partner's narrative affected their lexical-semantic processing. The pattern of this effect was more complex than we had expected: Exploratory analyses indicate that the polarity of the semantic context effect depends on whether speakers name the thematically-related pictures directly after the narrative or after naming the thematically-unrelated pictures: Those speakers who first name thematically-unrelated blocks and then the thematically-related blocks experience semantic interference. In contrast, those speakers who first name related and then unrelated blocks of pictures, seem to experience semantic facilitation.

Taken together, this data pattern indicates that participants respond to pictures that relate to the partner's narrative differently than to pictures that could not be related to the narrative. We take this as a first indication that the partner's narrative indeed evokes the activation of ad-hoc thematic relations. However, the consequences of such ad-hoc relations, whether they facilitate or interfere with lexical access, seem to depend on when the objects related to the partner's narrative are named. This implies that opposing mechanisms may be at play in shaping participants' speech production. Before we discuss the implications of these findings, we aimed to replicate these findings. Therefore, we conducted a second experiment with the identical materials and procedure, but in a new group of participants.

Experiment 2

In accordance with our original hypothesis, we expected that the partner's narrative, presented before participants performed the naming task, would generate ad-hoc thematic relations. These narrative-induced ad-hoc relations would express themselves in the ease of lexical access experienced when participants named pictures thematically related to the partner's narrative in the subsequent picture naming task. Based on the outcome of Experiment 1, we furthermore wanted to investigate the effect of block order, and specifically, we predicted in the second preregistration that semantic interference exclusively occurs when speakers name thematically related pictures after naming unrelated ones (Lin et al., 2018b). In addition, we also wanted to see whether the unexpected facilitation found in Experiment 1 could be replicated.

Methods

Materials, experimental design, and procedures were identical to Experiment 1.

Participants

Thirty-two native German speakers (20 female), aged 18 to 45 ($M = 31.9$, $SD = 6.97$), were recruited and gave informed consent. They were compensated for participation or received partial fulfilment of a curriculum requirement. None of the participants had participated in Experiment 1.

Data Analyses

In total, 0.66% of pictures were named incorrectly or disfluently. The voice-key was erroneously triggered in 2.53% of trials. These trials were excluded leaving 96.8% of all trials for analysis.

We applied an LMM including thematic blocking, repetition, and block order as fixed factors (compare exploratory analysis in Experiment 1).

Results

Pre-Registered Analyses

Overall, participants showed on average 11ms longer naming latencies in related compared to unrelated blocks (related: $M = 618.15$, $SD = 122.24$; unrelated: $M = 607.36$, $SD = 119.67$), regardless of block order. This resulted in a significant main effect of thematic blocking, see Table 3. In addition, replicating the results in Experiment 1, Experiment 2 demonstrated once again that semantic interference was more pronounced for those participants who named related pictures after naming unrelated ones: On average, they named pictures 19ms slower in related than in unrelated blocks (related: $M = 632.29$, $SD = 154.86$; unrelated: $M = 613.37$, $SD = 158.29$). In contrast, participants who named related pictures before naming unrelated ones were only 2ms slower to name related than unrelated pictures (related: $M = 603.94$, $SD = 144.85$; unrelated: $M = 601.33$, $SD = 139.42$). This yielded a significant interaction between thematic blocking and block order. The data pattern supports our hypothesis that participants experience different semantic context effects depending on how quick they name the related pictures after hearing their corresponding narrative context, see General Discussion for further discussion.

Lastly, over the course of repetitions, participants became on average 3ms faster in naming pictures (see Figure 3), which had a significant effect in our model. However, since this effect was not expected and absent in Experiment 1, we will not discuss it further.

[Figure 3 near here]

A nested LMM testing for the effect of blocking for each block order separately indicates that the main effect of thematic blocking found in our original LMM model was driven by the strong semantic interference experienced by the participants who named related pictures after naming unrelated ones: a significant interference effect was found only for those who named unrelated pictures first, but not for those who named related pictures first, see Table 4. This further supports our hypothesis that participants underwent semantic interference exclusively when they name related pictures after naming unrelated ones, but did not support the other hypothesis that participants underwent semantic facilitation when they name related pictures directly after hearing a related narrative context.

[Table 3 near here]

Forty percent of the participants reported that they noticed the relations between the narrative and the pictures ($\chi^2 = 0.12$, $p = .72$); 44% of the participants reported that they genuinely believed they were interacting with their task partner via a live video link (see Appendix C, Table C.3). The inter-object relatedness of the picture blocks scored on average 1.5 for homogeneous and -1.8 for heterogeneous condition ($\chi^2 = 0.07$, $p = .78$). All measures were entered on individual basis as covariates into the LMM separately, but had to be dropped during model selection because they did not improve the model performance.

Discussion

The data pattern of Experiment 2 confirms the central finding of Experiment 1, namely, that participants' naming latencies differ when the pictures are related to the partner's narrative. Furthermore, the block order effect observed in Experiment 1 and 2 clearly demonstrates that semantic interference is found only when related pictures are named after unrelated ones, but not in the reversed order. The main difference to Experiment 1 is that we found no semantic facilitation in Experiment 2 for the those who named related pictures first, but consistently, in both experiments we found *reduced interference* for these participants compared to those who named related pictures after naming unrelated ones.

The phenomenon that block order modulates the blocking effect has been reported before (for details in a different blocking design and focusing on the first cycle, please see Abdel Rahman and Melinger's study in 2007). In the context of our study, we suggest the following: when related blocks are presented first, the narrative context primes related semantic concepts and makes initial object identification easier. This facilitates naming, especially at the first encounter with the picture stimuli, and reduces the semantic interference effect (and may even turn to facilitation). On the contrary, when related blocks follow unrelated blocks, initial object identification takes place during unrelated blocks. Thus, in this block order, the facilitatory boost due to narrative priming is lost and the later presented related pictures mostly induce semantic interference.

This explanation is in line with a recent account of lexical-semantic processing during language production, which describes semantic context effects, facilitation or interference, as a result of a trade-off between concurrent conceptual priming and lexical competition (cf. the Swinging Lexical Network; Abdel Rahman & Melinger, 2009, 2019): While semantic context facilitates object identification on a conceptual level (Lin et al., submitted; Scheibel, 2020), it creates competition on the lexical level. Specifically, this account proposes that the number and strength of the co-activated lexical cohort play a crucial role in the final observable effect. Assume that the partner's narrative content activates a large number of associates, the one-to-one relations would induce relatively large conceptual priming and relatively small lexical competition. This effect would gradually fade away when the content details are no longer available in short-term memory. Therefore, facilitatory context effects should be most helpful when objects are initially presented and identification is most difficult, and when narrative context is very salient (i.e., when participants named related pictures immediately after hearing the narrative). Although alternative accounts of blocked-cyclic naming have been put forward (Oppenheim et al., 2010; Roelofs, 2018), they aim to account for the classic blocking effect, i.e., stable semantic interference in later cycles. Therefore, these models do not seem to be able to provide explanation for our findings.

Additional Analyses Exploring the Unexpected Block Order Effect

If indeed participants initially experience facilitated object identification through the partner's narrative, facilitation should be strongest in cycle 1 and when participants name blocks of related pictures immediately after the narration (vs. in latter blocks). Furthermore, based on the discussion above, we propose that this initial facilitation cancels out the net interference effect in cycles 2 to 6. Hence, we predict that those participants experiencing strong facilitation in cycle 1 should show less interference in cycles 2 to 6. We tested these predictions on the data pooled from Experiment 1 and 2.

To test our first prediction that participants experience stronger facilitation in cycle 1 when they name blocks of related pictures immediately after the narration, we set up an LMM including thematic blocking, block order and the interaction term as predictors to test naming latencies in presentation cycle 1 (*N* = 64, see Appendix C, Table C.4). This model showed a significant interaction between thematic blocking and block order. A nested LMM revealed significant semantic facilitation for participants who named related pictures directly after the narrations (see Appendix C, Table C.5). On the contrary, there was no facilitatory effect for those participants who named related pictures after naming unrelated ones. This is in line with our proposal that semantic priming facilitates most when thematically-related pictures directly follow the partner's narrative.

For our second prediction those participants experiencing strong facilitation in cycle 1 should show less interference in cycles 2 to 6, we ran another LMM testing naming latencies from cycle 2 to 6 (*N* = 64) with the given fixed effects (thematic blocking, block order and the interaction term), and as additional predictor the size of facilitation in cycle 1 (computed by subtracting naming latencies in unrelated blocks from related blocks; the negative values of blocking effects). As expected, this LMM showed a significant interaction between the size of facilitation in cycle 1 and blocking effects in cycles 2 to 6 across block orders (see Appendix C, Table C.6). An additional Pearson's correlation test revealed a strong correlation between facilitation in cycle 1 and interference in later cycles (R^2 = .198, 95% CI = [0.22, 0.62], $p < .001$; see Figure 4a, R^2 = .106, 95% CI = [0.08, 0.53], $p = .008$ with the outlier at the bottom left removed). In other words, the strength of priming participants initially experienced (cycle 1) predicted the strength of the interference participants later experienced (cycles 2 to 6).

In sum, collapsing data from Experiment 1 and 2, exploratory analyses showed that naming was most strongly facilitated in cycle 1 and when blocks of related pictures were named immediately after the narration. Moreover, participants who experienced stronger facilitation in cycle 1 showed less interference in cycles 2 to 6. This pattern of results is in line with our argument that semantic priming based on the narrative context may aid initial object identification and could attenuate the net interference effects for those participants who named related pictures immediately after hearing the partner's narrative.

Differences Between Experiment 1 and 2

But why was the interference effect attenuated to the extent that it turned to facilitation effects for the participants naming related picture blocks first in Experiment 1, but not in Experiment 2? One possibility was that facilitation and interference effects varied systematically with naming latencies: Slower participants experienced more priming in cycle 1, and less interference in cycles 2 to 6. This was supported by the outcome of an LMM testing naming latencies in cycle 1, including experiment, thematic blocking and subject's mean naming latencies from cycles 2 to 6 as fixed effects. Here we found a significant three-way interaction between experiment, thematic blocking and subjects' mean naming latencies (see Figure 4b and Appendix C, Table C.7), indicating that participants experienced different levels of semantic priming depending on how quickly they tend to name the pictures, and such facilitation effect varied between two experiments. Interestingly, subjects' mean naming latencies in Experiment 1 were overall longer than in Experiment 2, which could have amplified the facilitating priming effects in Experiment 1 compared to Experiment 2. Pearson's correlation test demonstrated a strong correlation between subject's mean naming latencies and the size of facilitation in cycle 1 for Experiment 1 (R^2 = .23, 95% CI = [-0.71, -0.16], p = .005), and in contrast, no correlation for Experiment 2 (R^2 = .04, 95% CI = [-0.14, 0.52], p = .238). Nevertheless, we do not rule out other possible explanations that might account for the differences observed between the two experiments. For instance, the facilitation or reduced interference effect experienced by participants when naming pictures immediately after hearing thematically related narratives may simply be not as reliable as the interference effect which arises later on. The exact cause of this difference would require further investigation in future studies.

[Figure 4 near here]

To summarize, in both Experiment 1 and 2, participants experienced interference when naming related pictures after having named unrelated pictures. When naming related pictures that immediately followed the task partner's narrations, this interference effect either turned to facilitation (Experiment 1) or was greatly attenuated (Experiment 2). Based on our exploratory analyses and the literature (Abdel Rahman & Melinger, 2007; Scheibel, 2020), we speculate that the effect of block order results from the strong semantic priming elicited by the narration when participants named pictures related to the narration first. This priming effect is stronger in participants with slower naming latencies, which we recruited by chance to a larger extent in Experiment 1. The ad-hoc formation of thematic relations cannot be accounted for by the strategic use of the story content to predict upcoming objects, because the participants who named related pictures immediately after the narration did not become faster over the course of a presentation cycle when naming thematically related objects (for extra analyses on an alternative explanation of participants applying strategic responses, see endnote[i]).

All in all, we take the semantic effects, especially the interference effects, as evidence that participants' semantic network activation is influenced by the narrative context provided by their task partner: Concepts that relate to this context form ad-hoc thematic relations. The facilitation (or reduced interference) observed in Experiment 1 and 2 may also indicate semantic network activation which, when objects are named first and the task is difficult for participants, may facilitate initial object identification and naming. On the one hand, when participants retrieve lexical entries relating to this narrative-induced network, other related members are co-activated and compete for selection, hence slowing down lexical selection. On the other hand, participants benefit from the contextual priming coming from the partner's narrative particularly when naming pictures related to the partner's narration immediately afterwards, most likely due to facilitated semantic processing. Before discussing the implications of these findings in detail, we test whether the described effects were indeed elicited by the semantic context conveyed in the partner's narrative.

Experiment 3

In our initial pre-registration, Experiment 3 served as a control experiment. We aimed to control for two potentially alternative explanations for our hypothesized effects: (1) that even without the partner's narrative, semantic relatedness can be construed between the pictures selected for our homogeneous blocks, and (2) that there is a general effect of listening to the partner that is unspecific to the semantic content conveyed in the narrative (e.g., perhaps some general motivational effect would speed up naming responses in the first relative to the second block of pictures regardless of the narrative's content). To this end, we presented the identical pictures in homogeneous and heterogeneous blocks as in Experiment 1 and 2, but these were preceded by narratives that were unrelated to the homogeneous blocks. If indeed the interference effects in the previous two experiments were elicited by the conversational context conveyed by the partner's narrative, there should be no semantic context effects under these conditions.

Methods

The unique feature of Experiment 3 was that each picture naming episode was preceded by a narrative that did not relate to either the homogeneous or the heterogeneous block of pictures. In all other aspects the experimental design, procedure and data analyses were identical to Experiment 1 and 2.

Participants

Thirty-two native German speakers (23 female), aged 18 to 45 (M = 29, SD = 8.41), were recruited and gave informed consent. They were compensated for participation or received partial fulfilment of a curriculum requirement. None had participated in the previous experiments.

Materials

The same five native German speakers who recorded the videos used in Experiments 1 and 2 recorded five additional narratives of themes that were unrelated to the pictures of the homogeneous blocks (additional themes: “car trip”, “supermarket”, “wedding”, “elementary school”, “fishing”). For details of recording, see description of video materials in Experiment 1. The picture stimuli were identical to Experiment 1 and 2.

Data Analyses

In total, 0.58% of the pictures were named incorrectly or disfluently, and the voice-key was erroneously triggered in 2.51% of trials. After excluding these trials this left 96.9% of all trials to be analysed.

Results

Pre-Registered Analyses

Participants named pictures on average less than 2ms faster in the homogeneous blocks compared with the heterogeneous blocks (homogeneous: *M* = 607.66, *SD* = 116.37; heterogeneous: *M* = 606.81, *SD* = 125.48). This resulted in no main effect of thematic blocking, see Table 5. Participants who named homogeneous blocks after naming heterogeneous blocks named pictures less than 2ms slower in homogeneous blocks compared with heterogeneous blocks (homogeneous: *M* = 618.14, *SD* = 148.59; heterogeneous: *M* = 616.49, *SD* = 168.73), whereas those who named homogeneous blocks before naming heterogenous blocks showed nearly no differences in naming latencies between blocking conditions (homogeneous: *M* = 597.14, *SD* = 141.13; heterogeneous: *M* = 597.31, *SD* = 139.85). This confirmed the absence of an interaction between thematic blocking and block order, indicating neither semantic interference nor facilitation in both orders (see Table 6). Naming latencies stayed consistent over the course of repetitions, see Figure 5, yielding no main effect of repetition. To sum up, these findings support our hypothesis that the semantic interference in Experiment 1 and 2 were indeed elicited by the narrative context provided by the partner.

[Figure 5 near here]

[Table 5 near here]

[Table 6 near here]

None of the participants reported that they noticed any sorts of relation between the narrative and the pictures; 40% of the participants reported that they genuinely believed they were interacting with their task partner via a live video link (see Appendix C, Table C.8). The inter-object relatedness of the picture blocks scored on average -0.8 for homogeneous and -2 for heterogeneous condition ($\chi^2 = 0.93$, $p = .33$). Since no one reported any relation between the narrative and the pictures, we did not include this as a covariate into the LMM. The other two measures were entered on individual basis as covariates into the LMM separately, but had to be dropped during model selection because they did not improve the model performance.

Discussion

These findings support our conclusion that the semantic context effects found in Experiment 1 and 2 are elicited by the specific contents of the partner's narratives, which match the homogeneous blocks of pictures, but not the heterogeneous ones. The control experiment thus demonstrates that the semantic blocking effect found in the previous experiments is not due to the underlying, inherent semantic relatedness between the pictures of the homogeneous block, or some unspecific, motivational influence of hearing a narrative prior to naming pictures.

General discussion

The present study demonstrates that narratives communicated by a partner elicit in participants the formation of ad-hoc thematic relations, which link seemingly unrelated concepts together if they pertain to the conversational context established through the narrative. Specifically, in two experiments implementing a blocked cyclic naming paradigm, we observed semantic interference between items thematically related to the partner's narrative, depending on whether these related pictures were named directly after the narrative or after an intervening block of pictures unrelated to the partner's narrative. Importantly, a third experiment demonstrated that the same pictures do not elicit semantic context effects if the partner's narrative does not provide a corresponding thematic context.

Pictures that related to the narrative elicited in speakers' semantic interference when these pictures were named after naming a block of pictures unrelated to the narrative. These same pictures did not elicit interference, and in Experiment 1 even promoted facilitation, when speakers named them immediately following the partner's narration. This data pattern is in line with the assumption that semantic context affects conceptual and lexical processing in parallel and that, crucially, the polarity of the effects of contexts on naming times depends on whether conceptual priming outweighs lexical interference, or vice-versa (Abdel Rahman & Melinger, 2009, 2019). In this scenario the partner's narrative results in the co-activation of entities related to the narrative at the conceptual level (e.g., a partner's narrative of a visit to the zoo activates associations such as "llama", "bone", "ice cream", etc.), resulting in semantic priming. Concurrently, the co-activated lexical entries compete with each other for selection, generating interference. Whether conceptual priming outweighs lexical competition, or vice-versa, depends on to which extent the narrative context elicits conceptual or lexical processing. Since conceptual priming facilitates most the initial identification of objects (Abdel Rahman & Melinger, 2007; Scheibel, 2020), facilitation is strongest immediately following the prime, in our case the partner's narrative.

In sum, the systematic pattern of semantic interference supports our hypothesis that a speaker's semantic activation spread can be influenced by conversational topics – in this case the narratives of their partners - which we regard as evidence for a flexible semantic system well-equipped for supporting mutual understanding between conversational partners.

Our work is in line with recent research on speech comprehension showing that listeners adapt their semantic network to information about the specific speaker. For example, a recent study by Ryskin and colleagues (2019) set up a two-speaker context, in which participants heard the speakers switched roles of cueing (e.g., Bob: "Susan, name a farm animal") and answering (e.g., Susan: "cow"). Crucially, before the main experiment, participants had heard both of them interviewed by an interviewer. During the interview, only Susan revealed strong associations with atypical exemplars (e.g., working on an ox farm), while Bob revealed no additional information. Listeners showed increased frontal positivity to a typical exemplar ("cow") said by Susan compared to Bob, implying that they perceived the typical exemplar as atypical particularly for Susan. These results suggest that listeners adapt their expectation based on world knowledge to the speaker. Our study demonstrates that information about a speaker not only shapes comprehension, but also has consequences when subsequently speaking to that speaker.

From Controlled Laboratory Research Toward Natural Conversation

Which insights does our paradigm provide into the processes underlying conversation? We find that a partner's narrative establishes ad-hoc thematic relations in the person listening to this narrative, i.e., the person who will take the turn to speak subsequently. The established ad-hoc relations align with the content of the narrative and could be a mechanism that supports mutual understanding between conversational partners. This is in line with theories of dialogue that propose mutual understanding is achieved through an alignment of linguistic representations (cf. Interactive Alignment Model, Pickering & Garrod, 2004). According to this theory, an alignment of linguistic representations between conversational partners results from activating linguistic representations while processing a partner's utterances. These activated linguistic representations are readily retrieved during subsequent language production. Alignments on local lexical or syntactic levels build up to an alignment on the level of situation models, thus enabling mutual understanding. We propose here that our experimental manipulation taps into the processes underlying alignment on the semantic level of situation models. By semantically processing the partner's narrative an overarching situation model is activated in the mind of the study participants. This situation model entails precisely those semantic themes whose consequences we observe in the subsequent naming task. Thus, our data can be explained by an alignment of representations activated during speech comprehension (semantic themes in partner's narrative) and representations accessed during subsequent speech production (words associated with narrative content). According to the Interactive Alignment model, this is the mechanism enabling mutual understanding.

Please note that we do not propose that the mechanism of flexibly adapting the semantic network to a given narrative context is *exclusive* to a conversational exchange between two interlocutors. In fact, Abdel Rahman and Melinger (2011) have demonstrated that, with the identical materials and a similar blocked-cyclic design, similar effects arise outside of a social setting. We propose instead that the flexibility of lexical-semantic processing revealed in this prior work forms the basis for what also happens during communicative exchanges with another person, as demonstrated here in this study.

That being said, the present study brings new insights on top of what has already been tested in Abdel Rahman and Melinger's work (2011), in which theme titles were presented instead of short videos. Most notably, our current study demonstrates that ad hoc semantic relationships can be generated from complex, multi-sensory linguistic input which resembles in many aspects more closely natural human communication - albeit, of course, our current setting is still yet only an approximation. For example, our need for experimental control made it necessary to pre-record the partners' narrations instead of having a live interaction. If we had a live person telling the narrative, for instance, some versions of a given narrative might have been more successful than others in inducing the intended narrative theme, speakers may have accidentally used target words reserved for the testing phase, or may have spontaneously produced paralinguistic cues, such as gestures, eliciting a different meaning representation in participants.

Demonstrating that ad hoc semantic relationships can be generated from complex, multi-sensory linguistic input is an important step towards applying mechanisms known to shape the semantic network in single speakers towards building theories of speech production in social interaction. Lastly, our finding that the narrative-induced semantic blocking effect is susceptible to the time elapsed between the narrative prime and naming the thematically related pictures sheds light on the interplay between lexical-semantic processing and the role of short-term memory. This will be an important stepping stone for further investigations.

Conclusions

Let's return to conversation sketched at the beginning of this article. In this scenario we introduced an overhearer of a dialogue and potential conversational partner who tried to align at the level of the situation model to be able to join the conversation. Our results indicate that speakers can align with their partners to flexibly engage in a conversation, and this alignment shapes semantic activation spread and in turn lexical selection. Until now, the microstructure of the planning stages involved in language production has been well-investigated. However, comparatively little is known about how these stages and their interactions are modulated by a task partner. The present study provides evidence on how the flexibility of lexical-semantic activation may be used in the service of successful dialogue.

In conclusion, our study introduces a novel paradigm which integrates a classic single-person picture naming paradigm into a communicative context, making a step further towards studying speech production in social interaction. Moreover, our results, although limited to certain conditions, still support the proposal that a speaker adjusts the semantic network activations to the content of their partner's narrative, establishing ad-hoc thematic relations that bind lexical entries related to the conversational topic together. We argue that this form of semantic alignment indicates a flexible semantic system, which enables a speaker to be rapidly tuned in to a conversation.

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Table 1. Experiment 1: Linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects						
Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***
Intercept		1.6100	0.038	1.53 – 1.69	42.059	< 0.001 ***
Thematic blocking		0.0032	0.010	-0.02 – 0.02	0.311	0.758
Block order		0.0447	0.071	-0.10 – 0.19	0.622	0.539
Repetition (cycles 2 to 6)		< 0.0001	0.001	-0.00 – 0.00	0.017	0.986
Block order × Thematic blocking		-0.0894	0.014	-0.12 – -0.06	-6.002	< 0.001 ***
Random effects		**Variance**	***SD***			
Participant	Intercept	0.0411	0.202			
	Thematic blocking	0.0008	0.029			
Picture	Intercept	0.0042	0.065			
	Thematic blocking	0.0013	0.036			
Residual		0.0563	0.237			
Likelihood ratio test		χ^2	**df**		***p***	
Block order × Thematic blocking		24.094	1		< 0.001 ***	
Coding formula in R						
`1000/RT ~ Thematic blocking * Block order + Repetition + (1 + Thematic blocking | participant) + (1 + Thematic blocking | picture)`						

*p < 0.05. **p < 0.01. ***p < 0.001. *SE* = standard error. *CI* = confidence intervals.*SD* = standard deviation.

Table 2. Experiment 1: Nested linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.6100	0.038	1.53 – 1.69	42.059	< 0.001	***
Block order		0.0447	0.071	-0.10 – 0.19	0.622	0.539	
Repetition (cycles 2 to 6)		< 0.0001	0.001	-0.00 – 0.00	0.017	0.986	
Homogeneous-first: blocking		*0.0479*	*0.012*	*0.02 – 0.07*	*3.755*	*<0.001*	***
Heterogeneous-first: blocking		*-0.0415*	*0.012*	*-0.07 – -0.02*	*-3.245*	*0.002*	**
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0411	0.202				
	Thematic blocking	0.0008	0.029				
Picture	Intercept	0.0042	0.065				
	Thematic blocking	0.0013	0.036				
Residual		0.0563	0.237				
Likelihood ratio test		χ^2	**df**		***p***		
Block order / Thematic blocking		24.094	1		< 0.001	***	

Coding formula in R

```
1000/RT ~ Block order / Thematic blocking + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

**p* < 0.05. ***p* < 0.01. ****p* < 0.001. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table 3. Experiment 2: Linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.6893	0.030	1.63 – 1.75	55.578	< 0.001	***
Thematic blocking		-0.0278	0.011	-0.05 – -0.01	-2.404	0.023	*
Block order		-0.0434	0.055	-0.15 – 0.07	-0.779	0.441	
Repetition (cycles 2 to 6)		0.0008	0.002	0.00 – 0.01	3.199	0.003	**
Block order × Thematic blocking		-0.0584	0.013	-0.08 – -0.03	-4.337	< 0.001	***
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0245	0.156				
	Thematic blocking	0.0003	0.018				
Picture	Intercept	0.0036	0.060				
	Thematic blocking	0.0022	0.046				
	Repetition	< 0.0001	0.007				
Residual		0.0668	0.258				
Likelihood ratio test		χ^2	**df**		***p***		
Block order × Thematic blocking		14.766	1		< 0.001	***	

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking + Repetition| picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table 4. Experiment 2: Nested linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***
Intercept		1.6893	0.030	1.63 – 1.75	55.578	< 0.001 ***
Block order		-0.0434	0.055	-0.15 – 0.07	-0.779	0.441
Repetition (cycles 2 to 6)		0.0008	0.002	0.00 – 0.01	3.199	0.003 **
Homogeneous-first: blocking		*0.0014*	*0.013*	*-0.02 – 0.03*	*0.105*	*0.917*
Heterogeneous-first: blocking		*-0.0570*	*0.013*	-0.08 – -0.03	*-4.263*	*<.001* ***
Random effects		**Variance**	***SD***			
Participant	Intercept	0.0245	0.156			
	Thematic blocking	0.0003	0.018			
Picture	Intercept	0.0036	0.060			
	Thematic blocking	0.0022	0.046			
	Repetition	< 0.0001	0.007			
Residual		0.0668	0.258			
Likelihood ratio test		χ^2	**df**		***p***	
Block order × Thematic blocking		14.766	1		< 0.001 ***	

Coding formula in R

```
1000/RT ~ Block order / Thematic blocking + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking + Repetition| picture)
```

**p* < 0.05. ***p* < 0.01. ****p* < 0.001. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table 5. Experiment 3: Linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***
Intercept		1.7040	0.030	1.65 – 1.76	56.796	< 0.001 ***
Thematic blocking		-0.0094	0.010	-0.03 – 0.01	-0.938	0.356
Block order		-0.0412	0.054	-0.15 – 0.07	-0.751	0.458
Repetition (cycles 2 to 6)		0.0019	0.002	-0.00 – 0.01	0.913	0.362
Block order × Thematic blocking		-0.0172	0.015	-0.05 – 0.01	-1.138	0.264
Random effects		**Variance**	***SD***			
Participant	Intercept	0.0238	0.154			
	Thematic blocking	0.0007	0.027			
Picture	Intercept	0.0036	0.060			
	Thematic blocking	0.0010	0.032			
Residual		0.0675	0.259			
Likelihood ratio test		χ^2	**df**		***p***	
Block order × Thematic blocking		1.2669	1		0.2604	

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

**p* < 0.05. ***p* < 0.01. ****p* < 0.001. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table 6. Experiment 3: Nested linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking, block order, repetition and the interaction between block order and thematic blocking.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***
Intercept		1.7040	0.030	1.65 – 1.76	56.796	< 0.001 ***
Block order		-0.0412	0.054	-0.15 – 0.07	-0.751	0.458
Repetition (cycles 2 to 6)		0.0019	0.002	-0.00 – 0.01	0.913	0.362
Homogeneous-first: blocking		*-0.0007*	*0.012*	*-0.03 – 0.02*	*-0.062*	*0.951*
Heterogeneous-first: blocking		*-0.0180*	*0.012*	*-0.04 – 0.01*	*-1.435*	*0.160*
Random effects		**Variance**	***SD***			
Participant	Intercept	0.0238	0.154			
	Thematic blocking	0.0007	0.027			
Picture	Intercept	0.0036	0.060			
	Thematic blocking	0.0010	0.032			
Residual		0.0675	0.259			
Likelihood ratio test		**χ^2**	**df**	***p***		
Block order × Thematic blocking		1.2669	1	0.2604		

Coding formula in R

```
1000/RT ~ Block order / Thematic blocking + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

$^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

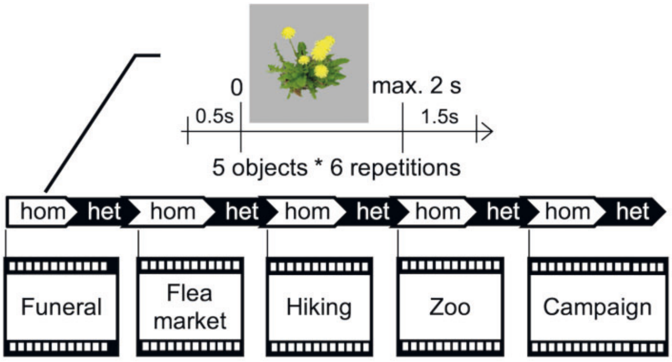

Figure 1. Design and procedure (hom: homogeneous block; het: heterogeneous block). Participants watched a video of one of the five task partners talking about one of five themes. Subsequently, participants named blocks of pictures from either homogeneous or heterogeneous sets in six repetition cycles each. Half of the participants (*n* = 16) first named homogeneous blocks and then heterogeneous blocks, whereas the other half (*n* = 16) did it in the reverse order. Each naming trial began with a fixation cross in the centre for 0.5s, followed by an object picture that was presented until a naming response was given, or for a maximum of 2s. An inter-stimulus interval of 1.5 s with a blank screen was presented before the next trial started. There was a 15s-break between the homogeneous and the heterogeneous block. This procedure was repeated five times, each time with a different partner and theme.

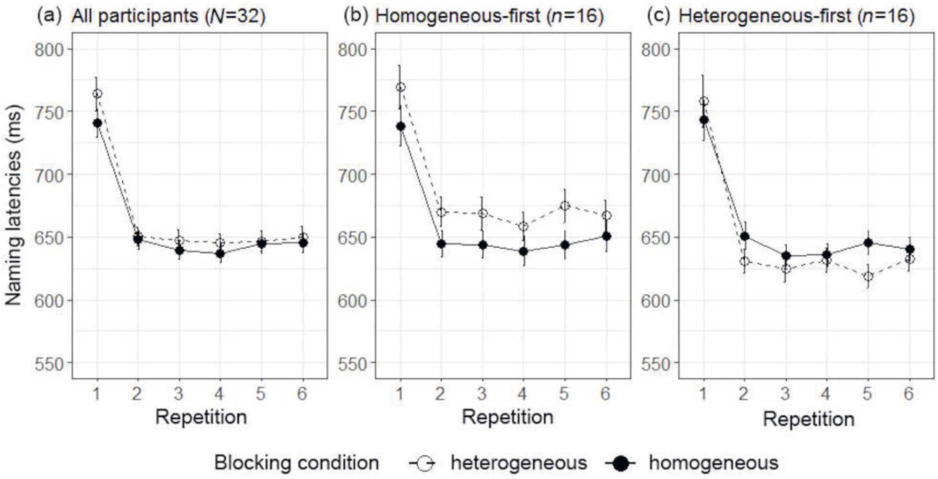

Figure 2. Naming latencies observed in Experiment 1 (congruent narratives) as a function of semantic relatedness of pictures to the partners' narrative (homogeneous vs. heterogeneous). Panel a shows no semantic context effects across all participants (*N* = 32). Panel b demonstrates unexpected semantic facilitation in participants who named thematically-related pictures in immediate succession to partner's narrative ("homogeneous-first"; *n* =16). Panel c demonstrates the expected semantic interference in participants who named thematically-unrelated pictures right after partner's narrative ("heterogeneous-first", *n* =16). Error bars represent the 95% confidence intervals.

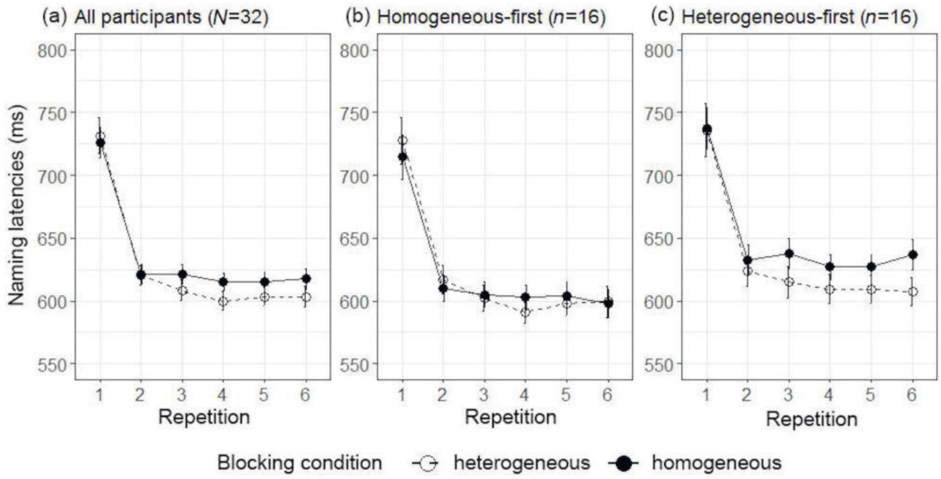

Figure 3. Naming latencies observed in Experiment 2 (congruent narratives) as a function of semantic relatedness of pictures to the partners' narrative (homogeneous vs. heterogeneous). Panel a demonstrates semantic interference across all participants (*N* = 32). Panel b shows no particular effects in participants who named thematically-related pictures in immediate succession to partner's narrative ("homogeneous-first"; *n* = 16). Panel c demonstrates the expected semantic interference in participants who named thematically-unrelated pictures right after partner's narrative ("heterogeneous-first", *n* = 16). Error bars represent the 95% confidence intervals.

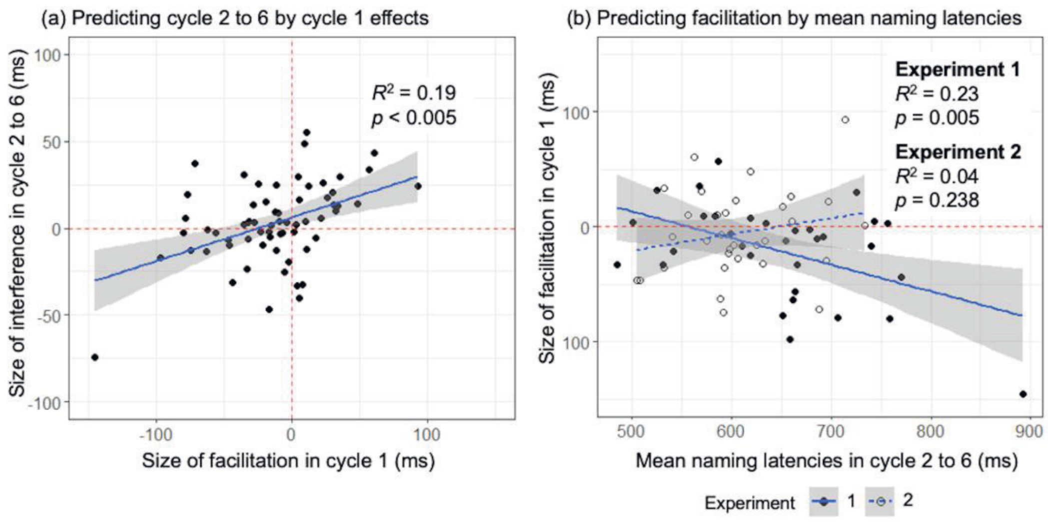

Figure 4. Exploratory analyses indicating the trade-off between semantic priming and interference, along with differences between Experiment 1 and 2. Negative values indicate facilitation; positive values indicate interference; the grey zone indicates 95% confidence interval for predictions from a linear model. All data pooled together from Experiment 1 and Experiment 2. (a) Predicting the size of interference in cycles 2 to 6 by the size of facilitation in cycle 1. The stronger the facilitation in cycle 1, the weaker the interference in cycles 2 to 6. (b) The size of facilitation in cycle 1 plotted against subjects' mean naming latencies in cycles 2 to 6. Slower participants experienced more semantic priming.

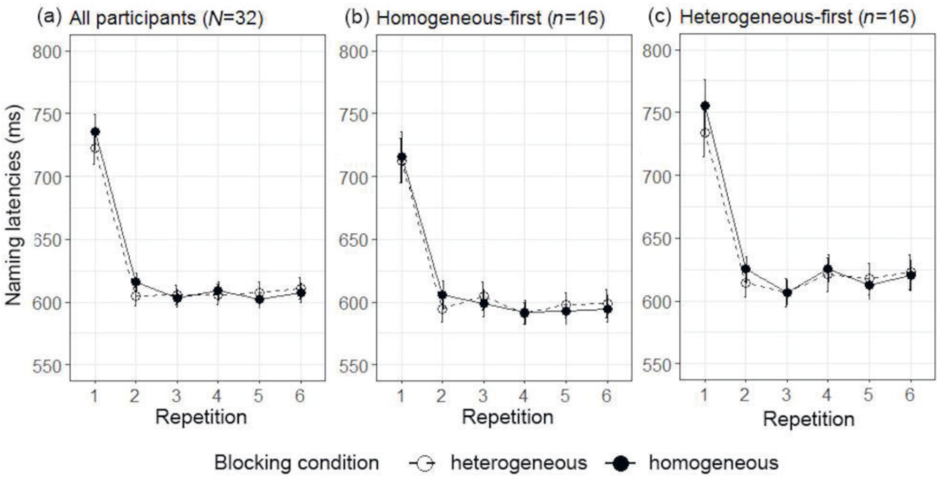

Figure 5. Naming latencies observed in Experiment 3 (incongruent narratives) as a function of semantic relatedness of pictures to the partners' narrative (homogeneous vs. heterogeneous). Panel a shows no semantic context effects across all participants ($N = 32$). Panel b shows no particular effects in participants who named thematically-related pictures in immediate succession to partner's narrative ("homogeneous-first"; $n = 16$). Panel c shows no effects in participants who named thematically-unrelated pictures right after partner's narrative ("heterogeneous-first", $n = 16$). Error bars represent the 95% confidence intervals.

Endnotes

[i] Alternatively, the difference between both experiments might be accounted for by participants applying strategic responses. Although merely a few participants indicated that they realized a thematic relation between a partner's story and the pictures they named for that partner, they might still be aware of the blocking design and made responses according to the given narrative context to predict upcoming items that belong to the same theme within a related block, especially for those who were assigned to the related-unrelated block order. If this was the case, then one should predict such strategic responses to be reflected in the naming latencies over the course of a cycle: Naming latencies decreases over ordinal positions in related blocks because participants took advantage of the thematic knowledge. Moreover, assuming that it was the effective use of information that led to faster naming over ordinal positions, such effect should be more pronounced in Experiment 1 than Experiment 2, which would explain the faster naming latencies in related blocks relative to unrelated blocks in Experiment 1, i.e., the blocking effect that revealed as facilitation in cycles 2 to 6.

To explore this possibility, we looked into the changes of naming latencies across ordinal positions in each blocking condition in related-unrelated and unrelated-related block order respectively. For cycles 2 to 6, visual inspection indicated that regardless of block order, naming latencies slightly *increased* over the course of a cycle in Experiment 1, whereas such effect was absent in Experiment 2. The results do not support the alternative explanation that participants applied strategic response to the blocking design based on the thematic information given by the partners, which should result in *decreasing* naming latencies specifically in the related-unrelated order.

Appendix A

An Example Transcription of the Stimulus Videos (Original in German)

Hiking

Hello, I am Christoph, 28, major in German studies. Today I will tell you a short story from my life. Last summer, I went hiking with a group of friends. We set off in the late morning. The fields were fresh and green, birds twittered and bees hummed everywhere. At noon, we looked for a shady spot, ate some snacks we had brought along. One of my friends is an amateur photographer. He took some photos of the animals that were running around. Yeah, but unfortunately, he also had on the wrong shoes for hiking, and his feet were full of blisters a short time later. So, we had to end the tour earlier than we had originally planned.

Wanderung

Hallo, ich bin Christoph, 28, studiere Germanistik. Und heute erzähle ich von einem kurzen Erlebnis von meinem Leben. Letzten Sommer war ich mit ein paar Freunden auf einer Wandertour. Wir sind so gegen späten Vormittag los, die Felder waren frisch und grün, und überall haben Vögel gezwitschert und Bienen gesummt. Gegen Mittag haben wir uns dann so ein schattiges Plätzchen gesucht, ein paar Snacks gegessen, die wir mitgenommen hatten. Einer von meinen Freuden, der Hobby-Fotograf ist, der hat ein paar Fotos gemacht von den Tieren, die da so rumgelaufen sind. Ja, leider hat er aber auch die falschen Schuhe an für so eine Wandertour, und hatte kurze Zeit später schon die ganzen Füße voller Blasen, so dass wir die Tour früher abbrechen müssen als wir es eigentlich ursprünglich geplant hatten.

Appendix B

Complete List of Objects and Corresponding Themes

Picture set	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Beerdigung (funeral)	Schaufel *f.* (shovel)	Anzug *m.* (suit)	Blume *f.* (flower)	Taschentücher *n.* (handkerchiefs)	Kaffee *m.* (coffee)
Flohmarkt (flea market)	Geldkassette *f.* (cash box)	Buch *n.* (book)	Tisch *m.* (table)	Stiefel *m.* (boots)	Puppe *f.* (doll)
Wanderung (hike)	Pflaster *n.* (plaster)	Löwenzahn *m.* (dandelion)	Socke *f.* (socks)	Müsliriegel *m.* (cereal bar)	Bussard *m.* (buzzard)
Zoobesuch (zoo)	Nest *n.* (nest)	Eis *n*. (ice cream)	Knochen *m*. (bone)	Lama *n.* (llama)	Seil *n.* (rope)
Wahlkampf (campaign)	Videokamera *f.* (video camera)	Schirm *m*. (sunshade)	Luftballon *m.* (balloon)	Kuli *m.* (pen)	Rednerpult *n.* (podium)

Note. Adapted from Abdel Rahman and Melinger (2011). *f.*= feminine noun. *m.* = masculine noun. *n.* = neuter noun.

Appendix C

Table C.1. Experiment 1: Original linear mixed effects model testing inverse-transformed naming latencies, including predictors: thematic blocking and repetition.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.6100	0.038	1.53 – 1.69	41.770	< 0.001	***
Thematic blocking		0.0032	0.013	-0.02 – 0.03	0.251	0.803	
Repetition (cycles 2 to 6)		< 0.0001	0.001	-0.00 – 0.00	0.016	0.987	
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0418	0.204				
	Thematic blocking	0.0028	0.053				
Picture	Intercept	0.0042	0.065				
	Thematic blocking	0.0013	0.036				
Residual		0.0563	0.237				
Likelihood ratio test		χ^2	**df**	***p***			
Thematic blocking		0.0629	1	0.802			

Coding formula in R

```
1000/RT ~ Thematic blocking + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

$*p < 0.05$. $**p < 0.01$. $***p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.2. Experiment 1: statistical analysis testing the influence of beliefs about one's partner.

Fixed effects

Predictor	**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept	1.6080	0.038	1.53 – 1.68	42.110	< 0.001	***
Thematic blocking	0.0034	0.010	-0.02 – 0.02	0.332	0.742	
Block order	0.0383	0.071	-0.10 – 0.18	0.534	0.597	
Belief about one's partner	0.0513	0.071	-0.09 – 0.19	0.716	0.479	
Repetition (cycles 2 to 6)	< 0.0001	0.001	-0.00 – 0.00	0.017	0.986	
Block order × Thematic blocking	-0.0885	0.014	-0.12 – -0.06	-5.922	< 0.001	***
Block order × Belief	0.0718	0.143	-0.21 – 0.35	-0.498	0.622	
Thematic blocking × Belief	-0.0074	0.014	-0.04 – 0.02	0.501	0.620	
Not believed: Blocking	*0.0069*	*0.012*	*-0.02 – 0.03*	*0.544*	*0.589*	
Believed: Blocking	*-0.0004*	*0.012*	*-0.03 – 0.02*	*-0.039*	*0.969*	
Block order × Blocking × Belief	-0.0071	0.029	-0.07 – 0.05	-0.239	-0.813	

Random effects		**Variance**	***SD***
Participant	Intercept	0.0402	0.200
	Thematic blocking	0.0008	0.028
Picture	Intercept	0.0042	0.065
	Thematic blocking	0.0013	0.036
Residual		0.0563	0.237

Likelihood ratio test	χ^2	**df**	***p***
Block order × Blocking × Belief	0.057	1	0.8113

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order * Belief + Repetition + (1 + Thematic
blocking | participant) + (1 + Thematic blocking | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.3. Experiment 2: statistical analysis testing the influence of beliefs about one's partner.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.6936	0.030	1.63 – 1.75	55.963	< 0.001	***
Thematic blocking		-0.0265	0.011	-0.05 – -0.0	-2.315	0.028	*
Block order		-0.0348	0.055	-0.14 – 0.07	-0.628	0.534	
Belief about one's partner		0.0022	0.055	-0.11 – 0.11	0.041	0.967	
Repetition (cycles 2 to 6)		0.0082	0.002	0.00 – 0.01	3.197	0.003	**
Block order × Thematic blocking		-0.0558	0.013	-0.08 - -0.03	-4.245	< 0.001	***
Block order × Belief		0.1322	0.011	-0.09 – 0.35	1.191	0.242	
Thematic blocking × Belief		0.0209	0.013	-0.00 – 0.05	1.591	0.121	
Not believed: Blocking		*-0.0370*	*0.012*	*-0.06 - -0.01*	*-2.896*	*0.006*	**
Believed: Blocking		*-0.0160*	*0.013*	*-0.04 – 0.01*	*-1.186*	*0.243*	
Block order × Blocking × Belief		-0.0003	0.026	-0.05 – 0.05	-0.012	0.990	
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0235	0.153				
	Thematic blocking	0.0002	0.015				
Picture	Intercept	0.0036	0.060				
	Thematic blocking	0.0022	0.046				
	Repetition	< 0.0001	0.007				
Residual		0.0668	0.258				
Likelihood ratio test		**χ^2**	**df**		***p***		
Block order × Blocking × Belief		0.0269	1		0.8696		

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order * Belief + Repetition + (1 + Thematic
blocking | participant) + (1 + Thematic blocking + Repetition | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.4. Linear mixed effects model testing inverse-transformed naming latencies in the first presentation cycle of experiment 1 and 2 ($N = 64$).

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.4200	0.028	1.36 – 1.48	49.803	< 0.001	***
Thematic blocking		0.0147	0.010	-0.01 – 0.03	1.436	0.163	
Block order		-0.0074	0.035	-0.08 – 0.06	-0.208	0.835	
Block order × Thematic blocking		-0.0477	0.018	-0.08 – -0.01	-2.571	0.010	*
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0191	0.138				
	Thematic blocking	< 0.0001	0.005				
Picture	Intercept	0.0123	0.110				
	Thematic blocking	0.0004	0.022				
Residual		0.0641	0.253				
Likelihood ratio test		χ^2	**df**	***p***			
Block order × Thematic blocking		6.6014	1	0.0101 *			

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.5. Nested linear mixed effects model testing inverse-transformed naming latencies in the first presentation cycle of experiment 1 and 2 ($N = 64$).

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.4200	0.028	1.36 – 1.48	49.803	< 0.001	***
Block order		-0.0074	0.035	-0.08 – 0.06	-0.208	0.835	
Homogeneous-first: blocking		*0.0386*	*0.013*	*0.01 – 0.07*	*2.792*	*0.006*	**
Heterogeneous-first: blocking		*-0.0091*	*0.013*	*-0.04 – 0.02*	*-0.0657*	*0.513*	
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0191	0.138				
	Thematic blocking	< 0.0001	0.005				
Picture	Intercept	0.0123	0.110				
	Thematic blocking	0.0004	0.022				
Residual		0.0641	0.253				
Likelihood ratio test		χ^2	**df**	***p***			
Block order × Thematic blocking		6.6014	1	0.0101	*		

Coding formula in R

```
1000/RT ~ Block order / Thematic blocking + Repetition + (1 + Thematic blocking |
participant) + (1 + Thematic blocking | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.6. Linear mixed effects model testing inverse-transformed naming latencies from cycle 2 to 6 (Experiment 1 and 2, $N = 64$) with the pre-registered fixed effects, with the size of facilitation in cycle 1 as a new predictor.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.6520	0.026	1.60 – 1.70	62.340	< 0.001	***
Thematic blocking		-0.0119	0.008	-0.03 – 0.01	-1.347	0.187	
Block order		-0.0130	0.046	-0.11 – 0.08	-0.279	0.781	
Facilitation in cycle 1		0.0009	< 0.001	-0.00 – 0.00	1.535	0.129	
Repetition (cycles 2 to 6)		0.0041	0.001	0.00 – 0.01	2.958	0.003	**
Block order × Thematic blocking		-0.0680	0.010	-0.09 – -0.05	-6.619	< 0.001	***
Blocking × Facilitation in cycle 1		-0.0004	< 0.001	-0.00 – -0.00	-3.113	0.002	**
Block order × Facilitation in cycle 1		-0.0006	0.001	-0.00 – 0.00	-0.531	0.597	
Block order × Blocking × Facilitation		< -0.0001	< 0.001	-0.00 – 0.00	-0.331	0.741	
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0337	0.183			-	
	Thematic blocking	0.0006	0.024				
Picture	Intercept	0.0037	0.061				
	Thematic blocking	0.0013	0.036				
Residual		0.0619	0.248				
Likelihood ratio test		χ^2	**df**	***p***			
Blocking × Facilitation in cycle 1		10.059	1	0.0015 **			

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order * Facilitation in cycle 1 + Repetition
+ (1 + Thematic blocking | participant) + (1 + Thematic blocking | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.7. Linear mixed effects model testing inverse-transformed naming latencies in cycle 1 (Experiment 1 and 2, *N* = 64), including experiment, thematic blocking and subject's mean naming latencies from cycle 2 to 6 as fixed effects.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.4193	0.023	1.37 – 1.47	60.733	< 0.001	***
Thematic blocking		0.0108	0.010	-0.01 – 0.03	1.028	0.313	
Experiment		-0.0128	0.015	-0.04 – 0.02	-0.848	0.399	
Mean naming latencies cycles 2 to 6		-1.1418	0.068	-1.28 – -1.01	-16.588	< 0.001	***
Thematic blocking × Experiment		-0.0158	0.019	-0.05 – 0.02	-0.835	0.403	
Thematic blocking × Mean naming latencies		-0.0371	0.087	-0.21 – 0.13	-0.427	0.669	
Experiment × Mean naming latencies		0.0705	0.137	-0.20 – 0.34	0.511	0.611	
Thematic blocking × Experiment × Mean naming latencies		-0.4003	0.174	-0.74 - -0.06	-2.298	0.021	*
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0020	0.045				
	Thematic blocking	< 0.0001	0.003				
Picture	Intercept	0.0122	0.110				
	Thematic blocking	0.0005	0.022				
Residual		0.0645	0.254				

Likelihood ratio test	χ^2	**df**	***p***	
Thematic blocking × Experiment × Mean naming latencies	5.2736	1	0.0216	*

Coding formula in R

```
1000/RT ~ Thematic blocking * Experiment * Mean naming latencies + (1 + Thematic
blocking | participant) + (1 + Thematic blocking | picture)
```

**p* < 0.05. ***p* < 0.01. ****p* < 0.001. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Table C.8. Experiment 3: statistical analysis testing the influence of beliefs about one's partner.

Fixed effects

Predictor		**Estimate**	***SE***	***95% CI***	***t***	***p***	
Intercept		1.7070	0.029	1.65 – 1.77	56.951	< 0.001	***
Thematic blocking		-0.0102	0.010	-0.03 – 0.01	-1.021	0.316	
Block order		-0.0461	0.054	-0.15 – 0.06	-0.842	0.406	
Belief about one's partner		-0.0172	0.054	-0.12 – 0.09	-0.315	0.755	
Repetition (cycles 2 to 6)		0.0019	0.002	-0.00 – 0.01	0.913	0.361	
Block order × Thematic blocking		-0.0155	0.015	-0.05 – 0.01	-1.014	0.318	
Block order × Belief		-0.1132	0.010	-0.33 – 0.10	-1.032	0.310	
Thematic blocking × Belief		-0.0019	0.015	-0.03 – 0.03	-0.128	0.899	
Not believed: Blocking		-0.0087	0.012	*-0.03 – 0.01*	*-0.723*	*0.475*	
Believed: Blocking		-0.0103	0.013	*-0.04 – 0.02*	*-0.777*	*0.442*	
Block order × Blocking × Belief		0.0242	0.030	-0.04 – 0.08	0.793	0.433	
Random effects		**Variance**	***SD***				
Participant	Intercept	0.0229	0.151				
	Thematic blocking	0.0007	0.026				
Picture	Intercept	0.0036	0.060				
	Thematic blocking	0.0010	0.032				
Residual		0.0675	0.259				
Likelihood ratio test		χ^2	**df**		***p***		
Block order × Blocking × Belief		0.6238	1		0.4296		

Coding formula in R

```
1000/RT ~ Thematic blocking * Block order * Belief + Repetition + (1 + Thematic
blocking | participant) + (1 + Thematic blocking | picture)
```

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. *SE* = standard error. *CI* = confidence intervals. *SD* = standard deviation.

Robust Cumulative Semantic Interference for (Very) Loose Semantic Relations in the Continuous Naming Paradigm

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Abstract

In this study, we investigated effects of loose semantic relations on object naming in the continuous naming paradigm, and whether relations among objects that would, prima facie, appear rather unrelated (e.g., glasses, syringe, houseplant, television etc.), become activated by the presence of a communication partner associated with the event-knowledge connecting these objects (e.g., having visited a retirement home). Participants (N = 32) named in interleaved sequence objects that were either related to the partner-specific knowledge or not. The objects were selected, based on a rating study, to be unrelated without direct categorical or associative links. Cumulative semantic interference (CSI) was only expected when objects relate to the event-knowledge associated with the communication partner, in which case naming latencies should increase with each named object. No CSI was expected for the same objects if they do not relate to the partner-specific knowledge. In contrast to our expectations, we found no partner-effects. Instead, robust CSI was observed both in the related and in the unrelated conditions. We further explored the nature of this effect by relating our findings to other reports with different types of semantic relations, and used a distributional semantic model to estimate semantic relatedness for the stimuli across studies. Results showed that (1) closer relations lead to larger CSI across different types of relations and that (2) even weak relations that hardly differ from unrelated items can induce small but robust CSI. Our study provides an estimate of the broad scope of semantic interference in the continuous naming task.

Keywords: cumulative semantic interference, lexical selection, continuous naming task, semantic relations, event-knowledge

Robust Cumulative Semantic Interference for (Very) Loose Semantic Relations in the Continuous Naming Paradigm

How does the situational and semantic context in which a word is produced affect language production? During speech planning, we proceed from conceptual to lexical, syntactic, phonological processing and articulation. Substantial research has shown that semantic context effects can reveal insights into the conceptual and lexical stages of speaking. Moreover, evidence has shown that the semantic system is flexible enough to take into account broader meaning-related contexts and social factors such as thematic contexts and the involvement of communication partners (e.g., Abdel Rahman & Melinger, 2011; Kuhlen & Abdel Rahman, 2017; Lin et al., 2021; Wudarczyk et al., 2021). Such dynamic features make the lexical-semantic system suitable for conversation, where theme- and partner-related semantic information becomes highly relevant for successful communication. The present study aimed to investigate whether lexical-semantic processing can be adapted to communication partners: After hearing that a task partner has recently visited her grandmother in the retirement home, would a speaker conceptualize and lexicalize items as "plate", "glasses", "syringe", "houseplant", and "television" as more related than before? We investigated this question by selecting sets of objects that are very loosely related, sharing neither semantic features or categories nor being directly associatively related in an obvious way. However, they do share loose event-knowledge relations so that their interrelatedness significantly increases when a common theme or event is uncovered (in the example: a fishing trip, see e.g., Abdel Rahman & Melinger, 2011; Lin et al., 2021). We expected such loose event relations to induce effects on naming times only if the underlying relation was conveyed by event-knowledge related to the conversational partner.

Semantic context effects can be inhibitory or facilitatory, depending on the type of relation and the context paradigm. While categorically related concepts share semantic features (e.g., "cow" and "horse" both have four legs and fur), associative relations are closely linked without sharing semantic features (e.g., mouse and cheese), and thematic relations very often co-occur in a specific context (e.g., "bee" and "honey" usually appear together in the context of an apiary), but do not necessarily share semantic features. Semantic context effects have been taken to reflect conceptual processing and lexical selection, proposed to take place about 200ms after stimulus onset (e.g., Costa et al., 2009; Levelt, 1992; Levelt et al., 1999; Piai et al., 2014; Strijkers et al., 2010). For example, in the picture-word interference (PWI) paradigm (e.g., Damian & Bowers, 2003; Glaser & Dungelhoff, 1984; Glaser & Glaser, 1989; Hantsch et al., 2005; Hutson & Damian, 2014; Mahon et al., 2007; Piai et al., 2014; Rose et al., 2019; Schriefers et al., 1990; Vigliocco et al., 2004), participants name a picture while ignoring a superimposed distractor word. Semantic interference (slower naming) is typically observed when a distractor word is categorically related to the picture compared to naming pictures that are superimposed with an unrelated distractor word. In contrast to the inhibitory effects induced by categorical relations, associative relations elicit either no effects or facilitatory effects on naming latencies in the PWI paradigm (e.g., Abdel Rahman & Melinger, 2007, Experiment 3; Alario et al., 2000; Costa et al., 2005; de Zubicaray et al., 2013; Wong et al., 2017).

In another widely used naming paradigm, blocked-cyclic naming (e.g., Belke et al., 2005; Belke, 2008; Damian & Als, 2005; Damian et al., 2001; Kroll & Stewart, 1994; Navarrete et al., 2012; Schnur et al., 2006; Vigliocco et al., 2002), participants name a small number of objects in short repeated cycles. When the objects are categorically related to one another, participants either show semantic facilitation or no effect compared to the unrelated naming condition in the first cycle of naming; in contrast, reliable semantic interference has been reported in later cycles of naming (e.g., Abdel Rahman & Melinger, 2011; Crowther & Martin, 2014; Navarrete et al., 2012; Janssen et al., 2015). The reliable semantic interference found for categorical relations are, however, not universally reported for associative relations. Associates have been reported to elicit semantic interference (e.g., Abdel Rahman & Melinger, 2007, Experiment 1 & 2; Aristei et al., 2011), or no effects (e.g., de Zubicaray et al., 2014; McDonagh et al., 2020).

The present study focuses on another commonly used paradigm to test semantic interference, the continuous naming task (e.g., Belke, 2013; Belke & Stielow, 2013; Costa et al., 2009; Howard et al., 2006; Navarrete et al., 2010; Rose & Abdel Rahman, 2017). In this task, participants name pictures in succession, with categorically related pictures interleaved with unrelated filler items. Naming latencies increase as the number of named exemplars of a given semantic category increases, an effect known as *cumulative semantic interference*. This effect implies that lexical selection becomes increasingly difficult the more categorially related exemplars are named. Testing effects of associative relations, Rose and Abdel Rahman (2016) reported cumulative interference in three experiments. Their findings suggest robust effects whether or not the associations were pre-activated before experiments, and irrespective of whether the stimuli partially contained categorical relations within an associative topic or not. One advantage of this paradigm is its simplicity, which distinguishes it from the dual-task PWI paradigm and the blocked-cyclic task, where response strategy might be easily applied (Belke & Stielow, 2013; Belke, 2017). Another advantage compared with the other two paradigms is that the continuous task seems to be able to detect semantic interference even for weaker semantic relatedness, such as associative relations (e.g., Rose & Abdel Rahman, 2016).

While semantic interference elicited by categorical relations have been relatively well-investigated, it is an ongoing debate whether non-categorical relations also induce semantic interference in the blocked-cyclic and the continuous naming paradigms. Unable to replicate the semantic interference elicited by associative relations as reported in prior studies using the blocked-cyclic paradigm (Abdel Rahman & Melinger, 2007; Aristei et al., 2011), de Zubicaray and colleagues (2014) criticized that some of the stimuli included in these studies shared semantic features. For example, in the “USA” context, a baseball cap was presented together with a person wearing a cowboy hat, which might have induced semantic interference due to their categorical relations. Taking this concern into account, Rose and Abdel Rahman (2016) reported reliable semantic interference for associates in the continuous naming paradigm, both when categorical relations were partially involved (Experiment 1 & 2) and when the categorically-related items were replaced with purely associated-related ones (Experiment 3). In contrast, employing the blocked-cyclic naming paradigm, McDonagh and colleagues (2020) applied objective measures of semantic similarity for both relations to achieve double dissociation, but reported no robust evidence of semantic interference for associates. One account for the heterogeneous evidence is that associative relations induce weaker interference that might be measured reliably better in the continuous task than in the blocked-cyclic task. Rose and Abdel Rahman (2016) argued that the continuous naming paradigm is particularly well-suited to reveal associative-thematic interference because the assumed conceptual-semantic priming induced by previously named related items should be stable across category members, whereas the lexical competition should increase with each related item, resulting in a cumulative increase of semantic interference in net naming times. Thus, associative interference should be observed more robustly in the continuous task than in the blocked-cyclic naming task. In sum, more evidence is needed for a deeper understanding on how non-categorical relations affect speech planning during lexical-semantic processing in the different context paradigms (see Abdel Rahman and Melinger, 2019 for a recent discussion).

The mechanisms behind semantic context effects have been explained by the activation spread within the structure of a lexical-semantic network. To produce a word (e.g., llama), a speaker first initiates conceptual preparation, which involves activating various semantic properties and semantic concepts related to the target concept (e.g., “mammal”, “wool”, “hooves”; Dell, 1986; Howard et al., 2006; Indefrey & Levelt, 2004; Levelt et al., 1999; Nozari & Hepner, 2018; Roelofs, 1992). The activated semantically related concepts activate their corresponding lexical representations, resulting in co-activated lexical representations. Such activation spreads through the lexical-semantic network bi-directionally via connections between conceptual and lexical representations. The target lexical representation (e.g., “llama”) is then selected from the cohort of co-activated lexical items for further morphological and phonological processing until final articulation.

A basic assumption of lexical selection, according to the competitive view, is that co-activated lexical candidates compete with the target lexical representation, with the most strongly activated lexical representation being ultimately selected for articulation (Dell, 1986; Howard et al., 2006; Levelt et al., 1999; Roelofs, 1992, 2018). As a consequence of the largely parallel activation at the conceptual and lexical level, lexical competition and facilitatory semantic priming during lexical-semantic processing contribute to the overall selection latency, resulting in semantic interference only when competition outweighs priming (Abdel Rahman & Melinger, 2009, 2019; Belke et al., 2005; Roelofs, 2018). Alternatively, non-competitive accounts do not assume lexical competition, but propose mechanisms related to specific paradigms. In the continuous naming task, an additional incremental learning mechanism is assumed to result in semantic interference (Navarrete et al., 2012; Navarrete et al., 2014; Oppenheim et al., 2010). Similar to competitive accounts, the connections between concepts and lexical entries of named items get strengthened; additionally, it is assumed that the connections between the concepts and co-activated but unselected lexical entries get weakened, leading to hampered naming and cumulative semantic interference.

In the continuous naming task, each exemplar from the same category is separated by unrelated items, so the relatively short-lived priming of same-category concepts decays fast, leading to overall stable semantic priming effect throughout ordinal positions because each time a new exemplar is named, the same-category concepts are re-activated. On the other hand, the long-lasting lexical interference survives through multiple activations of unrelated representations, and accumulates with each newly named same-category item because the links between concepts and lexical representations is strengthened upon naming (Howard et al., 2006; Oppenheim et al., 2010). With constant conceptual priming and a growing lexical cohort with each naming, it might be easier to find semantic interference compared to facilitation for different types of relations in this paradigm (Rose & Abdel Rahman, 2016), enabling the detection of robust effects for even less strongly related items as associates.

Apart from classic types of semantic relations, semantic context effects can even be built on the fly for objects that are seemingly unrelated, but share a common goal (Barsalou, 1983; Yeh & Barsalou, 2006) or are inter-related to the knowledge of a specific event

(Metusalem et al., 2012). It has been shown that such distantly-related objects (e.g., "ropes", "nest", "llama", "bone", "ice cream") would not induce semantic interference, unless a title uncovering their common theme or event (e.g., "zoo") was presented to the participants shortly before naming (Abdel Rahman & Melinger, 2011), suggesting that triggering the event-knowledge to link the distantly-related objects into this meaningful context, can induce the formation of ad-hoc categories. Taking a step further, Lin and colleagues (2021) tested whether such ad-hoc effects can also be induced in an experimental setting that simulated a social communicative environment. Instead of reading a theme title, participants watched a presumed task partner narrating a short autobiographical story about a recent event shortly before naming pictures. Also in this social context, participants showed semantic context effects when naming objects related to the event of their partner's narrative. The ad-hoc semantic context effects induced by verbal semantic cues or partner's narratives indicates that the semantic system is highly flexible, enabling a speaker to rapidly integrate information from broader meaningful contexts such as the thematic context or information associated with a communication partner.

The Present Study

Building on Lin and colleague's study (2021), which examines ad-hoc relation elicited by communicative context in a blocked-cyclic naming paradigm, here we aimed to investigate how a task partner's narrative influences a speaker's lexical-semantic processing in a continuous naming task. Our motivation was to replicate the partner-effect in a simulated communicative setting with a different paradigm that elicits semantic context effects related to learning mechanisms. Based on the assumption that semantic priming effects remain stable while lexical interference increases in a cumulative fashion with each newly named item of a given semantic relation, this paradigm has been used to reveal effects of non-categorical relations that may be difficult to observe in other context paradigms such as PWI and blocked-cyclic naming (see discussion above).

In the present study, we use the term *covert condition* to refer to the state of loose event relations that were not primed by the common event-knowledge or a task partner associated with such knowledge, but could potentially form an ad-hoc semantic category if doing so. The attribute of this type of loose event relations is that objects, by themselves, would not induce effects distinguishable from unrelated items without additional triggers that inter-relate them (Abdel Rahman & Melinger, 2011; Lin et al., 2021). We use the term *overt condition* to refer to their elevated state of relatedness if explicitly primed by the common event-knowledge or an event-associated task partner. To ensure a successful manipulation of loose event relations, we ran a pre-study that asked participants to rate the semantic relatedness among objects associated to an event before and after the title of the event was provided. Only those objects whose relatedness was significantly increased after title exposure were selected as experimental stimuli.

To examine how semantic relatedness increases between objects when they become associated with an event experienced by the task partner, we added to the classic continuous naming task the following feature: In a partner-block, a participant named two picture sets, one associated with the partners' narrative (from covert condition to overt condition), the other associated with a hidden narrative not revealed to the participant (remaining in covert condition), and additional intervening filler trials. We hypothesized that participants would form ad-hoc semantic relations among exemplars whose common event-knowledge was revealed by the partner's narrative, which would result in cumulative semantic interference. In contrast, we hypothesized that no interference should be present among those exemplars for which no partner's narrative was given to reveal the underlying common event. Note that we used a counterbalanced design such that across participants all sets were equally often related to the narrative (overt condition) or unrelated (covert condition).

This study was approved by the local ethics committee and was based on ethical principles put forward by the Declaration of Helsinki for research involving human subjects (Version 2013). The data that support the findings of this study are available online at OSF (Lin et al., 2021).

Pre-Study: Measuring Semantic Relatedness of Loose Event Relations

To ensure that our stimulus picture sets consisted of objects that would be perceived as significantly more related after being linked to a common event conveyed in partners' narratives later in the main experiment, we ran an online rating survey prior to the main study. The goal of this pre-study was, firstly, to validate and re-use the existing picture sets used in previous studies that investigated loose event relations in the blocked-cyclic naming paradigm (Abdel Rahman & Melinger, 2011; Lin et al., 2021). On top of that, the pre-study aimed to select new stimulus picture sets in order to obtain sufficient observations for the continuous naming task (unlike the blocked-cyclic naming task, where repeated cycles generate multiple observations, a given set generates less observations within the continuous naming task).

Method

Participants

We collected rating data from 32 native German speakers via an online recruitment platform, Psychological Experimental Server Adlershof (PESA), run by the Department of Psychology at the Humboldt-Universität zu Berlin. Participants received partial fulfillment of a curriculum requirement. All participants gave informed consent prior to the online survey.

Materials

One hundred colored photographs of common objects formed the complete picture set (ten existing sets, ten new sets, with five exemplars within each picture set; see Supplemental Materials for complete lists of objects and themes), from which we aimed to select sixteen sets. The exemplars in a given set were selected to be seemingly unrelated and visually dissimilar, and drawn from different categories. Crucially, each of the exemplars could potentially relate to an event (e.g., plate, glasses, syringe, houseplant, television seem unrelated to each other, but can all be related to the event “visit to a retirement home”). We ensured that none of the exemplars was prototypically associated with the event (e.g., we did not include a wheelchair, which may be more commonly associated with a retirement home).

To avoid strategies in the response task (deciding whether, or to what degree the items are related) and speculations that certain relations existed for every picture set, we included ten semantically unrelated sets (mixed sets), composed by mixing up the exemplars between the loose event relation picture sets. Similar to the loose event relation sets, these exemplars were from different categories, as seemingly unrelated and visually dissimilar as possible. We randomly assigned theme titles to these unrelated picture sets. The loose event relations and unrelated picture sets were interleaved in random order for the online survey.

Procedure

Participants were asked to rate how related the given exemplars in a picture set were to each other on a scale from one (totally unrelated) to seven (strongly related). The online survey consisted of two parts: In the first half of the survey, participants rated the semantic relatedness of exemplars in picture sets without knowing their underlying events. Object names were provided in text above their pictorial counterparts. To control for the possibility that participants spontaneously invented random stories to relate the items, we asked them to name the connection among the exemplars if they thought a relation existed for a given set. In the second half of the survey, the identical picture sets were rated again, this time alongside their corresponding event titles.

Data Analyses

All statistical analyses were carried out in R 4.0.5 (R Core Team, 2018).

Selecting Stimulus Picture Sets of Loose Event Relations. Our pre-defined selection criterion for the loose event relations was that picture sets' rated relatedness should score significantly different before and after the exposure of event titles. This would indicate that the selected picture sets are sensitive to our manipulation of loose event relations. For this purpose, we conducted a paired samples t-test for each picture set using the *t_test* function in the *rstatix* package (*v0.7.0*; Kassambara, 2021). A Box-Cox Test (*boxcox* function in the *MASS* package, *v7.3-53.1*; Venables & Ripley, 2002) suggested a log transformation on the rating data to achieve normal distribution. Bonferroni correction was applied to adjust the alpha for multiple comparisons.

Evaluating the General Properties of Loose Event Relations. To evaluate the general properties of the selected loose event relation sets, we conducted linear mixed effects models (LMM; Baayen et al., 2008) on log-transformed relatedness using the *lme4* package (Bates et al., 2015a, *v1.1-21*). As fixed effects, we entered the predictor Set Type (loose event relations vs. mixed; the latter being the reference level) and Event Title (with title vs. without title; the latter being the reference level) into the models. Both predictors were modelled to compare the means of the factor levels to the respective reference level (numerically: covert sets = 0.5, mixed sets = -0.5; with title = 0.5, without title = -0.5).

A nested model (Set Type nested within Event Title) was run in order to examine whether the selected loose event relation sets, *before* event title exposure, were rated just as unrelated as the mixed sets. Models were initially run with a maximum random effects structure, including intercepts for subjects and items, as well as hypotheses-based a priori contrasts of the fixed effects as random slopes (cf. Schad et al., 2020). When the maximal model failed to converge, we set all correlation parameters to zero by using the double-bar syntax (cf. Kliegl, 2014). Applying singular value decomposition, this initial random effect structure was simplified by successively removing those random effects whose estimated variance was zero until the maximal informative model was identified (Bates et al., 2015b). Both models converged.

For fixed effects, we report estimates, 95% confidence intervals, and *t*-values. We considered fixed effects as significant if $|t| \geq 1.96$ (cf. Baayen et al., 2008), but also computed *p*-values by Satterthwaite approximation (using the *summary* function in the *lmerTest* package, *v3.1-1*; Kuznetsova et al., 2017). For random effects, we report estimates of variance as well as the standard deviations. Goodness-of-fit statistics are also reported.

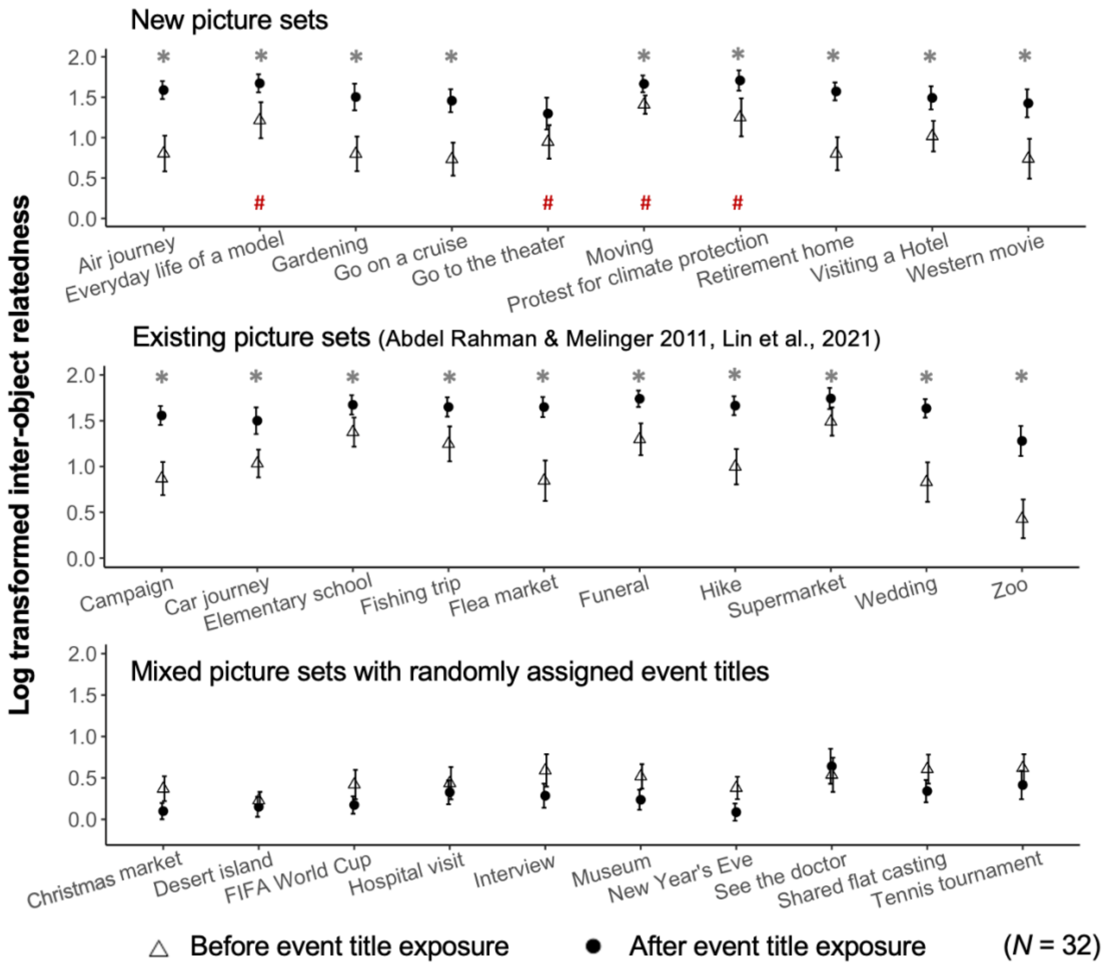
Results

Selecting Stimulus Picture Sets of Loose Event Relations

For all picture sets of loose event relations, with only one exception, participants rated the exemplars as significantly more inter-related after a common event title was exposed, see Figure 1 and Table 1. In contrast, for all mixed picture sets which were randomly assigned unrelated titles, participants perceived the exemplars not significantly different after being exposed to the event. These findings indicate that both the newly selected sets (with one exception) and the existing picture sets (Abdel Rahman & Melinger, 2011; Lin et al., 2021) fulfil our definition of loose event relations, validating that these sets could indeed be perceived as more related once the titles are provided, sensitive enough to our manipulation. For best quality, we discarded four new picture sets that showed the smallest difference in rating before and after the exposure to the event title (including the one exception whose relatedness score did not differ significantly before and after title exposure). This resulted in a final picture set of 16 events, each consisting of five exemplar pictures.

Figure 1

Log-Transformed Semantic Relatedness Among Exemplars Within Picture Sets, Rated by Participants Before and After Event Title Exposure



Notes. The figure shows the log-transformed inter-object relatedness scores rated by participants before and after event title exposure. Asterisks (*) indicate *p*-values < .05, alpha corrected for multiple comparisons. Hash signs (#) mark the picture sets of new events that were estimated as the least differently related before and after the exposure to the event title and were hence discarded. The error bars refer to the 95% confidence intervals.

Table 1

Paired Samples T-Tests Comparing the Means of Log-Transformed Relatedness Rated by Participants After versus Before Event Title Exposure

		Picture sets	Estimates (after vs. before)	*t*	*df*	*95% CI*			*p* (corrected)	
Loose event	1	Zoo	0.85	6.66	31	0.59	-	1.11	< .001	***
	2	Flea market	0.80	5.99	31	0.53	-	1.07	< .001	***
	3	Wedding	0.80	6.45	31	0.55	-	1.05	< .001	***
	4	Air journey	0.78	5.79	31	0.50	-	1.06	< .001	***

	5	Retirement home	0.77	6.63	31	0.53	-	1.00	< .001	***
	6	Go on a cruise	0.72	5.82	31	0.46	-	0.97	< .001	***
	7	Gardening	0.70	5.38	31	0.43	-	0.97	< .001	***
	8	Campaign	0.68	5.56	31	0.43	-	0.94	< .001	***
	9	Western movie	0.68	4.49	31	0.37	-	0.99	.002	**
	10	Hike	0.66	6.17	31	0.44	-	0.88	< .001	***
	11	Visiting a hotel	0.47	4.96	31	0.27	-	0.66	< .001	***
	12	Car journey	0.46	4.45	31	0.25	-	0.68	.003	**
	13	Everyday life of a model [a]	0.45	4.10	31	0.22	-	0.68	.008	**
	14	Protest for climate protection [a]	0.45	4.17	31	0.23	-	0.67	.006	**
	15	Funeral	0.44	4.15	31	0.22	-	0.66	.007	**
	16	Fishing trip	0.40	4.16	31	0.20	-	0.60	.006	**
	17	Go to the theater [a]	0.35	3.31	31	0.13	-	0.56	.070	n.s.
	18	Elementary school	0.29	3.59	31	0.12	-	0.46	.033	*
	19	Moving [a]	0.25	4.45	31	0.13	-	0.37	.003	**
	20	Supermarket	0.25	3.65	31	0.11	-	0.39	.028	*
Mixed sets	**21**	See the doctor	0.10	0.68	31	-0.20	-	0.40	1.000	n.s.
	22	Desert island	-0.07	-1.01	31	-0.23	-	0.07	1.000	n.s.
	23	Hospital visit	-0.10	-1.08	31	-0.31	-	0.09	1.000	n.s.
	24	Tennis tournament	-0.20	-1.54	31	-0.47	-	0.06	1.000	n.s.
	25	FIFA World Cup	-0.24	-2.15	31	-0.48	-	-0.01	1.000	n.s.
	26	Shared flat casting	-0.26	-2.35	31	-0.49	-	-0.03	.744	n.s.
	27	Christmas market	-0.27	-2.82	31	-0.46	-	-0.07	.244	n.s.
	28	Museum	-0.28	-3.18	31	-0.46	-	-0.10	.098	n.s.
	29	New Year's Eve	-0.29	-2.97	31	-0.49	-	-0.09	.168	n.s.
	30	Interview	-0.30	-2.20	31	-0.58	-	-0.02	1.000	n.s.

CI = confidence intervals. *SD* = standard deviation.

*p < .05, **p < .01, ***p < .001. n.s. = statistically not significant.

[a] New sets discarded based on small difference between rating before and after the exposure to the event title

Evaluating the General Properties of Loose Event Relations

After individually selecting picture sets whose exemplars were perceived as significantly more inter-related once the underlying event titles were revealed, we examined further the general properties of this type of relation: We looked at whether these picture sets were perceived as "unrelated" as the mixed sets if no title information was provided.

In the first half of the survey (i.e., before the event titles were exposed), participants rated the loose event relation sets as on average 1.41 points more related than the mixed sets on a seven-point scale (loose event relation sets: M = 3.33, SD = 2.12; mixed sets: M = 1.92, SD = 1.36). This resulted in a significant effect of Set Type under the without title condition in the first nested LMM, see Table 2. These findings indicate that, even without any common event information, loose event relations were regarded as more related than purely random and unrelated sets by raters, albeit this difference was quite small (merely 1.41 points). Once participants were provided with the corresponding event titles (randomly assigned titles for the mixed sets), they rated the loose event relation sets as clearly more related than the mixed sets, on average 3.84 points more (covert sets: M = 5.36, SD = 1.94; mixed sets: M = 1.52, SD = 1.05). This resulted in a significant effect of Set Type under the with title condition, see Table 1. In accordance with our expectation, this finding indicates that when presented together with an event title, loose event relations are perceived as stronger related than the unrelated sets.

Table 2

Linear Mixed Effects Model on Log-Transformed Relatedness in the Pre-study

Log-transformed Relatedness

Set Type nested within Event Title

Fixed effects						
Predictors		***Estimates***	***95% CI***	***t***	***p***	
(Intercept)		0.8184	0.70 – 0.94	13.282	< .001	***
With title vs. Without title		0.2093	0.10 – 0.32	3.802	< .001	***
With title: Loose relation vs. Mixed		1.2951	1.11 – 1.48	14.064	< .001	***
Without title: Loose relation vs. Mixed		0.4863	0.31 – 0.66	5.336	< .001	***
Random effects						
Groups		***Variance***	***SD***			
Participant	(Intercept)	0.0903	0.3005			
	Loose relation vs. Mixed	0.0950	0.3083			
	With title vs. Without title	0.0654	0.2557			

	Set Type: Event Title		0.0691	0.2628		
Set	(Intercept)		0.0195	0.1398		
	Loose relation vs. Mixed		0.0147	0.1212		
	With title vs. Without title		0.0033	0.0579		
	Set Type: Event Title		0.0470	0.2169		
Residual			0.1864	0.4318		
Observations	1664	**N** participant	32	**N** set	26	
Formula						
`Log-relatedness ~ Set Type / Event Title + (1 + Set Type * Event Title | subject) + (1 + Set Type * Event Title | set)`						
Likelihood Ratio Test						
			***X*²**	***df***	***p***	
Set Type			4.926	1	.026	*
Event Title			19.941	1	< .001	***
Event Title / Set Type			36.681	1	< .001	***

CI = confidence intervals. *SD* = standard deviation.

*p < .05, **p < .01, ***p < .001.

Discussion

In our pre-study, we evaluated the relatedness of the exemplars within our prepared picture sets. First of all, we validated the manipulation of loose event relations in previous studies (Abdel Rahman & Melinger, 2011; Lin et al., 2021) and selected new picture sets to show comparable properties. We set the a priori criterion for identifying appropriate sets as followed: A common event title should reveal meaningful connections among objects of this type of relation, leading to a significant increase in perceived relatedness of a given set after the corresponding event title is revealed. Compared to mixed sets, without unifying event-knowledge, the selected sets are indeed perceived as significantly more related after event titles were provided. In other words, we were able to identify the loose event relation sets that provides us the ideal test bed for looking at semantic interference.

While we were able to ascertain, as desired, that the selected loose event relation sets increased in perceived relatedness, our results also suggest that the selected loose event relation sets were regarded as more related than the mixed sets, crucially, already before the event title exposure. Taken together, these findings imply differential properties between loose event relation sets and mixed sets - although objects associated with knowledge of an event seem to be processed as unrelated objects before the event-knowledge are revealed, when named in a blocked-cyclic task (Abdel Rahman & Melinger, 2011; Lin et al., 2021).

To conclude, this pre-study provides evidence that information of a common event significantly increases the perceived relatedness among our selected object sets, and that the objects are perceived as very loosely related if no information of the event were given. Given that evidence that such loose relations may, by themselves, induce semantic interference effects in semantic context paradigms is lacking, we did not expect cumulative semantic interference without triggering event-knowledge. Thus, the manipulation of event-knowledge should reveal whether a task partners' autobiographical information can induce ad-hoc semantic relations among objects associated with the event-knowledge provided by the partner, and that this results in partner-induced cumulative semantic interference.

Main Study: Partner-Effects in the Continuous Naming Task

To examine whether a speaker integrate autobiographical information of their task partner during lexical-semantic processing, we introduced a cover story that the participant would be a teacher of an online learning experiment who would work with students (task partners) that were located in different rooms. Before beginning the learning task, students introduced themselves to the teachers and told a brief autobiographical story designed to trigger a specific event-knowledge. In a given partner-block, a participant named a loose event picture set whose underlying event-knowledge was associated with their partner, while the knowledge of the other loose event set was not. Our hypothesis was that participants would form ad-hoc relations among exemplars whose common event-knowledge was revealed by the partner's narrative, leading to cumulative semantic interference. In contrast, no interference was expected for the other loose event set.

Method

Participants

We collected data from 32 healthy, right-handed, native German speakers between the ages 18 to 36 ($M = 27.84$, $SD = 5.51$). They were either paid for participation or received partial fulfillment of a curriculum requirement. All participants gave consent prior to participation, and were fully informed of the true purpose of the study after completing the experiment. The sample size was decided based on a previous study investigating the same research question using a similar experimental setting and materials in a blocked-cyclic picture naming paradigm (Lin et al, 2021).

Materials

The materials consisted of video recordings of the partners' narratives presented prior to the naming task, and the object pictures presented during the naming task. The use of narrative videos has been shown to successfully reveal the common event underlying the associated set of object pictures (Lin et al., 2021).

Task Partners' Narratives. Eight invited narrators (4 female) contributed two videos (one-minute long), each consisting of an autobiographical narrative about a common event associated with a set of loose event relation pictures. Narrators first introduced their name, age and study major, and then narrated a story about the assigned event as if it had been a personal experience of theirs. Narrators were provided with storylines in bullet points, each implying a specific target concept (for an example of narrated story, see Appendix A). While the narratives were otherwise produced spontaneously, narrators were instructed not to mention explicitly the objects which were later presented as stimulus pictures, but always mention the topic of the event. Ten out of the sixteen narrative videos were the same videos used in a prior study (Lin et al., 2021).

Object Pictures. The loose event relation sets selected from the pre-study were taken as the target stimuli. In total, 136 coloured photographs of common objects, including 80 targets and 56 fillers, formed the complete stimuli set (see Appendix B for a complete list of objects and events). Filler items were selected so that they could not be related to any given event. All pictures were scaled to 3.5 x 3.5 cm and presented on the computer screen with grey background.

Experimental Design

Event Context (Overt vs. Covert Condition). For a given participant, one of the two underlying events within a partner-block always stayed hidden while the other was revealed by the task partner's narrative. We implemented this by randomly assigning participants to two groups: Group A watched one version of a narrator's video, and Group B watched the other version of the same narrator's video. With this counterbalancing-procedure, each narrator was associated with two distinct events.

Ordinal Position. Pictures were organized in blocked stimulus lists, generated for every participant individually; the same stimulus lists were used for participants assigned to Group A and Group B. A partner-block contained two loose event relation sets. We randomly selected the ordinal position in which pictures of one event were presented by the program "Mix" (van Casteren & Davis, 2006). We imposed the following constraints: Pictures of one event were separated randomly by a minimum of two, and a maximum of six items not belonging to this event (separating items can be filler items or items belonging to the other event). Within each partner-block, participants were presented with the same loose event relation sets and filler items five times. The same item never appeared in two consecutive trials. The order of the narratives was shuffled through a Balanced Latin Square Design (Kim & Stein, 2009) so that narrative videos were presented in different order for each participant.

Procedure

Participants were informed prior to the experiment that they would take part in a study aiming to investigate the social communicative influence in virtual teaching and learning. Participants were instructed the following: they would be assigned the role of a teacher for eight learners involved in a virtual teaching program where learners were remotely located; their task was to name pictures for the learners for later recall. All pictures including targets and fillers were printed in unsorted order on paper and given to the participant for familiarization (max. five minutes) before the start of the experiment.

Participants watched the eight pre-recorded videos from task partners one after another. After this round of self-introduction of task partners (participants did not have to introduce themselves), a snapshot of a partner was presented in the center of the screen. The experimenter, sitting outside of the cabin, asked via microphone whether the participant remembered the partner's name and the topic they had talked about. If the participant failed to recall, the experimenter provided the answer. Slight delays were simulated to further increase plausibility of a live stream setting. Each trial began with a fixation cross in the center of a light gray screen for 0.5s. Following up, a picture appeared and was presented until the response was registered, or else for maximally for 2s, after which a blank screen was presented for 1.5s. Participants were instructed to name the pictures as fast and as accurately as possible. Naming latencies were measured with a voice key during the picture presentation. By the end of each block, a count-down for 30 seconds were presented on screen, representing the period in which the partner presumably recalled the items. Finally, the participant received feedback on the learner's performance (pre-generated offline and assigned randomly).

After the main part of the experiment, participants completed a rating task to evaluate the relatedness among picture sets. The rating task was carried out in the same way as the procedure described in the pre-study. The higher the relatedness score, the more semantically similar a group of items are. Lastly, participants were fully informed about the true nature of the setting and the research purpose of the experiment.

Data Analyses

Naming Latencies. We analyzed naming latencies excluding trials in which pictures were named incorrectly or disfluently (1.36%), and trials in which the voice-key was erroneously triggered (2.21%). Naming latencies shorter than 200ms were removed (0.04%). Around 96.43% of all target trials were analyzed. Based on the result of a Box-Cox Test which identified the most suitable transformation for our data to achieve normal distribution, we performed all analyses on log-transformed naming latencies.

Linear mixed effects models (LMM; Baayen et al., 2008) testing the relationship between log-transformed naming latencies and the predictors were run using R (R Core Team, 2018) and the *lme4* package (Bates et al., 2015a, version 1.1-21). We entered as fixed effects the critical predictor Event Context (overt vs. covert, with covert condition being the reference level), Ordinal Position (position 1 to 5), along with the control predictor Repetition (repetition 1 to 5) into the models. The predictor Event Context was modelled to compare the means of factor levels to the respective reference level (numerically: overt = 0.5, covert = -0.5). The predictor Ordinal Position and Repetition were both centered and coded as a continuous variable. To test our core hypothesis, we entered the interaction between Event Context and Ordinal Position. We tested a possible contribution of the interaction including Repetition during the model selection process via the likelihood ratio test (cf. Luke, 2017) to assure whether the interaction term significantly contributed to explaining naming latencies. In addition, we included the relatedness rating as a covariate into the models. However, it did not show a significant contribution to the fixed effect variance and thus was dropped after model selection via the likelihood ratio test, $\chi^2(1) = 0.10$, $p = .74$. The random structure reduction process was the same as described in the pre-study. All models converged.

For fixed effects, we report estimates, 95% confidence intervals, and *t*-values. We considered fixed effects as significant if $|t| \geq 1.96$ (cf. Baayen et al., 2008), but also computed *p*-values by Satterthwaite approximation (using the *summary* function in the *lmerTest* package, version 3.1-1, Kuznetsova et al., 2017). For random effects, we report estimates of variance as well as the standard deviations. Goodness-of-fit statistics are also reported.

Post-Experiment Relatedness Rating. To ascertain whether participants' rating confirmed our stimulus selection criteria, i.e., whether our manipulation of event-knowledge worked, participants' relatedness rating was analysed and reported analogous to the pre-study. Different from the pre-study, we only included the selected loose event relation sets into the rating. Therefore, we did not have mixed (unrelated) sets and the predictor Set Type was thus removed from the LMM analysis. Instead, we added another predictor Narrative Group (matched vs. mismatched, contrast-coding: matched = 0.5, mismatched = -0.5), referring to the stimulus sets whose event-knowledge was either revealed by (i.e. matched) the partners' narratives or not (see Experimental Design of the main study for detailed explanation). This two-level factor served as a manipulation check if participants, after having watched their partners' videos, rated picture sets with matched narratives differentially from those with mismatched narratives.

Results

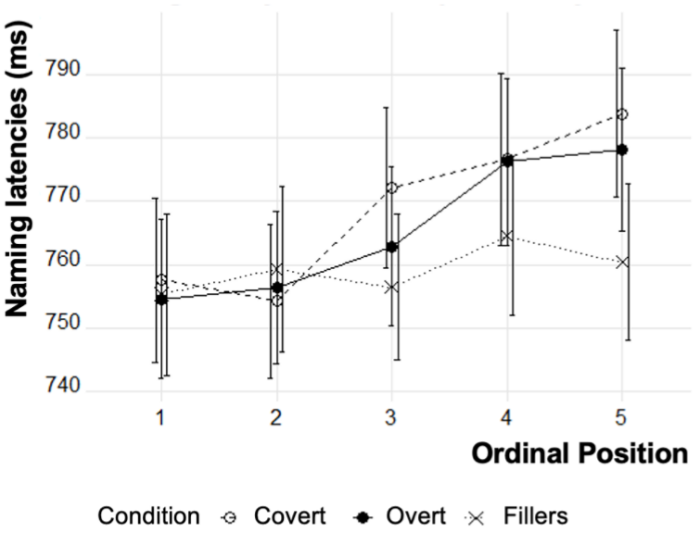
Naming Latencies

Across both event contexts (excluding filler items), the cumulative semantic interference was on average 24.86ms (position 1: M = 756.09, SD = 245.57; position 5: M = 780.96, SD = 251.61). This resulted in a significant main effect of Ordinal Position, see Table 3. Across ordinal positions, participants named objects in the covert condition (no common event context provided) slower than in the overt condition (common event context provided), on average by 3.15ms (overt: M = 765.69, SD = 268.54; covert: M = 768.85, SD = 272.71). This led to no significant main effect of Event Context. Finally, participants named objects on average 48.3ms faster across repetitions (repetition 1: M = 908.54, SD = 299.12; repetition 5: M = 715.32, SD = 209.79), yielding a significant main effect of Repetition.

When the task partner's narrative related to the picture sets, naming latencies increased with each ordinal position (cumulative semantic interference), on average by 23.5ms (position 1: M = 754.64, SD = 223.97; position 5: M = 778.15, SD = 232.39), see Figure 2. Surprisingly, also when the partner's narrative did not relate to the picture sets, naming latencies increased with ordinal position, on average by 26.3ms (position 1: M = 757.55, SD = 230.30; position 5: M = 783.81, SD = 234.40). The outcome of the LMM indicates that, in contrast to our expectation, participants experienced cumulative semantic interference regardless of whether the event context was overt or covert. Confirming the descriptive statistics, the interaction between Event Context and Ordinal Position did not improve model fit, see Table 3. Thus, participants did not seem to respond differentially to objects associated with their partner's narrative compared with objects unrelated to the narrative.

Figure 2

Naming Latencies Plotted Against Ordinal Positions, Grouped by Event Context



Notes. The figure shows that participants experienced cumulative semantic interference when naming objects both in the overt and covert event contexts, but not when naming filler pictures. The error bars refer to the 95% confidence intervals.

Could the loose event relation among target pictures indeed have induced cumulative semantic interference, when their common event context was not revealed by the partners' narrative? To examine this unexpected effect further, we included the unrelated filler items as a control condition in an additional analysis. For this, we set up an additional LMM including fillers as another naming condition (i.e., making the predictor Event Context a three-level contrast, with filler as the reference level: Overt vs. Filler, Covert vs. Filler; following the hypothesis-based a priori contrast method, cf. Schad et al., 2020). While participants also showed a very slight increase in naming latencies with each ordinal position for filler items, on average by 5.07ms (position 1: $M = 755.34$, $SD = 227.96$; position 5: $M = 760.41$, $SD = 221.62$), the model output indicates that participants named both overtly-related and covertly-related items increasingly slower than the filler items across ordinal positions, see Table 3. Critically, this implies that filler items, selected to be semantically unrelated to other objects within the same partner-block (see Experimental Design in the Method section), did not induce cumulative interference, while target objects named in the covert event context induced semantic interference in a similar way as when named in the overt event context.

Table 3

Linear Mixed Effects Models on Log-Transformed Naming Latencies in the Main Study

Log-transformed Naming Latencies

Contrast of Event Context: Overt vs. Covert

Fixed effects						
Predictors		***Estimates***	***95% CI***	***t***	***p***	
(Intercept)		0.0039	-0.05 – 0.06	0.135	.893	
Overt vs. Covert		-0.0055	-0.02 – 0.00	-1.070	.288	
Ordinal position		0.0087	0.01 – 0.01	6.06	< .001	***
Repetition		-00.050	-0.06 – -0.04	-12.644	< .001	***
Overt vs. Covert: ordinal position		-0.0015	-0.01 – 0.00	-0.533	.594	
Random effects						
Groups		***Variance***	***SD***			
Participant	(Intercept)	0.0024	0.1551			
	Repetition	0.0008	0.0161			
Picture	(Intercept)	0.0058	0.0766			
	Overt vs. Covert	0.0008	0.0292			
	Repetition	0.0004	0.0214			
Residual		0.0502	0.2241			
Observations	12424	**N participant**	32	**N picture**	80	
Formula						
`Log-RT ~ Event Context * Ordinal position + Repetition + (1 + Repetition | subject) + (1 + Event Context + Repetition | item)`						
Likelihood Ratio Test						
		***X*²**	***df***	***p***		
Ordinal position		36.657	1	< .001	***	
Repetition		67.595	1	< .001	***	
Overt vs. Covert: ordinal position		0.2842	1	.594		

Log-transformed Naming Latencies

Contrast of

Fixed effects				
Predictors	***Estimates***	***95% CI***	***t***	***p***
(Intercept)	0.0052	-0.05 – 0.06	0.190	.851
Overt vs. Filler	0.0090	-0.02 – 0.04	0.632	.528

Covert vs. Filler		0.0153	-0.01 – 0.04	1.104	.271	
Ordinal position		0.0062	0.00 – 0.01	5.371	< .001	***
Repetition		-0.0526	-0.06 – -0.05	-14.285	< .001	***
Overt vs. Filler: ordinal position		0.0065	0.00 – 0.01	2.291	.022	*
Covert vs. Filler: ordinal position		0.0081	0.00 – 0.01	2.841	.004	**
Random effects						
Groups		***Variance***	***SD***			
Participant	(Intercept)	0.0235	0.1533			
	Overt vs. Filler	0.0002	0.0152			
	Repetition	0.0002	0.0170			
Picture	(Intercept)	0.0056	0.0752			
	Overt vs. Filler	0.0008	0.0297			
	Repetition	0.0004	0.0207			
Residual		0.0495	0.2227			
Observations	18638	**N** participant	32	**N** picture	136	
Formula						
`Log-RT ~ Event Context * Ordinal position + Repetition + (1 + Overt vs. Filler + Repetition || subject) + (1 + Overt vs. Filler + Repetition || item)`						
Likelihood Ratio Test						
		***X*²**	***df***	***p***		
Ordinal position		28.846	1	< .001	***	
Repetition		70.472	1	< .001	***	
Overt vs. Filler: ordinal position		5.2478	1	.022	*	
Covert vs. Filler: ordinal position		8.0688	1	.004	**	

Note. This table demonstrates two linear mixed effects models testing the effect of Event Context, Ordinal Position, their interaction and Repetition on log-transformed naming latencies in the main study. The upper part shows the output of the model with Event Context contrasted as Overt vs. Covert; the lower part shows the output of the model including filler items, with Event Context contrasted as Overt vs. Filler, and Covert vs. Filler.

CI = confidence intervals. *SD* = standard deviation.

*p < .05, **p < .01, ***p < .001.

Post-Experiment Relatedness Rating

Overall, participants rated the loose event relation sets on average 1.75 points more related after the event titles were revealed (on a seven-point scale; with title: *M* = 5.07, *SD* = 2.40; without title: *M* = 3.35, *SD* = 3.11). This resulted in a significant main effect of Event Title in the LMM, see Table 4. With this, we replicated the effects tested in the pre-study rating, ensuring that the stimulus picture sets meet our criterion of loose event relations.

Critically, before event titles were revealed, participants rated the picture sets whose event-knowledge was conveyed via partners' narratives (i.e., the matched narrative condition) on average merely 0.28 points more related than the sets named with mismatched narratives (matched: *M* = 3.49, *SD* = 2.56; mismatched: *M* = 3.21, *SD* = 2.52). This did not yield a significant effect of Narrative Group under the without title condition in the LMM, see Table 4. The finding indicates that our narratives were not as successful in providing event-knowledge as revealing the event titles.

Table 4

Linear Mixed Effects Model on Log-Transformed Relatedness in the Main Study

Log-transformed Relatedness

Narrative Group nested within Event Title

Fixed effects						
Predictors		***Estimates***	***95% CI***	***t***	***p***	
(Intercept)		1.2289	1.06 – 1.40	14.122	< .001	***
With title vs. Without title		0.5925	0.45 – 0.74	7.886	< .001	***
Without title: Matched vs. Mismatched		0.0991	-0.04 – 0.24	1.359	.184	
With title: Matched vs. Mismatched		0.0449	-0.05 – 0.14	0.900	.371	
Random effects						
Groups		***Variance***	***SD***			
Participant	(Intercept)	0.0272	0.1649			
	Matched vs. Mismatched	0.0481	0.2194			
	With title vs. Without title	0.0485	0.2204			
	Event Title: Narrative	0.0491	0.2216			

Set	(Intercept)		0.1035	0.3218		
	With title vs. Without title		0.0498	0.2233		
Residual			0.2588	0.5088		
Observations	1024	**N participant**	32	**N set**	16	
Formula						
`Log-relatedness ~ Event Title / Narrative Group + (1 + Narrative Group * Event Title | subject) + (1 + Event Title | set)`						
Likelihood Ratio Test						
			***X*²**	***df***	***p***	
Matched vs. Mismatched			1.512	1	.218	
With title vs. Without title			27.985	1	< .001	***

CI = confidence intervals. *SD* = standard deviation.

*p < .05, **p < .01, ***p < .001.

Discussion

The present study set out to investigate how event-knowledge conveyed in a task partner's narrative can reveal semantic relationships between objects that, without this information, are not perceived as being closely related. This should in turn result in conceptual and lexical adaptations and cumulative semantic interference. Rather unexpectedly, we observed semantic interference both among objects with and without the integrating information of the partner's narrative. This pattern of finding suggests that the continuous naming task is sensitive to even very loose event relations shared among the objects. In fact, the post-experiment relatedness rating of the main study suggests that participants did not seem to consciously detect the semantic relation even for those picture sets whose common event-knowledge was overtly given by their partners.

It is surprising that we found such robust effects of loose event relations in a covert event context. Evidence for interference effects induced by loose semantic relations is scant and heterogeneous in the blocked-cyclic naming task (Abdel Rahman & Melinger, 2007; Aristei et al., 2011; de Zubicaray et al., 2014; McDonagh et al., 2020). In fact, there is no evidence so far in the continuous naming task that would suggest the loose event relations investigated here can induce semantic interference without explicit triggers such as event-knowledge. We could not find an effect for partner-conveyed event-knowledge, presumably because there are cumulative interference effects in both overt and covert event context conditions, and it may not be necessary for the participants to consciously know about the relations. The high sensitivity of the continuous naming task to pick up cumulative interference effects motivated us to compile data from previous studies, with a goal to explore the relationship between the strength of cumulative semantic interference and the strength of different types of semantic relatedness.

In the following post-study, we will turn to an investigation of semantic relations of different types and strengths tested in the continuous naming task to relate our loose event relations to the empirical evidence on semantic context effects. We used distributional semantic models to directly relate the different semantic manipulations and to get an estimate of the strength of semantic relation, realized here a mega-analysis to investigate the nature of cumulative semantic interference in the continuous naming paradigm.

Post-Study: Mega-analysis Exploring the Nature of Cumulative Semantic Interference - Effects of Strong and Loose Relations

In order to investigate further the semantic relatedness of loose event relations that are neither categorically nor associatively related at first sight, we resorted to distributional semantic models (DSMs) as a widely applied measure of the strength of semantic relations in computational linguistics and natural language processing research (for discussions on applying DSMs for psycholinguistic theories, see Günther et al., 2019; Mandera et al., 2017). Based on the assumption that words with similar meanings tend to occur in similar contexts, DSMs work with a large collection of text documents, i.e., a corpus, and represent words in terms of vectors in a semantic space. To compute the strength of semantic relatedness between two words, we used the most commonly applied method, *cosine similarity*, which computes the cosine of the angle between two words, with 0 indicating unrelated and 1 indicating identical vectors (Günther et al., 2015). Since the strength of relatedness among target items is essential to our research questions, we applied DSMs to generate cosine similarity values for target items associated with the same event.

The first goal of this investigation is to re-measure the strength of relatedness among exemplars within the target picture sets, so that we could ensure that the partners' narrative in our design was a valid manipulation of event-knowledge context. Our goal was to ascertain whether semantic items selected as stimulus sets would be, without title, measured by DSMs as unrelated. The second goal of this follow-up investigation is to further explore the unexpectedly robust cumulative semantic interference when participants named the loose event relation sets regardless of event context. Including datasets from the selected studies that used items of various semantic relations, we aimed to explore the nature of cumulative semantic interference by relating cosine similarity values to the strength of semantic relatedness. We hypothesized that a systematic relation exists between semantic relatedness and semantic interference, which should result in a correlation between cosine similarity values and cumulative semantic interference across studies.

Method

To study various semantic relations beyond the present study, we included stimulus sets and datasets from previous studies using continuous naming task from our lab: three experiments testing categorical relation (Rose & Abdel Rahman, 2017; Döring et al., 2021; Döring et al., under review) and one testing associative relation (Rose & Abdel Rahman, 2016), see Appendix C for a complete list of included stimuli. We selected these studies based on two criteria: The selected studies 1) used items of semantic relations other than ours, and 2) investigated semantic interference with the continuous naming paradigm. Please note that we adopted a convenient sample for the purpose of exploring systematic relations between semantic relatedness and semantic interference, and did not aim at a comprehensive meta- or mega-analysis.

Selection of Semantic Space

The prediction-based algorithm Continuous Bag of Words model (CBOW) generally offers a better fit to the behavioural data compared to other count-based approaches (Mandera et al., 2017). We therefore worked with the CBOW-created semantic space to compute cosine similarity. We implemented our analyses on the corpus "de_wiki" (Günther et al., 2015), a semantic space created by the CBOW algorithm as applied in the word2vec model (Mikolov et al., 2013), which includes vectors for all words that appear at least 50 times in the Wikipedia corpus (526,004 different words).

Computation of Cosine Similarity Values

To generate cosine similarity values for items, we used the *LSAfun* R package (cf. Günther, Dudschig, & Kaup, 2015) in order to compute the co-occurrence of the exemplars within a given picture set. For all types of semantic relations (categorical, associative/thematic, loose event relations, unrelated/fillers), the function used for computing cosine similarity value is *multicostring*. This allows us to compute cosine similarity between a word and all its combinations in a list of words. The inter-relation of items in a given set was calculated by averaging the individual cosine similarity values. The output thus indicates the strength of semantic relatedness among all items within the same picture set.

Data Analysis

To test whether the covert relation as rated in our pre-study would be assigned cosine similarity values similar to unrelated items and distinct from other types of relations, we conducted a between-subject Omnibus ANOVA on the means of cosine similarity values for each of the semantic relations. Post-hoc pairwise comparisons were conducted after obtaining a significant F-test using the Tukey's HSD test to control for family-wise error rate for post-hoc tests. To test whether a systematic relation exists between the strength of semantic relatedness and semantic interference, Pearson's correlation test was performed for the mean increase over ordinal positions (i.e., the strength of cumulative semantic interference) and the cosine similarity computed by the *LSAfun* R package. Note that we generated cosine similarity values separately for the three selected categorical sets because the selection of stimuli differed in these studies (Döring et al., 2021; Döring et al., under review.; Rose & Abdel Rahman, 2017). Besides, we were able to directly conduct the correlation tests between cosine similarity and the cumulative interference effects for the three studies.

Results

Validating the Strength of Relatedness of Loose Event Relation Sets

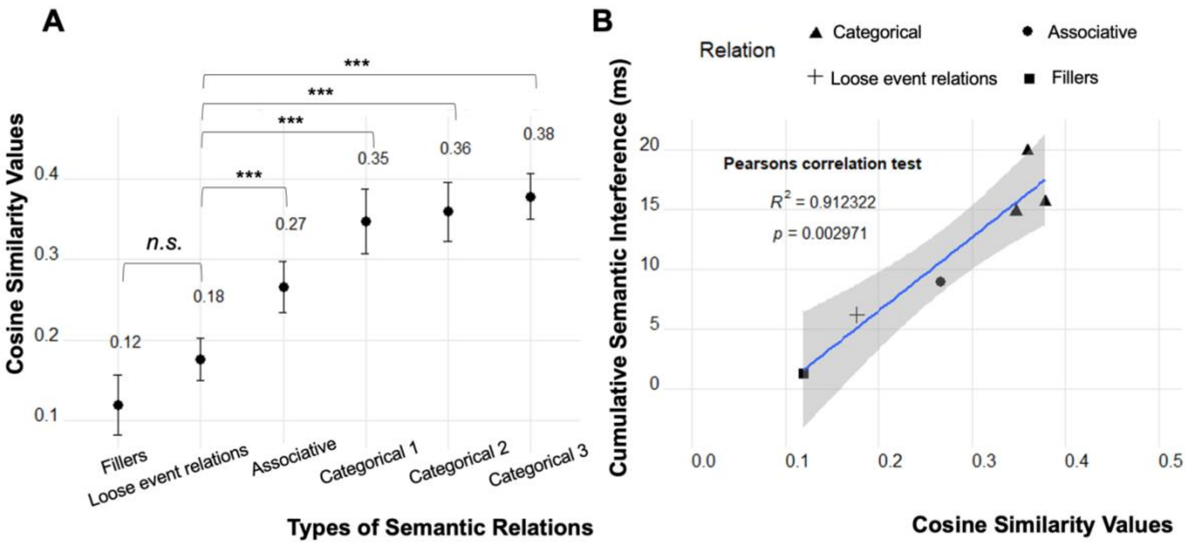
The mean cosine similarity values for each type of semantic relations are illustrated in Figure 3, Panel A. Omnibus ANOVA showed a significant main effect of semantic relation on cosine similarity values, $F_{(5,\ 105)} = 32.60$, $p < .001$, MSE = 0.01. Pairwise comparisons demonstrated that categorical relations showed significantly higher cosine similarity than associative, loose event relations and filler items, see Table 5. Besides, the cosine similarity of associative relations was significantly lower than categorical relations, but higher than loose event relations and fillers. As expected, loose event relations scored the second lowest in cosine similarity, while filler items scored the lowest. Critically, the cosine similarity values of loose event relations were statistically indistinguishable from those of filler items. This finding supports our hypothesis that the loose event relation items used in the present study are evaluated as rather unrelated based on the distributional semantic models.

Testing the Correlation Between Relatedness and Cumulative Semantic Interference

Including the raw behavioural data from the previous studies, we measured cumulative semantic interference by computing mean increase in naming latencies over ordinal positions for each single study because the included studies contain different number of ordinal positions. The mean increase in naming latencies is for categorical relations 15.6ms (Rose & Abdel Rahman, 2017), 19.89ms (Döring et al., under review.), and 14.85ms (Döring et al., 2021), respectively; for associative relations (Rose & Abdel Rahman, 2016, Experiment 3) 9ms; for loose event relations 6.21ms and for fillers 1.26ms (both from the present study). Pearson's correlation test indicates a strong positive correlation between cosine similarity values and the mean increase in naming latencies over ordinal positions (R^2 = 0.91, p = .002), see Figure 3, Panel B. This positive correlation supports our hypothesis that cumulative semantic interference in the continuous naming paradigm varies systematically with the strength of semantic relatedness.

Figure 3

Cosine Similarity Values Among Stimulus Items Across Studies Using Continuous Naming Task, With Various Types of Semantic Relations.



Notes. Panel A: The figure shows that generally, items of categorical relations share higher semantic relatedness than those of associative, loose event relations and filler items. Crucially, cosine similarity values of covert relations are not significantly different from those of filler items, whereas they are significantly lower than those of associative items and categorical items. That is, the target stimuli used in the present study can be regarded as unrelated, validating our manipulation of the loose event relations. The error bars refer to the 95% confidence intervals. (Fillers and loose event relation items from the present study; Associative: Rose & Abdel Rahman, 2016, Experiment 3; Categorical 1: Döring et al., under review; Categorical 2: Rose & Abdel Rahman, 2017; Categorical 3: Döring et al., 2021). Panel B: Pearson's correlation test indicates a very strong positive correlation between cosine similarity values and the cumulative semantic interference (mean increase in naming latencies over ordinal positions). The figure illustrates that the more semantically similar items are, the stronger the cumulative semantic interference participants experience when naming those pictures.

Table 5

Pairwise Comparison Tests After Obtaining a Significant F-Test of the Effect of Semantic Relations on Cosine Similarity Values

Pairwise comparisons

Contrast	*Estimates*	*SE*	*t*	*p*	
Loose event relations[a] vs. Filler[a]	0.0567	0.0311	1.822	.4564	
Loose event relations[a] vs. Associative[b]	-0.0898	0.0258	-3.477	.0094	***
Loose event relations[a] vs. Categorical 1[c]	-0.1833	0.0247	-7.422	< .0001	***
Loose event relations[a] vs. Categorical 2[d]	-0.2021	0.0216	-9.359	< .0001	***
Loose event relations[a] vs. Categorical 3[e]	-0.1711	0.0247	-6.928	< .0001	***
Associative vs. Filler	0.1465	0.0315	4.657	.0001	***
Associative vs. Categorical 1	-0.0935	0.0251	-3.719	.0043	**
Associative vs. Categorical 2	-0.1123	0.0221	-5.084	< .0001	***
Associative vs. Categorical 3	-0.0813	0.0251	-3.234	.0197	*
Categorical 1 vs. Filler	0.2400	0.0305	7.858	< .0001	***
Categorical 1 vs. Categorical 2	-0.0188	0.0207	-0.908	.9437	
Categorical 1 vs. Categorical 3	0.0122	0.0240	0.509	.9957	
Categorical 2 vs. Filler	0.2588	0.0281	9.213	< .0001	***
Categorical 2 vs. Categorical 3	0.0310	0.0207	1.495	.6680	
Categorical 3 vs. Filler	0.2278	0.0305	7.459	< .0001	***

SE = standard error.

*p < .05, **p < .01, ***p < .001.

[a] stimuli used in the present study.

[b] stimuli used in Rose & Abdel Rahman, 2016, Experiment 3.

[c] stimuli used in Döring et al., under review.

[d] stimuli used in Rose & Abdel Rahman, 2017.

[e] stimuli used in Döring et al., 2021.

Discussion

To investigate the unexpectedly robust semantic interference found when participants named pictures without a related event-knowledge context provided by the partner, we first ensured that our selected pictures indeed shared very loose semantic relatedness. The low cosine similarity values computed by DSMs confirm the relatedness rating results in the pre-study and in the main study, reassuring that our pre-defined selection criterion of loose event relation sets was a valid manipulation. This finding indicates that the robust semantic interference observed in the covert event context was truly due to semantic relatedness, albeit so loose that it cannot be distinguished from "unrelated" if no common event was given.

After validating the manipulation of loose event relations, we took a step further to explore whether a systematic relation exists between the degree of semantic relatedness and cumulative semantic interference. Including data from previous work that investigated different types of semantic relations, we found that the degree of semantic relatedness positively correlates with the strength of semantic interference. This finding brings about new insights into the nature of cumulative semantic interference in the continuous naming paradigm: it is sensitive for capturing the strength of semantic relatedness.

General Discussion

The present study set out to investigate whether a speaker integrates autobiographical information of a task partner during lexical-semantic processing in speech planning. Critically, we did not find traces of partner-effects, and hence could not find support for our hypothesis that the event-knowledge conveyed in a partner' narrative provides a meaningful context to associate seemingly unrelated objects with the underlying, common event. Instead, we found robust semantic interference even for loosely related objects whose common event was not revealed by their partner's narrative.

Our results are noteworthy given the mixed empirical evidence for non-categorical relations producing semantic context effects. One possibility for not finding partner-effects is that the narratives were not effective in conveying event-knowledge, although this manipulation has successfully induced semantic interference in a previous study (Lin et al., 2021). As supporting evidence for this explanation, participants did not rate the loose event sets named with matched narratives as more related than the sets named with mismatched narratives until the underlying event titles were revealed. Although we did not find the partner-effects, we do find robust cumulative interference for loose event relations. This suggests that semantic context effects can emerge already among very loosely related words independent of the narratives.

Crucially, we found robust cumulative semantic interference with target items regardless of event context, but not with filler items. This control condition supports that the interference effects we observe are indeed semantic in nature. Thus, another possible explanation why the unifying context presented in the task partner's narrative did not affect semantic context might be the choice of the specific semantic context paradigm. Prior studies that investigated loose thematic/event relations used the blocked-cyclic naming paradigm (Abdel Rahman & Melinger, 2011; Lin et al., 2021). This paradigm has yielded rather mixed evidence for associative relation inducing interference effects: while some studies reported semantic interference (Abdel Rahman & Melinger, 2007; Aristei et al., 2011), some others reported null results (de Zubicaray et al., 2014; McDonagh et al., 2020). In contrast, the continuous naming paradigm has been more sensitive to detect non-categorical relations such as associative relations (Rose & Abdel Rahman, 2016). Our study contributes to this pattern of finding by demonstrating that stimulus material that may not elicit semantic interference effects in the blocked-cyclic naming paradigm, can elicit semantic interference in the continuous naming paradigm, as argued previously (Rose & Abdel Rahman, 2016).

To better understand the scope and limits of cumulative semantic interference, we related the effects induced by our loose event relations to effects of other types of relations with various strength of relatedness, such as categorical and associative/thematic relations. Our mega-analysis that included prior studies on different types of relation demonstrates that cumulative semantic interference systematically increases with the strength of semantic relatedness of the experimental materials. The loose semantic relations we employed in the current study shows the lowest degree of semantic relatedness (as measured by cosine similarity) among all studies that entered our analyses. In fact, the degree of semantic relation among our items (prior to providing the unifying context information) was statistically indistinguishable from semantically unrelated filler items, as indicated by cosine similarity[1]. Correspondingly, these loose semantic relations also induced the smallest cumulative semantic

[1] It is worth noting that the results from our pre-study indicate that the selected sets were subjectively perceived as slightly more related than unrelated sets even before event titles were shown. Here the cosine similarity measured our stimulus sets as numerically more related, but statistically equally unrelated as filler items - which again demonstrates how loosely related our selected sets are.

interference compared with associative and categorical relations. This systematic relationship provides evidence for the claim that the continuous naming paradigm is highly sensitive to the strength of semantic relatedness (Rose & Abdel Rahman, 2016), and is able to detect very weak semantic context effects. Crucially, this high sensitivity might have caused the effects of event context (i.e., partner-effects) to become undetectable because the amount of cumulative interference elicited by event-knowledge relation was sufficient in the continuous naming task even without context.

The systematic relationship between cumulative semantic interference and the strength of semantic relatedness points toward an important theoretical question: are different types of semantic relations – e.g., categorical/taxonomic and associative/thematic relations – processed in the semantic system with the same mechanisms? A recent study investigating categorical and associative relations in a blocked-cyclic naming paradigm proposes that these two relations are processed differentially during naming (McDonagh et al., 2020). To achieve double dissociation between categorical and associative relations, the authors selected materials with respective quantitative measures such that categorical objects scored low in associative measure, and vice versa. They reported interference for categorical relation, but null effects for associative relation (a trend towards facilitation). In contrast to their findings, the present study demonstrates that even though these types of semantic relations are defined differently (e.g., categorical relations share features whereas loose event relations do not), the elicited cumulative semantic interference varies systematically with their distributional semantic relatedness. Hence, the systematic relationship between semantic relatedness and context effects seem to provide evidence for the same mechanisms of processing different types of semantic relations.

Why is the continuous naming paradigm particularly sensitive in revealing semantic interference (compared to the blocked-cyclic naming task)? As argued previously (Rose & Abdel Rahman, 2016), this could be due to lexical competition increasingly outweighing conceptual-semantic priming. On the one hand, previously named related items should induce relatively short-lived activations across the conceptual-semantic network, leading to stable priming upon each naming of the follow-up category members. On the other hand, lexical competition increases with each newly named category member, resulting in cumulative semantic interference. The net effects would be the observed longer naming latencies for even very loosely related items. This speculation might seem at odds with the proposal of conceptual accumulation hypothesis at first sight (Belke et al., 2005; Belke, 2013; Kroll & Stewart, 1994), according to which semantic facilitation effects in semantic classification tasks are cumulative in the continuous naming paradigm. Empirically, cumulative semantic facilitation was only reported in a semantic classification task (e.g., to classify whether an item belongs to natural or men-made entities) but not in an object-naming task (Belke, 2013). A possible reason is that the links between task-relevant features and concepts are only strengthened in a cumulative way via learning mechanisms, if the semantic features are actively accessed due to task-specific responses. Investigations on how loose semantic relations contribute to these two accounts is required in future studies.

To conclude, we did not find evidence supporting that a speaker integrates the autobiographical information of their task partner when naming loosely related objects. We observed that cumulative semantic interference is so sensitive that it can be induced by very loose relations. The high sensitivity of continuous naming paradigm to pick up small semantic context effects makes it a suitable tool to investigate non-categorical relations. Even very loose relations based on event-knowledge can induce lexical competition. All in all, the present study makes a theoretical contribution to understand the nature of lexical selection during language production.

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Appendix A

An Example Transcription of the Stimulus Videos (Original in German)

Hike

Hello, I am Christoph, 28, major in German studies. Today I will tell you a short story from my life. Last summer, I went hiking with a group of friends. We set off in the late morning. The fields were fresh and green, birds twittered and bees hummed everywhere. At noon, we looked for a shady spot, ate some snacks we had brought along. One of my friends is an amateur photographer. He took some photos of the animals that were running around. Yeah, but unfortunately, he also had on the wrong shoes for hiking, and his feet were full of blisters a short time later. So, we had to end the tour earlier than we had originally planned.

Wanderung

Hallo, ich bin Christoph, 28, studiere Germanistik. Und heute erzähle ich von einem kurzen Erlebnis von meinem Leben. Letzten Sommer war ich mit ein paar Freunden auf einer Wandertour. Wir sind so gegen späten Vormittag los, die Felder waren frisch und grün, und überall haben Vögel gezwitschert und Bienen gesummt. Gegen Mittag haben wir uns dann so ein schattiges Plätzchen gesucht, ein paar Snacks gegessen, die wir mitgenommen hatten. Einer von meinen Freuden, der Hobby-Fotograf ist, der hat ein paar Fotos gemacht von den Tieren, die da so rumgelaufen sind. Ja, leider hat er aber auch die falschen Schuhe an für so eine Wandertour, und hatte kurze Zeit später schon die ganzen Füße voller Blasen, so dass wir die Tour früher abbrechen müssen als wir es eigentlich ursprünglich geplant hatten.

Appendix B

Complete List of Objects and Corresponding Themes and Partner in the Present Study

Partners	Themes	Target and filler items				
A	**Beerdigung (funeral)**	Schaufel *f.* (shovel)	Anzug *m.* (suit)	Blume *f.* (flower)	Taschentücher *n.* (handkerchiefs)	Kaffee *m.* (coffee)
	Supermarkt (supermarket)	Milch *f.* (milk)	Waage *f.* (scale)	Korb *m.* (basket)	Regal *n.* (shelf)	Parkplatz *m.* (parking lot)
	Filler	Fußballer (soccer player), Delphin (dolphin), Fallschirm (parachute), Pumpe (pump), Kegel (pin), Streichholz (matchstick), Zähne (teeth)				
B	**Flohmarkt (flea market)**	Geldkassette *f.* (cash box)	Buch *n.* (book)	Tisch *m.* (table)	Stiefel *m.* (boots)	Puppe *f.* (doll)
	Autoreise (car journey)	Butterbrot *n.* (bread and butter)	Verbandkasten *m.* (first aid kit)	Tasche *f.* (bag)	Fußmatte *f.* (mat)	Werkstatt *f.* (garage)
	Filler	Kamel (camel), Pilot (pilot), Kino (cinema), Kohlrabi (kohlrabi), Moschee (mosque), Yacht (yacht), Waschbecken (washbasin)				
C	**Wanderung (hike)**	Pflaster *n.* (plaster)	Löwenzahn *m.* (dandelion)	Socke *f.* (socks)	Müsliriegel *m.* (cereal bar)	Bussard *m.* (buzzard)
	Hochzeit (wedding)	Reis *n.* (rice)	Kamera *f.* (camera)	Geschenkkarton *m.* (gift box)	Altar *m.* (altar)	Zelt *n.* (marquee)
	Filler	Bohrmaschine (drill), Aal (eel), Mikrowelle (microwave), Oscar (oscar paddel), Vogelhaus (bird house), Treppenhaus (stairwell)				
D	**Zoobesuch (zoo)**	Nest *n.* (nest)	Eis *n.* (ice cream)	Knochen *m.* (bone)	Lama *n.* (llama)	Seil *n.* (rope)
	Grundschule (elementary school)	Fischstäbchen *n.* (fish sticks)	Zirkel *m.* (compass)	Brotdose *f.* (lunchbox)	Tafel *f.* (blackboard)	Spielplatz *m.* (playground)
	Filler	Filmvorführgerät (film projectionist), Horn (horrn), Mühle (miller), Rollschuhläufer (roller skater), Würfel (dice), Steinpilz (cep), Pullover (pullover)				
E	**Wahlkampf (campaign)**	Videokamera *f.* (video camera)	Schirm *m.* (sunshade)	Luftballon *m.* (balloon)	Kuli *m.* (pen)	Rednerpult *n.* (podium)
	Angeln (fishing trip)	Tee *n.* (tea)	Messer *n.* (knife)	Eimer *m.* (bucket)	Stuhl *m.* (stool)	Bach *m.* (creek)
	Filler	Mosaik (mosaic), Vinyl (vinyl), Nudelholz (rolling pin), Ring (ring), Seepferd (sea horse), Wattestäbchen (cotton swab), Tor (gate)				
F	**Altenheim (retirement home)**	Teller *m.* (plate)	Brille *f.* (glasses)	Zimmerpflanze *f.* (houseplant)	Fernseher *m.* (television)	Spritze *f.* (syringe)
	Kreuzfahrt (go on a cruise)	Orchester *n.* (orchestra)	Liegestuhl *m.* (deckchair)	Braten *m.* (roast)	Pumps *m.* (court shoe)	Insel *f.* (island)
	Filler	Ampel (traffic lights), Bulle (bull), Pilz (fungus), Schloss (lock), Tempel (temple), Wegweiser (signpost), Rutsche (playground slide)				
G	**Flugreise (air journey)**	Orangensaft *m.* (orange juice)	Funkgerät *n.* (walkie talkie)	Kopfhörer *m.* (head phones)	Tablett *n.* (tray)	Wolken *f.* (clouds)
	Westernfilm (western movie)	Feder *f.* (feather)	Pfeife *f.* (pipe)	Kaktus *m.* (cactus)	Schal *m.* (scarf)	Hängematte *f.* (hammock)

	Filler	Vorhang (curtain), Badewanne (bathtub), Pinguin (penguin), Schlitten (sleigh), Parfüm (perfume), Rosmarin (rosemary), Laterne (lamp)				
H	**Gartenarbeit (gardening)**	Tomate *f.* (tomato)	Schere *f.* (scissors)	Kappe *f.* (cap)	Handschuh *m.* (gloves)	Ameise *f.* (ant)
	Hotelbesuch (visiting a hotel)	Aufzug *m.* (elevator)	Toilette *f.* (toilet)	Staubsauger *m.* (vacuum cleaner)	Zigarette *f.* (cigarette)	Seife *f.* (soap)
	Filler	Akkordeon (accordion), Briefmarke (postage stamp), Puppenhaus (dollhouse), Taucher (diver), Parlament (parliament), Lineal (ruler), Kanu (canoe)				

Note. f.= feminine noun. *m.* = masculine noun. *n.* = neuter noun.

Appendix C

Complete List of Objects Used in the Previous Study Investigating Other Types of Semantic Relations With the Continuous Naming Paradigm

Categorical relations 1

Categories	Target items				
Accessoires (accessoires)	Tuch (towel)	Hut (hat)	Mütze (cap)	Brille (glasses)	Schal (scarf)
Bürobedarf (office supplies)	Klammer (clamp)	Zettel (note)	Stift (pen)	Lineal (ruler)	Schere (scissors)
Gebäude (building)	Laube (arbor)	Hütte (cottage)	Mühle (mill)	Burg (castle)	Villa (mansion)
Gemüse (vegetables)	Salat (salad)	Sellerie (celery)	Tomate (tomato)	Kohl (cabbage)	Zwiebel (onion)
Geschirr (table ware)	Teller (plate)	Tasse (cup)	Glas (glass)	Becher (mug)	Schüssel (bowl)
Getränke (drinks)	Saft (juice)	Bier (beer)	Schorle (spritzer)	Wasser (water)	Wein (wine)
Insekten (insects)	Assel (isopod)	Käfer (beetle)	Biene (bee)	Laus (louse)	Spinne (spider)
Kleidung (clothing)	Hose (pants)	Mantel (coat)	Bluse (blouse)	Hemd (shirt)	Rock (skirt)
Körperteile (body parts)	Zahn (tooth)	Nase (nose)	Finger (finger)	Mund (mouth)	Bauch (belly)
Lebensmittel (food)	Käse (cheese)	Quark (curd)	Wurst (sausage)	Schinken (ham)	Salami (salami)
Meerestiere (marine animals)	Krabbe (crab)	Fisch (fish)	Wal (whale)	Hai (shark)	Qualle (jelly fish)
Möbel (furniture)	Tisch (table)	Regal (shelf)	Schrank (cabinet)	Sessel (armchair)	Bett (bed)
Pflanzen (plants)	Baum (tree)	Pilz (mushroom)	Blume (flower)	Palme (palm)	Busch (bush)
Säugetiere (mammals)	Maus (mouse)	Katze (cat)	Hund (dog)	Hase (hare)	Hamster (hamster)
Süßspeisen (desserts)	Kuchen (cake)	Torte (tart)	Pudding (puddding)	Keks (cookie)	Eis (ice cream)
Tragebehälter (carrying container)	Tasche (handbag)	Ranzen (satchel)	Beutel (carrier bag)	Koffer (suitcase)	Tüte (bag)
Transportmittel (transportation)	Boot (boat)	Schiff (ship)	Kutsche (carriage)	Wagen (trolly)	Jet (jet)
Werkzeuge (tools)	Säge (saw)	Hammer (hammer)	Nagel (nail)	Zange (pliers)	Dübel (dowel)

Note. Items taken from Döring et al., under review.

Categorical relations 2

Categories	Target items					
Vögel (birds)	Adler (eagle)	Kolibri (hummingbird)	Papagei (parrot)	Strauß (ostrich)	Eule (owl)	Schwan (swan)
Fische (fishes)	Hai (shark)	Aal (eel)	Kugelfisch (blowfish)	Rochen (ray)	Goldfisch (goldfish)	Karpfen (carp)
Insekten (insects)	Fliege (fly)	Biene (bee)	Schmetterling (butterfly)	Käfer (bug)	Ameise (ant)	Libelle (dragonfly)
Huftiere (hoofed animals)	Kamel (camel)	Reh (deer)	Pferd (horse)	Esel (donkey)	Schaf (sheep)	Ziege (goat)
Affen (apes)	Schimpanse (chimpanzee)	Pavian (baboon)	Gorilla (gorilla)	Orang-utan (orang-utan)	Mandrill (mandrill)	Kapuzineraffe (capuchin monkey)
Reptilien (reptiles)	Salamander (salamander)	Krokodil (crocodile)	Schildkröte (turtle)	Kobra (cobra)	Leguan (iguana)	Chamäleon (chameleon)
Kopfbedeckung (headdress)	Turban (turban)	Hut (hat)	Mütze (cap)	Cappy (baseball cap)	Zylinder (top hat)	Combrero (sombrero)
Mäntel (coats)	Mantel (coat)	Jacke (jacket)	Poncho (poncho)	Anorak (parka)	Sakko (sport coat)	Stola (stole)
Schmuck (jewelry)	Armband (bracelet)	Kette (necklace)	Ohrring (earring)	Brosche (brooch)	Diadem (tiara)	Ring (ring)
Schuhe (footwear)	Gummistiefel (gumboot)	Highheels (high heels)	Turnschuh (sneaker)	Clog (clog)	Sandale (sandal)	Pantoffel (slipper)
Unterwäsche (underwear)	BH (bra)	Tanga (thong)	Socke (sock)	Korsett (corset)	Unterhemd (sleeveless shirt)	Boxershorts (boxer shorts)
Taschen (bags)	Rucksack (backpack)	Handtasche (purse)	Koffer (siutcase)	Beutel (bag)	Reisetasche (carryall)	Aktenkoffer (briefcase)
Obst (fruit)	Apfel (apple)	Birne (pear)	Kirsche (cherry)	Trauben (grapes)	Mandarine (mandarin)	Erdbeere (strawberry)
Getränke (beverages)	Tee (tea)	Milch (milk)	Bier (beer)	Wein (wine)	Cocktail (cocktail)	Schnaps (schnaps)
Pilze (funguses)	Pfifferling (chanterelle)	Steinpilz (porcini)	Morchel (morel)	Champignon (champignon)	Austernpilz (oyster mushroom)	Fliegenpilz (fly agaric)
Kräuter (herbs)	Basilikum (basil)	Petersilie (parsley)	Dill (dill)	Schnittlauch (chives)	Rosmarin (rosemary)	Lorbeer (laurel)
Süßigkeiten (sweets)	Kuchen (cake)	Eis (ice cream)	Muffin (muffin)	Bonbon (candy)	Lakritz (licorice)	Zuckerwatte (cotton candy)
Gemüse (vegetable)	Paprika (capsicum)	Kartoffel (potato)	Spargel (asparagus)	Gurke (cucumber)	Radieschen (radishes)	Tomate (tomato)
Sitzen (seating furniture)	Couch (couch)	Hocker (stool)	Sessel (armchair)	Bank (bench)	Stuhl (chair)	Thron (throne)
Liegemöbel (lounge furniture)	Bett (bed)	Luftmatratze (air mattress)	Liege (divan bed)	Hängematte (hammock)	Schlafsofa (sofa bed)	Wiege (cradle)
Aufbewahrung (storage)	Regal (shelf)	Kleiderschrank (wardrobe)	Vitrine (cabinet)	Truhe (footlocker)	Kommode (commode)	Safe (safe)
Sanitär (sanitation)	Badewanne (bathtub)	Pissoir (urinal)	Waschbecken (basin)	Dusche (shower)	Bidet (bidet)	Toilette (toilet)

Textil (textile)	Teppich (carpet)	Vorhang (curtain)	Rollo (roller blind)	Fußabtreter (doormat)	Tischdecke (tablecloth)	Kissen (pillow)
Küche (kitchen)	Kühlschrank (fridge)	Herd (stove)	Geschirrspüle r (dishwasher)	Dunstabzugs haube (exhaust hood)	Mikrowelle (microwave)	Backofen (oven)
Küche (kitchen)	Schneebesen (egg whip)	Kelle (dipper)	Nudelholz (rolling pin)	Messer (knife)	Dosenöffner (can opener)	Gabel (fork)
Bauernhof (farm)	Pflug (plow)	Rechen (rake)	Heugabel (hayfork)	Sense (scythe)	Axt (ax)	Rasenmäher (lawn-mower)
Friseur (coiffeur)	Kamm (comb)	Lockenstab (curling iron)	LLockenwick ler (hair roller)	Bürste (brush)	Haarschneide r (hair clippers)	Fön (hair-dryer)
Arzt (doctor)	Refelxhamm er (reflex hammer)	Spritze (syringe)	Pinzette (tweezers)	Skalpell (scalpel)	Thermometer (thermometer)	Stethoskop (stethoscope)
Büro (office)	Edding (permanent marker)	Tacker (stapler)	Bleistift (pencil)	Lineal (ruler)	Klammer (paper clip)	Anspitzer (sharpener)
Schneiderei (tailoring)	Bügeleisen (electric iron)	Nadelkissen (pincushion)	Maßband (measuring tape)	Nähmaschine (sewing machine)	Fingerhut (thimble)	Garn (yarn)
Wasser (water)	Yacht (yacht)	Segelschiff (sailing boat)	Tretboot (paddleboat)	U-boot (submarine)	Kanu (canoe)	Gondel (gondola)
Straße (street)	Auto (car)	LKW (truck)	Bus (bus)	Jeep (jeep)	Taxi (cab)	Wohnmobil (mobile home)
Luft (air)	Hubschraube r (helicopter)	Motorsegler (motor glider)	Heißluftballo n (hot-air balloon)	Flugzeug (airplane)	Zeppelin (airship)	Rakete (rocket)
Bau (construction)	Bagger (digger)	Planierraupe (bulldozer)	Kehrmaschin e (road sweeper)	Traktor (tractor)	Betonmischer (cement mixer)	Walze (road roller)
Zweiräder (two-wheelers)	Fahrrad (bicycle)	Vespa (motor scooter)	Motorrad (motorcycle)	Roller (scooter)	Dreirad (tricycle)	Tandem (tandem)
Aufzüge (elevators)	Paternoster (paternoster)	Aufzug (lift)	Riesenrad (ferris wheel)	Skilift (ski lift)	Förderband (band-conveyor)	Rolltreppe (escalator)

Note. Items taken from Rose & Abdel Rahman, 2017.

Categorical relations 3

Categories	Target items				
Körper (body)	Arm (arm)	Hand (hand)	Hals (neck)	Kopf (head)	Fuß (foot)
Gesicht (face)	Auge (eye)	Zahn (tooth)	Nase (nose)	Stirn (forehead)	Lid (eyelid)
Pflanzen (plants)	Baum (tree)	Hecke (hedge)	Gras (grass)	Blume (flower)	Strauch (shrub)
Tragebehälter (carrying container)	Koffer (suitcase)	Beutel (carrier bag)	Tasche (handbag)	Tüte (bag)	Sack (sack)
Metalle (metals)	Gold (gold)	Silber (silver)	Eisen (iron)	Kupfer (copper)	Blei (lead)
Transportmittel (transportation)	Auto (car)	Schiff (ship)	Boot (boat)	Zug (train)	Wagen (trolley)
Tiere (animals)	Pferd (horse)	Zebra (zebra)	Esel (donkey)	Maus (mouse)	Katze (cat)
Insekten (insects)	Fliege (fly)	Spinne (spider)	Ameise (ant)	Biene (bee)	Wespe (wasp)
Wetter (weather)	Regen (rain)	Sonne (sun)	Schnee (snow)	Wind (wind)	Nebel (fog)
Möbel (furniture)	Spiegel (mirror)	Tisch (table)	Lampe (lamp)	Sofa (sofa)	Bett (bed)
Getränke (drinks)	Bier (beer)	Wasser (water)	Milch (milk)	Kaffee (coffee)	Sekt (sparkling wine)
Obst (fruits)	Kirsche (cherry)	Apfel (apple)	Zitrone (citron)	Traube (grapes)	Orange (orange)
Elektrogeräte (eletricall appliances)	Telefon (telephon)	Computer (computer)	Drucker (printer)	Radio (radio)	Handy (mobile)
Gebäude (building)	Kirche (church)	Scheune (barn)	Haus (house)	Hütte (cottage)	Turm (tower)
Gewürze (spices)	Knoblauch (garlc)	Salz (salt)	Curry (curry)	Pfeffer (pepper)	Ingwer (ginger)
Formen (forms)	Linie (line)	Kreis (circle)	Kreuz (cross)	Quadrat (sqare)	Raute (rhombus)
Küche (kitchen)	Gabel (fork)	Ofen (oven)	Pfanne (pan)	Topf (pot)	Löffel (spoon)
Natur (nature)	See (lake)	Strand (beach)	Meer (sea)	Fluss (river)	Berg (mountain)

Note. Items taken from Döring et al., 2021.

Associative relations

Association Topics	Target items				
Silvester (New Year's Eve)	Sekt (champagne)	Feuerwerk (firework)	Raclette (raclette grill)	Luftschlange (streamer)	Bleigießen (lead- pouring)
Fußball (soccer)	Fußball (soccer ball)	Pokal (cup)	Stadion (stadium)	Pfeife (whistle)	Trikot (tricot)
Militär (military)	Hubschrauber (helicopter)	Funkgerät (radio device)	Gewehr (rifle)	Uniform (uniform)	Lazarett (sickbay)
Büro (office)	Computer (computer)	Bürostuhl (office chair)	Ordner (folder)	Briefmarke (stamp)	Whiteboard (whiteboard)
Baby (baby)	Kinderwagen (buggy)	Schnuller (pacifier)	Windel (diaper)	Mobile (crib mobile)	Babybrei (baby pap)
Labor (laboratory)	Periodensystem (period ic table)	Schutzbrille (safety glasses)	Mikroskop (microscope)	Zelle (cell)	Chemikalien (chemicals)
Bahnhof (train station)	Zug (train)	Schaffner (train guard)	Gleis (rail)	Anzeigetafel (destination board)	Fahrkartenauto mat (ticket machine)
Morgenroutine (morning routine)	Wecker (alarm clock)	Bett (bed)	Zahnbürste (toothbrush)	Zeitung (newspaper)	Müsli (cereal)
Weihnachten (Christmas)	Geschenke (presents)	Weihnachtsbau m (Christmas tree)	Schlitten (sled)	Plätzchen (cookies)	Adventskranz (Advent wreath)
Imkerei (apiary)	Biene (bee)	Honig (honey)	Imkeranzug (apiarist suit)	Pollen (pollen)	Bienenstock (beehive)
Fischen (fishing)	Angel (fishing rod)	Boot (boat)	See (lake)	Gummistiefel (gumboot)	Wurm (worm)
Hochzeit (wedding)	Ring (ring)	Torte (cake)	Brautkleid (wedding dress)	Blumenstrauß (bouquet)	Kirche (church)
Bauernhof (farm)	Kuh (cow)	Traktor (tractor)	Stall (stable)	Tränke (drinking trough)	Heuballen (hay bale)
Urlaub (holidays)	Strand (beach)	Flugzeug (plane)	Sonnencreme (sunblocker)	Koffer (suitcase)	Bikini (bikini)
Zirkus (circus)	Clown (clown)	Manege (circus ring)	Zuckerwatte (cotton candy)	Jonglierkeule (juggling club)	Elefant (elephant)

Note. Items taken from Rose & Abdel Rahman, 2016, Experiment 3.

Supplemental Materials

List of Objects and Theme Titles Used in the Pre-study

Covert Sets

Themes	Objects				
Beerdigung (funeral)	Schaufel (shovel)	Anzug (suit)	Blume (flower)	Taschentücher (handkerchief s)	Kaffee (coffee)
Supermarkt (supermarket)	Milch (milk)	Waage (scale)	Korb (basket)	Regal (shelf)	Parkplatz (parking lot)
Flohmarkt (flea market)	Geldkassette (cash box)	Buch (book)	Tisch (table)	Stiefel (boots)	Puppe (doll)
Autoreise (car journey)	Butterbrot (bread and butter)	Verbandkaste n (first aid kit)	Tasche (bag)	Fußmatte (mat)	Werkstatt (garage)
Wanderung (hike)	Pflaster (plaster)	Löwenzahn (dandelion)	Socke (socks)	Müsliriegel (cereal bar)	Bussard (buzzard)
Hochzeit (wedding)	Reis (rice)	Kamera (camera)	Geschenkkart on (gift box)	Altar (altar)	Zelt (marquee)
Zoobesuch (zoo)	Nest (nest)	Eis (ice cream)	Knochen (bone)	Lama (llama)	Seil (rope)
Grundschule (elementary school)	Fischstäbchen (fish sticks)	Zirkel (compass)	Brotdose (lunchbox)	Tafel (blackboard)	Spielplatz (playground)
Wahlkampf (campaign)	Videokamera (video camera)	Schirm (sunshade)	Luftballon (balloon)	Kuli (pen)	Rednerpult (podium)
Angeln (fishing trip)	Tee (tea)	Messer (knife)	Eimer (bucket)	Stuhl (stool)	Bach (creek)
Altenheim (retirement home)	Teller (plate)	Brille (glasses)	Zimmerpflanz e (houseplant)	Fernseher (television)	Spritze (syringe)
Kreuzfahrt (go on a cruise)	Orchester (orchestra)	Liegestuhl (deckchair)	Braten (roast)	Pumps (court shoe)	Insel (island)
Flugreise (air journey)	Orangensaft (orange juice)	Funkgerät (walkie talkie)	Kopfhörer (head phones)	Tablett (tray)	Wolken (clouds)
Westernfilm (western movie)	Feder (feather)	Pfeife (pipe)	Kaktus (cactus)	Schal (scarf)	Hängematte (hammock)
Gartenarbeit (gardening)	Tomate (tomato)	Schere (scissors)	Kappe (cap)	Handschuh (gloves)	Ameise (ant)
Hotelbesuch (visiting a hotel)	Aufzug (elevator)	Toilette (toilet)	Staubsauger (vacuum cleaner)	Zigarette (cigarette)	Seife (soap)
Ins Theater gehen (go to the theater)	Leiter (ladder)	Perücke (wig)	Kleiderbügel (cloth hanger)	Sekt (champagne)	Broschüre (booklet)
Protest für Klimaschutz (protest for climate protection)	Plakat (placard)	Trillerpfeife (whistle)	Flugzeug (airplane)	Schornstein (chimney)	Erde (earth)

Alltag eines Fotomodels (everyday life of a model)	Salat (salad)	Maßband (tape measure)	Zeitschrift (magazine)	Lippenstift (lipstick)	Schmuck (jewelry)
Umzug (moving)	Nachttischlampe (bedside lamp)	Waschmaschine (washing machine)	Farbeimer (paint bucket)	Trinkflasche (drinking bottle)	Schlüssel (key)

Mixed Sets

Themes	**Objects**				
WG-Casting (shared flat casting)	Schaufel (shovel)	Geldkassette (cash box)	Pflaster (plaster)	Nest (nest)	Videokamera (video camera)
Tennisturnier (tennis tournament)	Anzug (suit)	Buch (book)	Löwenzahn (dandelion)	Eis (ice cream)	Schirm (sunshade)
Arztbesuch (see the doctor)	Blume (flower)	Tisch (table)	Socke (socks)	Knochen (bone)	Luftballon (balloon)
Krankenhausbesuch (hospital visit)	Taschentücher (handkerchiefs)	Stiefel (boots)	Müsliriegel (cereal bar)	Lama (llama)	Kuli (pen)
Silvester (New Year's Eve)	Kaffee (coffee)	Puppe (doll)	Bussard (buzzard)	Seil (rope)	Rednerpult (podium)
Weihnachtsmarkt (Christmas market)	Bach (creek)	Tafel (blackboard)	Reis (rice)	Verbandkasten (first aid kit)	Korb (basket)
Museum (museum)	Butterbrot (bread and butter)	Kamera (camera)	Eimer (bucket)	Regal (shelf)	Spielplatz (playground)
Fußball-Weltmeisterschaft (FIFA world cup)	Fischstäbchen (fish sticks)	Messer (knife)	Altar (altar)	Parkplatz (parking lot)	Tasche (bag)
Einsame Insel (desert island)	Werkstatt (garage)	Milch (milk)	Zirkel (compass)	Geschenkkarton (gift box)	Stuhl (stool)
Vorstellungsgespräch (interview)	Tee (tea)	Waage (scale)	Brotdose (lunchbox)	Fußmatte (mat)	Zelt (marquee)

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Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt,

1. dass keine Zusammenarbeit mit gewerblichen Promotionsberatern stattfand,
2. dass ich die Dissertation auf der Grundlage der angegebenen Hilfsmittel und Hilfen selbstständig angefertigt habe,
3. dass ich mich nicht anderwärts um einen Doktorgrad beworben habe bzw. einen entsprechenden Doktorgrad besitze,
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Berlin, den 14. Februar 2022 Hsin-Pei Lin