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Homophone Priming in Bilingual Preference Formation

Dieter Thoma, Felicia Heilmann, and Madeleine Trotno
Department of Pycholinguistics, University of Mannheim

Homophone (HP) priming occurs when phonologically ambiguous words persistently coactivate their contextually irrelevant meanings. If suppressing those meanings fails, they subliminally bias preferences. Yet, it is unclear if prior findings generalize beyond individual words and to bilingual contexts. This has implications for consumer behavior and the debate on differences between first (L1) and second language (L2) lexical processing. We present four multi-item experiments with German–English bilinguals. An initial eye-tracked primed choice task established that homophones affect decision making. Three visual preference experiments with written and/or auditory primes and high- or low-proficiency L2 users found that homophones bias preferences more in L1 than L2. The L1–L2 gap widened if listening or low proficiency made suppression more difficult. We argue that the interplay between reduced suppression in L2 as predicted by activation–suppression models and lower subjective frequency of L2 homophones assumed by the frequency lag hypothesis explain the size of the L1–L2 priming gap.

Keywords: homophone priming, bilinguals, ambiguity, preference, cognitive load

Reading “bye, bye” increases our intention to BUY (Davis & Herr, 2014). Such homophone (HP) priming occurs if a contextually irrelevant, yet initially coactivated meaning of an identical, phonologically ambiguous word form (here the homophone/baɪ/) persists long enough to affect semantic processing sustainably (Gernsbacher, 1993; Humphreys et al., 1982; Swinney, 1979). Homophone priming is automatic, such that reading the prime word “maid” always facilitates the identification of “made” (Humphreys et al., 1982). Hearing the auditory prime/meɪd/facilitates the recognition of its high-frequency meaning MADE and of its low-frequency meaning MAID (Grainger et al., 2001), whereby the relatively more frequent meaning receives more activation (e.g., Hogaboam & Perfetti, 1975). Usually, the ambiguity is very short-lived and quickly resolved by suppressing the coactivation of the irrelevant meaning with the help of orthographic, syntactic, semantic, and pragmatic cues (Gaskell & Marslen-Wilson, 1997; Grainger et al., 2001; Swinney, 1979; van Assche et al., 2019).

Researchers have extensively used homophone priming to study interfaces in language processing between orthography, phonology, and semantics (e.g., Blott et al., 2021; Gernsbacher, 1993; Lukatela & Turvey, 1994). Few studies from consumer research investigated cognitive and behavioral consequences of homophone priming. In an original study, Davis and Herr (2014) found that a written text ending in “bye” increased the intention to “buy.” We review such research below, yet the existing evidence is limited to a few individually tested English homophones.

While it is practically relevant to understand if subtle persuasive effects of priming apply to homophones in general, it is similarly important for advertisers to know if homophone priming is equally effective in unbalanced bilinguals’ dominant first language (L1) and weaker second language (L2), given that many consumers are bilingual. This recurs to the theoretical debate on differences between L1 and L2 processing. Although there seems to be no experimental evidence to date, major models of bilingual lexical processing consistently predict smaller homophone priming in L2 than in L1 (Dijkstra et al., 2019; Kroll et al., 2010; Kroll & Stewart, 1994). However, activation–suppression models of homophone processing (e.g., Swinney, 1979) lead to conflicting predictions about the size of the L1–L2 priming gap when inhibiting contextually irrelevant meaning gets more difficult.

On the one hand, monolingual homophone priming is stronger for poor readers who cannot use orthography as a reliable disambiguation cue (Gernsbacher, 1993; Gernsbacher & Faust, 1991; Ilicic et al., 2018). In analogy, L2 primes may be harder to suppress

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Tessa Warren served as action editor.

Dieter Thoma https://orcid.org/0000-0001-6984-623X

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Correspondence concerning this article should be addressed to Dieter Thoma, University of Mannheim, Schloss, 68131 Mannheim, Germany. Email: thoma@uni-mannheim.de

when orthography is not perceptually available in listening or at low proficiency so that L2 priming increases, and the L1–L2 gap narrows. On the other hand, bilinguals use L2 less often resulting in lower subjective frequencies of L2 words (Cop et al., 2015; Gollan et al., 2008, 2011; Mor & Prior, 2022). Within the activation–suppression logic, the activation and, thereby, frequency of a homophone increasingly determine priming if suppression dwindles. Put differently, if a homophone does not sufficiently activate its irrelevant meaning, priming also cannot benefit much from weaker suppression. Hindering suppression could thus prioritize existing L1–L2 prime frequency differences so that the L1–L2 gap widens. More generally, a widening gap aligns with the frequency lag hypothesis (Gollan et al., 2008, 2011) that L1–L2 differences increase if frequency plays a more important role in processing.

Overall, this research follows three goals. Methodologically, our aim was to replicate cognitive–behavioral consequences of homophone priming in preference decisions using multi-item designs with German and English to foster generalizability. Empirically, we will provide evidence that homophone priming is weaker in L2. Theoretically, we address the conflict if the L1–L2 priming gap narrows or widens when listening (vs. reading), or poor reading skills hinder suppression. In the following, we first detail homophone priming processes. Next, we review research on behavioral consequences of homophone priming to develop our methodological replication hypothesis before we summarize what is known about bilingual homophone processing to develop our theoretical research hypothesis.

Homophone Priming

Homophones (often used synonymously with the superordinate term *homonyms*) can be classified according to their orthographic representation. Homographic homophones share the same orthography (e.g., a wooden vs. a financial *bank*), whereas heterographic ones have different spellings (e.g., *pair* and *pear*; Biedermann & Nickels, 2008). Understanding homophones recruits an ambiguity resolution process that is a function of the initial coactivation determined by an individual's familiarity with the prime and each of the multiple meanings and of a secondary process called homophone suppression or (lateral) inhibition (Gernsbacher & Faust, 1991; Grainger et al., 2001; Lukatela & Turvey, 1994; Swinney, 1979).

Research has shown accordingly that priming increases when integral (e.g., task difficulty) or incidental (e.g., memory tasks) cognitive load interferes with homophone suppression (Davis & Herr, 2014; Grainger et al., 2001; Lukatela & Turvey, 1994). For example, Grainger et al. (2001) demonstrated that facilitative or inhibitory speed effects of homophone priming differ with the difficulty of lexical decision tasks including homophones. Further, homophone suppression/priming varies with reading skill (Blott et al., 2021; Gernsbacher, 1993; Gernsbacher & Faust, 1991; Ilicic et al., 2018). In Gernsbacher and Faust's (1991) experiments, less skilled readers took longer to reject homophone meanings after phonologically ambiguous sentences, such as the word *calm* following upon "He had a lot of patients {homophone}/students {control}." Note however, that better readers also tend to know more homophone meanings, strengthening the coactivation and making ambiguity resolution harder (Blott et al., 2021).

Homophone priming generally works across modalities. For example, listening to homophones in puns that are only funny if one activates the homophone's multiple unrelated meanings can facilitate the coactivation of both meanings during subsequent picture naming (Rose et al., 2015). At least in written word recognition, the divergent orthography of heterographic homophones provides an additional formal cue to resolve the temporary ambiguity faster than in spoken word recognition (Fleming, 1993). In other words, this resolution process of "spelling verification" may resolve the semantic ambiguity before readers have fully activated conceptual–semantic representations (Drieghe & Brysbaert, 2002; Lukatela & Turvey, 1994; Van Orden, 1987). The additional inhibition cue at the orthographic level makes heterographic homophones more versatile word material in studies on homophone suppression, also because the priming effects from homographic homophones seem similar across visual and auditory modalities (Gilbert et al., 2018).

Postlinguistic Homophone Priming Effects

Davis and Herr (2014) and three follow-up studies (Baxter et al., 2017; Ilicic et al., 2018; Kulczynski et al., 2017) investigated cognitive and behavioral consequences of priming English speakers with heterographic homophones beyond faster and more accurate lexical–semantic processing. Most experiments operationalized the behavioral priming with preference measures, such as choice, ratings of willingness, intentions, or liking. In theory, preferences should be susceptible to automatic priming because we construct most of them actively in decision contexts (Bettman et al., 1998).

Starting from the assumption in Lukatela and Turvey's (1994) activation–verification model that homophone priming depends on insufficient suppression of the contextually irrelevant meaning, Davis and Herr (2014) designed five between-subjects reading experiments crossing priming and cognitive-load induction and testing adult English speakers. Cognitive load was induced via counting the occurrence of the letter "a" or retaining a seven-digit number while reading. All experiments showed significant prime–load interactions. Namely, participants under cognitive load were willing to pay more for a meal in a restaurant when its description ended in "bye" versus "so long," wrote longer essays when told to focus on the "right" versus "left" side of their body, reported lower risk propensity after an almost-accident story ending in "phew" versus "Close call!," and rated the customer value promised in a restaurant advertisement higher when the text ended in "goodbye" versus "so long." It therefore seems that the contextually irrelevant homophone meanings (i.e., BUY, WRITE, and FEW) biased participants toward intentions and actions related to their semantic features. Partially consistent with activation–verification theory, homophone priming was stronger under cognitive load, and only some experiments showed significant main effects of priming.

Instead of inducing cognitive load, Ilicic et al. (2018) tested the variability of homophone priming at the level of behavioral intentions as a function of individual differences in reading skill in 6- to 13-year-old, English-speaking children. In addition to replicating David and Herr's bye–BUY effect, they found children to report higher intentions to eat chicken, that is, MEAT, after reading the homophone prime "Meet up with friends" versus the control sentence "Get together with friends" and to have a better attitude toward a cheese presented in an advertisement after reading "grate" potentially priming GREAT, compared to the control word "shred." Yet, interaction effects at group level showed that younger children, and thus less skilled readers, were more susceptible to priming than older ones. Further, when the children were instructed to focus on spelling, the priming effect became nonsignificant.

Kulczynski et al. (2017) replicated Davis and Herr's (2014) prime–load interaction with two different homophones. They found that the word "sail" increased the perceived amount of discount (SALE) announced in an advertisement for a water bottle more than "cruise," with a stronger priming effect under more intense cognitive load (two- vs. seven-digit number to memorize). After reading the prime {control} advertisement "Decorate your room. Add to wood {metal} furniture," participants reported a higher intention (reflecting the conditional concept of WOULD) to purchase a chair. Priming occurred independently of load with a pictorial prime (a sailboat vs. a motorboat) only with pictures (of a wooden or metal chair), and it was reduced when the task encouraged spelling verification. The same research group (Baxter et al., 2017) extended the findings to semantic priming of pseudohomophones. For example, participants aged 6 to 88 years rated a brand of bread labelled "Whyte" (pseudohomophone) or "White" (target) comparably less dark than "Strel" (meaningless pseudoword).

In sum, four studies found practically intriguing priming effects of heterographic English homophones biasing intentions and actions. Consistent with activation–suppression theories, these effects were stronger if incidental cognitive load or insufficient readings skills hindered the inhibition of the nontarget homophone meaning. However, compared to the psycholinguistic experiments analyzing homophone priming in lexical processing with typically about 20–80 homophones per experiment (e.g., Gernsbacher & Faust, 1991; Gilbert et al., 2018; Humphreys et al., 1982), it is difficult to generalize the findings. To prime the specific meanings of a particular homophone, all four behavioral studies relied on single-item experiments with altogether only seven English homophones. The experiments recruited large samples of L1 English speakers ($N = 76$–1,102), yet statistical power is not only a function of the size of the participant sample but also of the number of items, that is, measurement reliability (Brysbaert, 2019).

Against this methodological background, the aim of the present study was to replicate and generalize postlinguistic homophone priming effects in a paradigm that allows testing multiple homophones in parallel trials within one experiment. We also intend to replicate that the strength of homophone priming varies with the resources available to suppress contextually irrelevant meanings so that it may only occur under cognitive load (Davis & Herr, 2014; Grainger et al., 2001; Lukatela & Turvey, 1994). Therefore, we formulate the replication hypothesis as a moderation:

> *Hypothesis 1:* Homophone priming biases preference formation toward the homophone target meaning—at least under cognitive load.

Bilingual Homophone Processing

Models of bilingual lexical–semantic processing attempt to explain why most bilinguals experience an asymmetry between L1 and L2 processing. Two prominent models are the modular revised hierarchical model (RHM; Kroll et al., 2010; Kroll & Stewart, 1994) and the localist–connectionist multilink model (Dijkstra et al., 2019), which builds on the bilingual interactive activation model (Dijkstra & van Heuven, 2002). Both models allow for predictions about language-dependent homophone priming in bilinguals. The RHM assumes that the links between form-meaning representations are weaker in an L2 lexicon that is stored separately from a larger L1 lexicon. In early phases of L2 acquisition, these weak lexical–semantic connections need indirect support from the L1 lexicon, while L2 establishes direct and stronger links with growing proficiency. As the strength of homophone priming depends on the activation that initially reaches the contextually irrelevant semantic representation (e.g., Swinney, 1979) and the RHM's weaker form-meaning links in L2 transmit activation less efficiently, L2 priming should be weaker than in L1. In the multilink model, words from all languages are stored in an integrated bilingual lexicon and differ in their resting level of activation irrespective of which language they belong to. Instead, the resting level activation depends on how familiar or subjectively frequent a word is for an individual. As bilinguals use most L2 words less frequently, their resting level is lower so that the same task-related activation that pushes a word over an activation threshold in L1 can be insufficient in L2. As L2 homophones also have a lower resting-level activation, they can spread less coactivation to their contextually irrelevant meaning so that their priming should be less pronounced than for L1 homophones. Despite its high theoretical plausibility, to our knowledge, reduced L2 homophone priming still awaits empirical confirmation. Further, the theoretical interaction between homophone activation and meaning suppression in the priming process (Gernsbacher, 1993; Humphreys et al., 1982; Lukatela & Turvey, 1994; Swinney, 1979) leads to conflicting predictions about the size of the L1–L2 gap. Specifically, we could expect the gap to narrow or to widen if suppressing contextually irrelevant meaning gets more difficult.

The argument for a narrowing L1–L2 priming gap follows directly from the activation–suppression models' assumption that hindering the suppression process increases priming. In L2, the suppression mechanism may suffer more if cue availability is reduced. This may be the case during listening that poses particularly high real-time processing demands in L2 and deprives hearers from orthography as an overt disambiguation cue. In a similar vein, unbalanced bilinguals have poorer reading skills in L2 coinciding with reduced orthographic knowledge (Whitford & Titone, 2015). Therefore, the suppression mechanism could be more vulnerable in L2, L2 priming would become relatively stronger, and the gap to L1 would narrow. Monolingual studies provide indirect support for this prediction with stronger priming in less skilled readers (Gernsbacher, 1993; Gernsbacher & Faust, 1991; Ilicic et al., 2018).

The alternative argument for a widening L1–L2 priming gap can be developed by combining the activation–suppression logic with the frequency–lag hypothesis (Gollan et al., 2008, 2011). The latter entails that L2 words as a group lag behind L1 words in subjective frequency because bilinguals use L2 words less often. This lag of practice could explain why bilinguals experience larger frequency effects in L2 than in L1 (e.g., Cop et al., 2015; Gollan et al., 2008; Mor & Prior, 2022) and leads to the prediction that differences between L1 and L2 processing increase when frequency effects become more important for the performance in a language task (Gollan et al., 2011, p. 189). Gollan et al. (2011) found accordingly that weaker L2 performance was more pronounced in visual lexical decision, where performance is strongly driven by frequency (Brysbaert et al., 2017), than in semantically predictable picture naming. The activation–suppression logic holds, in turn, that the weaker the suppression, the stronger the influence of homophone frequency on the priming outcome because frequency drives coactivation. In conjunction, the two theories would therefore predict that weakening the suppression mechanism widens the priming gap between L1 and L2 by strengthening the relative influence of lower L2 prime frequencies. In other words, bilinguals would experience even less priming in L2 in listening or with low reading proficiency because the reduced coactivation from subjectively less frequent L2 homophones outweighs less efficient suppression in L2.

Against this theoretical background, we therefore first aim to provide empirical evidence for the prediction of weaker homophone priming in L2 than L1 developed from the RHM and multilink model. Second, we want to investigate if the L1–L2 priming gap narrows or widens as a function of the ease of homophone suppression. As both directions seem plausible, the research hypothesis is open:

> *Hypothesis 2:* The L2 homophone priming reduction (vs. L1) varies if the suppression of the contextually irrelevant meaning is more difficult (i.e., in listening and at low proficiency).

The Present Study

The Experiments

We conducted four experiments to test the hypotheses with unbalanced German-English bilinguals and heterographic homophones in L1 and L2. Study 1 used a homophone-primed visual choice task in an eye-tracking experiment. While the orthographic priming of choices replicated prior research in a bilingual multi-item design with or without incidental memory load, the eye-tracking measures helped to validate if homophones influence the decision-making process. Based on mixed results from Study 1, we adapted the priming task in Study 2 to make it more sensitive to preference biases induced by the prime. Further, we provided audio instead of written input to deprive participants of orthographic cues in the homophone suppression process. Study 3 was most complex. It used the primed preference task from Study 2 and manipulated homophone suppression twofold. First, it induced incidental cognitive load by a memory task. Second, it changed the integral cognitive load along with written versus audio input, where the listening task also made suppression more difficult without the disambiguating orthography. As Study 3 yielded different language effects in reading and listening and recruited (as Study 1 and 2) advanced L2 users, Study 4 was a simplified replication and comparison of the reading part of Study 3 with younger and less proficient German learners of English.

Despite the reduction of statistical power, we implemented priming in all experiments as a between-subjects factor for four reasons. First, there was a high risk of response biases. All previous research on behavioral consequences of homophone priming used single-item experiments in between-subjects designs. We also observed in pretests that if the same participants perceived sentences with and without homophones, they recognized their presence. Second, there was no space for fillers because participants made up to 36 preference decisions, which was the maximum before fatigue set in. Third, given the fatigue issue, fillers would have reduced the number of homophones in the experiment, which is the major limitation of prior research. Finally, we opted for language as a within-subjects factor instead, since repeating the same task in two languages was natural and motivating for the participants. Randomization checks for group assignments in terms of gender and German and English language skills did not show any significant differences.

The experiments were approved by the institutional research ethics committee and complied with the Declaration of Helsinki. This study was not preregistered. The materials, data, and analysis code are available at the Open Science Framework and can be accessed at https://osf.io/6fvyw/.

Analyses

The data were analyzed with mixed-effects regression models using functions from the packages *lme4* (Bates et al., 2023) for binary choice and eye-tracking measures as well as *ordinal* (Christensen, 2023) for preference ratings in *R* Studio (RStudio Team, 2023). The exact type of mixed model used is reported for each dependent variable. Categorical fixed factors were deviation-coded with −0.5 versus 0.5 (in the order mentioned in the design). The *p* values were estimated with *lmerTest* (Kuznetsova et al., 2017), and *interactions* (Long, 2021) was used for plots.

All fitted models included random intercepts for participants and items and a by-participant random slope for the within-subjects factor language (Barr, 2013). As they represent the hypotheses, we kept interactions in all models, even if they did not improve model fit significantly in log-likelihood comparisons. To understand interactions, we plotted them and fitted separate models to data subsets defined by the values of the moderator.

Study 1: Written Homophone Priming of Choice

The experiment had a 2 (Prime: control|homophone) × 2 (Load: off|on) × 2 (Language: L1 German|L2 English) factorial design, with orthographic prime and memory load as between-subjects factors and language as a within-subjects factor. It served to replicate and generalize the homophone priming effect across items and languages.

Participants

Seventy-six university students participated for €10. Their mean age was 20.57 years ($SD = 2.23$), and 64 were female. They lived in Germany, German was their L1 with a mean age of acquisition (AoA) of $M_{\mathrm{AoA}} = 0.33$ years ($SD = 1.20$), while they had learned English as L2 in school, $M_{\mathrm{AoA}} = 7.42$ years, $SD = 2.69$; $t(75) = -20.53, p < .001$. Participants self-assessed their skills in each language in reading, writing, listening, speaking, vocabulary, and grammar on 7-point rating scales, for example, "How do you rate your German writing skills?" with 1 = *poor*, 7 = *excellent*. Their self-assessment score was averaged across the six items. It was significantly higher for German (Cronbach's $\alpha = .83$; $M = 6.46$, $SD = 0.65$) than for English, Cronbach's $\alpha = .84$; $M = 5.68$, $SD = 0.64$; $t(75) = 8.26$, $p < .001$. Therefore, participants were unbalanced German–English bilinguals yet with advanced L2 English skills, which they mostly used in university contexts.

Method

For a primed visual choice task, we sampled 16 German and 16 English heterographic homophones. The main selection criterion was that at least one of their meanings could be visualized with a photograph so that most primes and all target meanings were nouns. We could not strictly control for dominant and subordinate homophone meanings, but in a German (COSMAS II web, 2022) and English (Corpus of Contemporary American English, Davies, 2019) frequency corpus, 10/16 prime heterographs were more or similarly frequent than the targets. The word lists were complemented to triplets with 16 German and 16 English control words. Controls were matched with homophones in that they were from the same semantic field, ideally synonyms. A homophone–target–control triplet was, for example, "aisle"–"isle"–"corridor," and "sale"–"sail"–"discount." We further tried to minimize homophone–control frequency differences. Due to the visualization and semantic selection constraints, log frequencies per million words in the above corpora were slightly but not significantly higher for controls ($M = 1.24$, $SD = 0.90$) than homophones, $M = 0.69$, $SD = 1.10$; $t(30) = 1.56$, $p = .129$ in German and in English, $M = 1.83$, $SD = 0.87$ versus $M = 1.61$, $SD = 0.84$; $t(30) = 0.70$, $p = .488$.

Figure 1 illustrates a sample trial of the primed visual choice task in the control and homophone condition. The prime showed a two-sentence advertisement slogan against the background of a picture. The slogan contained the control word (here "couple") or homophone prime (here: "pair"). The background picture supported the meaning of the control and homophone prime. Next, there was a choice question specific to the slogan followed by a four-option choice set showing four, about equal-size photographs of comparably attractive alternatives (here: pairs of fruit). One of the options represented the target meaning (here: "pear"). Its position within the four-option grid varied randomly. Note that the initial background picture was not or equally related to the four choice options by semantic category. For example, participants saw a landscape photograph with the prime and then four landscape photographs on the target screen or one of a human face and then four with cleaning devices. Therefore, a bias for the target in the prime relative to the control condition could only be triggered by the shared phonology.

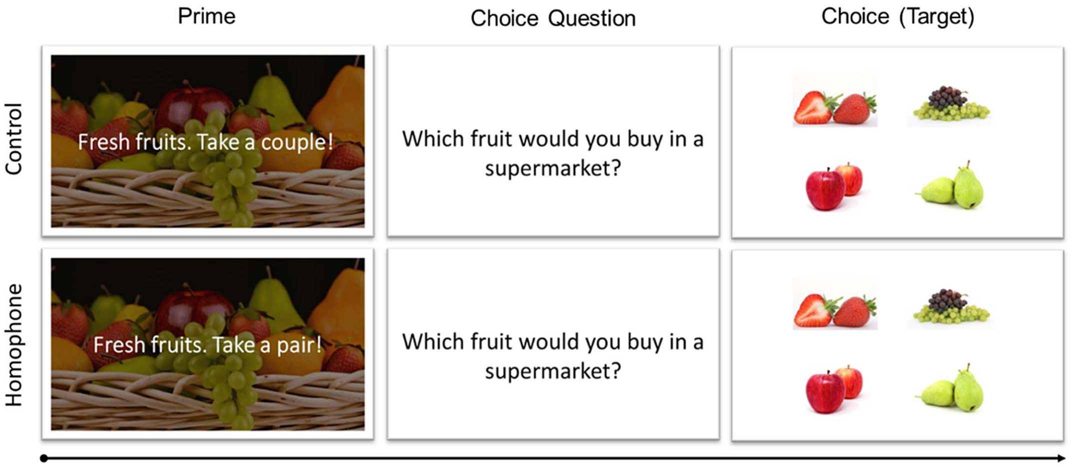
Participants were invited to an eye-tracking study on German–English advertising. After providing written informed consent, they sat approximately 70 cm in front of a 24-in. computer screen combined with a remote SensoMotoric Instruments RED 500-Hz eye tracker and a keyboard. The remote tracking setup allowed for a noninvasive, naturalistic viewing. Participants were randomly assigned to the four between-subjects groups ($n = 19$ in each). The experiment started with a German block, or an English block for half of the participants, each followed by a 3-min break. Each block began with a 9-point eye-tracking calibration and validation procedure aiming for a position accuracy ≤5° of visual angle. In both language blocks, participants read the same instructions in the language of the experiment, followed by two practice trials and 16 experimental trials, respectively. Each trial started with a fixation screen visible for 5 s in the load-off condition. To induce memory load, the fixation was shortened to 2.5 s followed by a five-letter string displayed for another 2.5 s in the load-on condition. The letter strings made up phonologically illicit nonwords in both languages, for example, RGTSD, VIPTB. In contrast to previous homophone priming research, where participants memorized digit numbers (e.g., Davis & Herr, 2014; Kulczynski et al., 2017), we opted for these nonsyllabic, meaningless letter strings to reduce interactions between phonology and semantics during their memorization that may interfere with homophone processing. Within the following primed visual choice task (see Figure 1), participants first saw the prime screen, proceeded to a trial-specific choice question by keyboard response, and made their choice by looking at one of four picture options for longer than 3 s. Then, the load-on group saw a letter string again and decided if it was identical to the one they memorized or not. The load-off group proceeded directly to the next trial. After the eye-tracking task, participants answered a survey, where they were invited to comment on the experiment, report on their demographic data, and self-assess their German and English AoA and language proficiency.

Results

We report the analyses for the frequency of choice of the homophone target picture and then those for gaze fixations and net dwell time (NDT) within the quarter of the choice screen (see Figure 1) showing the chosen picture. While choice represents the decision outcome, the eye movement data can provide insights into the decision-making process leading to this outcome. Remember that here

Figure 1

Primed Visual Choice Task in Study 1



Note. See the online article for the color version of this figure choices were made by fixating one of four pictures for 3 s without looking at the others again. People spend longer looking at what they like (for review, Spering, 2022; Wedel et al., 2023), but since the last 3 s of looking time determined the choice, the differences between chosen pictures must originate in the process before the choice was made. Homophone primes speed up the recognition of their meanings visualized in pictures (Burke et al., 2004). Further, less deliberate and more intuitive decision processes are associated with a lower number of gaze fixations and shorter gaze duration (Horstmann et al., 2009). Therefore, we assume that fewer fixations and shorter dwell times index that a homophone prime successfully induced a preference bias toward the picture representing its contextually irrelevant meaning.

Thirty-six participants made an open comment on the task. Only one recognized that the materials included homophones, but their response behavior did not differ systematically. All other comments referred to the quality of the pictures, a perceived lack of coherence between the advertisements and choices, and the difficulty of remembering the letter strings.

Choice

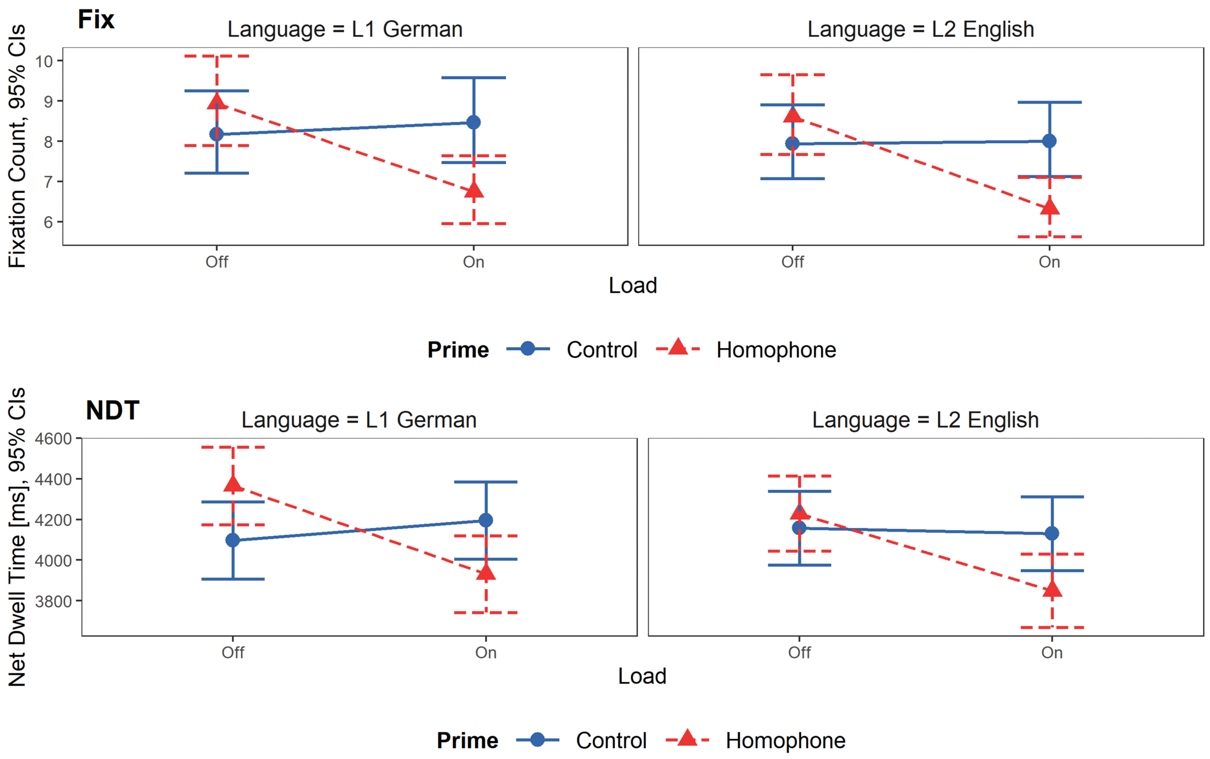
The observed choices did not deviate systematically from the 25%-chance level created by four-option choice sets in any of the experimental conditions. The frequency with which participants chose the picture representing the homophone meaning ranged between 23 and 30%. The priming effect (choice of homophone target in the homophone minus the control condition) was unreliably small in all conditions (L1 load-off: $M = 0.03$, $SD = 0.02$; L1 load-on: $M = 0.03$, $SD = 0.01$; L2 load-off: $M = -0.06$, $SD = -0.03$; L2 load-on: $M = 0.08$, $SD = 0.04$). Accordingly, a logistic mixed model was difficult to fit to the binomial choice data. It yielded no significant main effect of prime ($b = 0.08$, $SD = 0.10$, $z = 0.79$, $p = .428$) and no significant interactions with load, language, or both (all $p > .12$).

Fixations

During fixations, the eyes barely moved within 100–400 ms (Rayner, 1998). To normalize the fixation data ($M = 9.24$, $SD = 7.58$), we excluded trials with visually identified outliers at about 2.5 *SD*s above the mean (>26 fixations, 3% of data). As fixations represent count data, we used a *glmer* function from the Poisson family. The outcome model revealed no significant main effects of prime ($b = -0.07$, $SE = 0.08$, $z = -0.93$, $p = .352$), load ($b = -0.14$, $SE = 0.08$, $z = -1.76$, $p = .079$), and language ($b = 0.04$, $SE = -0.04$, $z = -1.14$, $p = .253$) but a significant prime–load interaction ($b = -0.36$, $SE = 0.16$, $z = -2.30$, $p = .022$) plotted in Figure 2. Subset analyses revealed that the load-off-control groups fixated comparably often ($M = 8.28$, $SD = 4.64$) as the load-on-homophone groups ($M = 9.23$, $SD = 4.75$; $b = 0.04$, $SE = 0.11$, $z = 0.93$, $p = .355$). However, under memory load, the control groups fixated the target significantly more often ($M = 8.64$, $SD = 4.55$) relative to the homophone prime groups ($M = 6.77$, $SD = 3.75$; $b = -0.24$, $SE = 0.11$, $z = -2.21$, $p = .027$). As Figure 2 suggests, this interaction

Figure 2

Study 1 (Reading): Interaction Model Plots for Fixations and Net Dwell Time (Untransformed for Ease of Interpretation) Within the Visual Area of the Chosen Picture in L1 German and L2 English



Note. CIs = confidence intervals; L1 = first language; L2 = second language. See the online article for the color version of this figure.

pattern was similar in L1 and L2. The remaining interaction effects were not significant (all $p > .19$).

NDT

NDT corresponded to the total duration of eye fixations and movements within the area of interest of the chosen picture alternatively corrected for inaccuracies induced by the remote eye-tracking setup (SensoMotoric Instruments, 2013). To reduce skewness of NDT ($M = 4{,}848$, $SD = 3{,}107$), we excluded 1% of the trials that were visually identified outliers and longer than 7,010 ms, and we log-transformed the data. The remaining data qualified for a normal linear mixed regression. The outcome model contained no significant main effects of prime ($b = -0.01$, $SE = 0.02$, $t = 0.63$, $p = .528$), load ($b = -0.04$, $SE = 0.02$, $t = -1.91$, $p = .061$), or language ($b = -0.01$, $SE = 0.01$, $t = -0.93$, $p = .359$). However, Figure 2 visualizes a significant prime–load interaction ($b = -0.10$, $SE = 0.05$, $t = -2.24$, $p = .028$). The inspection of this interaction in the subsample data sets revealed slightly faster dwell times in the control group ($M = 4{,}401$, $SD = 1{,}507$), relative to the homophone group ($M = 4{,}756$, $SD = 1818$) if there was no load ($b = 0.07$, $SE = 0.06$, $t = 1.09$, $p = .281$). Under cognitive load, however, the control groups' dwell times ($M = 4{,}456$, $SD = 1{,}505$) were significantly slower than the homophone groups' ($M = 4{,}040$, $SD = 1{,}180$; $b = -0.09$, $SE = 0.04$, $t = -2.27$, $p = .029$). The other interaction effects did not improve model fit significantly (all $p > .19$).

Discussion

In Study 1, participants' visual choice was primed by reading advertising slogans with heterographic homophones in L1 German and L2 English, while cognitive load was induced or not. Results suggest that the experimental manipulation was not strong enough to yield measurable differences in the four-option, visual word paradigm at choice level so that none of the hypotheses could be confirmed. The choice between four options may have induced intense thought processes (Hick, 1952) overriding automatic priming. Note that none of the prior homophone preference studies following up on Davis and Herr (2014) used more than two alternatives. Whereas priming preferences in multioption choice sets may also require more statistical power, the analyses of participants' saccadic eye movements (fixations and NDT) during the decision-making process prior to their choices consistently showed a homophone priming effect under cognitive load. This confirmed our replication hypothesis (Hypothesis 1) that homophones can bias preference formation, if only under cognitive load. When primed with the homophone, the decision-making processes seemed faster and more determined, irrespective of whether the homophone target was chosen or not.

Study 2: Auditory Homophone Priming of Preference

The experiment had a 2 (Prime: control|homophone) × 2 (Load: off|on) × 2 (Language: L1 German|L2 English) factorial design. An auditory prime and memory load served as between-subjects factors, while language was a within-subjects factor. The aim of Study 2 was to replicate homophone priming at the level of preference decisions (Hypothesis 1) and, in contrast to Study 1, to show that L2 priming differs from L1 in a listening task (Hypothesis 2).

Participants

A total of 207 German university students (143 female, $M_{\text{age}} = 23.54$, $SD = 4.22$) volunteered in reward of €10. According to their self-reports, they had learned German ($M_{\text{AoA}} = 1.00$ years, $SD = 2.98$) about 6 years before English, $M_{\text{AoA}} = 7.48$ years, $SD = 2.72$; $t(206) = -22.50$, $p < .001$. They self-assessed their language skills as in Study 1. Their mean proficiency score based on their 7-point ratings of reading, writing, listening, speaking, vocabulary, and grammar was also higher in German (Cronbach's $\alpha = .83$; $M = 5.56$, $SD = 0.53$) than in English, Cronbach's $\alpha = .92$; $M = 4.76$, 0.86; $t(206) = 13.00$, $p < .001$. Therefore, participants were unbalanced bilinguals with German as their dominant L1 and English as their weaker but still advanced L2, which they used regularly in academic contexts.

Method

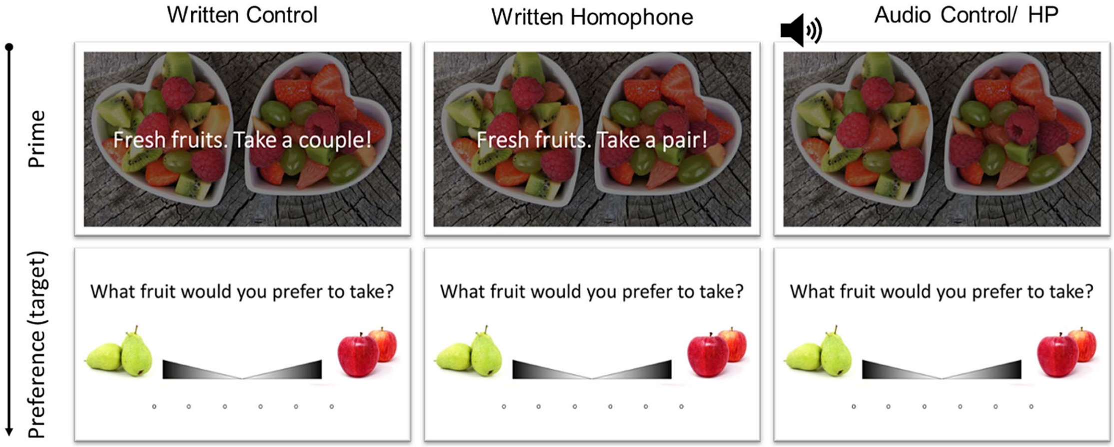
We adapted the materials from Study 1 in three ways. First, we changed the response paradigm from a four-option single-choice setup to a bipolar preference rating because (a) the choice paradigm may have been overwhelming and fatiguing for participants (Hick, 1952) and (b) a binary choice may not be sensitive enough to measure a gradual preference bias. Figure 3, third column, illustrates the task design. As in Study 1, participants first saw a prime screen while they heard an advertising slogan containing the control or homophone word. The screen displayed a background picture that supported the meaning of the control word (here: "couple") and the contextually irrelevant homophone meaning (here: "pair"). Then, they saw two pictures at the poles of a 6-point rating scale. One picture represented the homophone target (here: "pear"), the other a distractor from the same semantic field, usually a cohyponym (here: "apple"). Above the pictures and rating scale, there was a written preference question. In half of the trials, the target was on the left side.

Second, we reduced the number of trials from 32 to 24 (12 in German and 12 in English) by selecting those prime–target–control triplets from Study 1, whose pictorial representation was most clear (validated by discussion and word–picture queries in search engines). Some words were replaced to improve the visualization of the target meaning. Log frequencies per million words did not differ significantly between controls ($M = 0.99$, $SD = 0.61$) and homophones, $M = 0.69$, $SD = 1.10$; $t(22) = -0.83$, $p = .414$ in German and in English, $M = 1.72$, $SD = 0.65$ versus $M = 1.54$, $SD = 0.57$; $t(22) = 0.72$, $p = .461$. Third, instead of written primes, we presented participants with audio-recorded primes. In theory, this should deprive them of orthographic cues and increase the incidental cognitive load so that homophone suppression gets more difficult. For the audio trials, the advertisement slogans were recorded by a bilingual female speaker without a distinctive accent in German or English who was unaware of the purpose of the study.

The procedure followed that of Study 1 without the eye-tracking setup. It was a laboratory experiment to guarantee that participants listened to the audio primes, while sitting in front a screen and two speakers. The experiment was implemented in SoSci Survey (Leiner, 2019). Half of the participants ($n = 103$) started with the German item block, while 104 participants started with the English block, each containing two practice trials before the 12 targets. Each

Figure 3

Primed Visual Preference Task in Study 2 (Last Column) and 3 (First and Second Column)



Note. HP = homophone. See the online article for the color version of this figure.

of the eight groups, as defined by list order and experimental conditions (Language Order × Prime × Load), contained at least 25 participants. As the list assignment depended on the weekday, some groups gained one to three more participants. The experimental groups included 50 (control, load-off), 55 (homophone, load-off), 52 (control, load-on), and 50 (homophone, load-on) participants. In the load conditions, each trial was embedded in the presentation and memory validation of a nonword five-letter string (reused from Study 1). Participants responded by clicking on a point on the rating scale. Trials were separated by 1-s fixation screens. At debriefing, participants were asked about the purpose of the experiment. Only two recognized some homophones and thought that these should make the memory task more challenging.

Results

We fitted a cumulative link mixed model with the Laplace approximation (Christensen, 2023) to the ordinal preference rating data. The model found a significant main effect of prime ($b = 0.59$, $SE = 0.05$, $z = 11.03$, $p < .001$), such that preference for the homophone target was stronger after a homophone ($M = 3.76$, $SD = 2.11$) than control word ($M = 3.17$, $SD = 1.79$). The main effects of load and language were not significant ($p > .18$), but both factors qualified the priming effect. First, priming increased with incidental cognitive load ($b = 0.27$, $SE = 0.11$, $z = 2.54$, $p = .011$), which is visualized by the positive slope of the dotted homophone line in Figure 4 (most clearly in L1). Subset analyses found that priming was only slightly stronger under load (off: $b = 0.50$, $SE = 0.07$, $z = 7.01$, $p < .001$; on: $b = 0.67$, $SE = 0.08$, $z = 8.51$, $p < .001$). Second, the main effect of prime was also moderated by a significant interaction with language ($b = -0.65$, $SE = 0.11$, $z = -6.07$, $p < .001$). The gap between the straight and dotted lines in Figure 4 indicates accordingly that homophone priming was stronger in L1 compared to L2. To further analyze this interaction, we fitted separate models to the German and English data set. The analysis confirmed that priming was significant in both languages but stronger in L1 ($b = 0.91$, $SE = 0.07$, $z = 12.33$, $p < .001$) than in L2 ($b = 0.27$, $SE = 0.08$, $z = 3.46$, $p < .001$). The load–language interaction ($b = -0.01$, $SE = -0.11$, $z = -0.09$, $p = .928$) and the three-way interaction of prime, load, and language ($b = -0.22$, $SE = 0.21$, $z = -1.04$, $p = .297$) were not significant.

Discussion

In Study 2, participants' preferences were primed during listening to advertisement slogans with heterographic homophones in L1 German and L2 English without or with incidental cognitive load. Here, homophone priming successfully biased preferences toward the picture representing the meaning of the homophone target contextually irrelevant in the prime context. Consistent with activation–suppression models (e.g., Grainger et al., 2001; Lukatela & Turvey, 1994a) and prior reading experiments (e.g., Davis & Herr, 2014), we observed homophone priming that was stronger under cognitive load (Hypothesis 1).

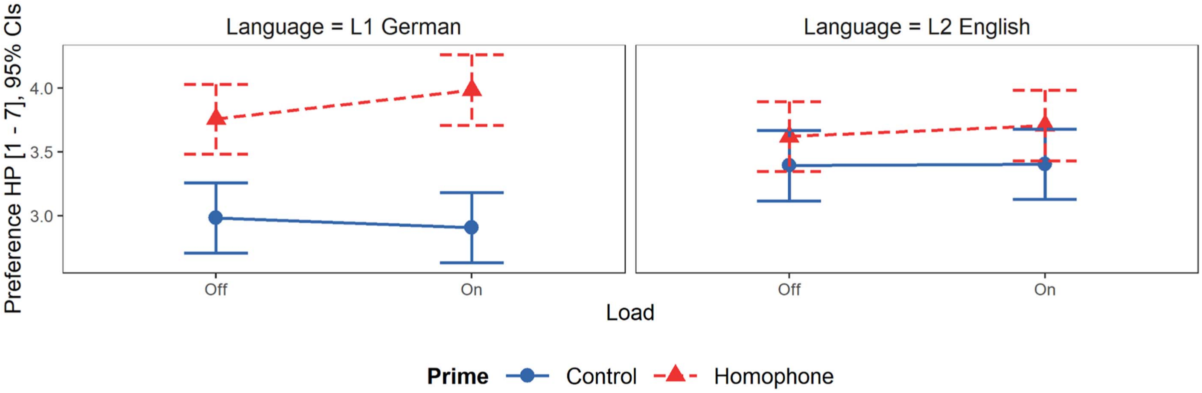
In contrast to the reading task in Study 1, where the effects of prime and load observed during the decision-making process (eye measures) were similar across languages, homophone priming was significantly stronger in L1 than L2 with auditory primes. This indirectly supports our second hypothesis (Hypothesis 2) that the L1–L2 priming gap varies and, in fact, widens when listening makes the suppression of the irrelevant meaning more difficult.

Study 3. Preference Depending on Prime, Load, Language, and Mode

The experiment had a 2 (Prime: control|homophone) × 2 (Load: off|on) × 2 (Language: L1 German|L2 English) × 2 (Mode: read|listen) factorial design, with prime, load, and mode as between-subjects factors and language as a within-subjects factor. Next to replicating homophone priming that increases with incidental cognitive load (Hypothesis 1), this study manipulated mode to

Figure 4

Study 2 (Listening): Interaction Model Plots for Preference for the Homophone Target



Note. CIs = confidence intervals; HP = homophone; L1 = first language; L2 = second language. See the online article for the color version of this figure.

test directly if the L1–L2 gap is larger in listening than in reading (Hypothesis 2).

Participants

A total of 304 participants recruited from Germany completed the online experiment with a chance to win one out of 10 €25 online vouchers. Their mean age was 31.59 (SD = 13.60), and 207 were women. They reported an earlier AoA of German (M = 0.67, SD = 2.12) than of English, M = 9.74, SD = 11.50, $t(303) = 13.63$, $p < .001$. Additionally, they rated their proficiency in reading, writing, listening, speaking, grammar, and vocabulary using German school grades (from 1 = *excellent* to 6 = *very poor*) on average better in German (Cronbach's $\alpha = .90$; M = 1.43, SD = 0.49) than English, Cronbach's $\alpha = .92$; M = 2.30, SD = 0.83; $t(303) = -20.07$, $p < .001$. The sample can therefore be characterized as unbalanced German–English bilinguals with good L2 English proficiency yet predominant use of German.

Method

We used the materials (12 German, 12 English, and two practice trials per language) and an auditory and a written version of the primed visual preference task from Study 2. Figure 3 schematically illustrates the task. The experiment was conducted online via SoSci Survey (Leiner, 2019). Participants were invited to a study about German and English advertising via a newsletter and social media. The software randomly assigned them to the eight experimental groups leading to n = 33–41. We were concerned that many online survey participants would drop out if the experiment started with L2 English instructions. As we did not observe systematic language order effects in Studies 1 and 2, all participants started with the German block and were then encouraged to take a 3-min break before answering the English block. In an open comment at the end of the survey, only one participant mentioned that they recognized homophones in the English slogans. The other comments praised the joy of the picture task or mentioned the challenges posed by memorizing the letter strings in the load condition.

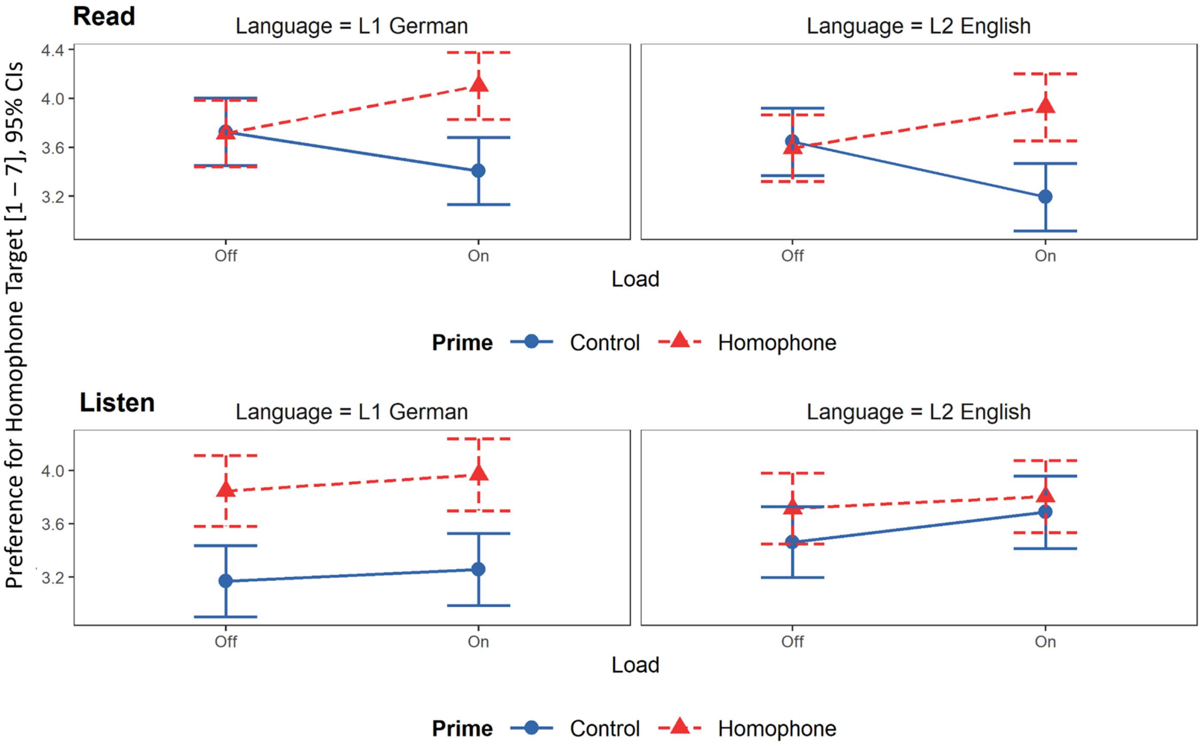
Results

The fitted cumulative link mixed model confirmed a significant priming effect (b = 0.42, SE = 0.05, z = 8.39, $p < .001$) with stronger preference for the homophone target after a slogan with a homophone (M = 3.83, SD = 1.87) instead of the control word (M = 3.44, SD = 1.87). The main effects of load, language, and mode were not significant (all $p > .20$). The priming effect was qualified by significant two-way and three-way interactions (see Figure 5). First, cognitive load qualified priming (b = 0.38, SE = 0.10, z = 3.80, $p < .001$), in that it was stronger with (load-on: b = 0.61, SE = 0.07, z = 8.19, $p < .001$) than without (load-off: b = 0.24, SE = 0.07, z = 3.48, p = .001). Yet, a prime–load–mode interaction (three-way: b = −0.81, SE = 0.20, z = −4.00, $p < .001$) supported the visual impression in Figure 5 that memory load in fact modulated priming significantly in reading (b = 0.82, SE = 0.14, z = 5.78, $p < .001$) but not in listening (b = −0.04, SE = 0.15, z = −0.25, p = .807). Second, priming interacted with language (b = −0.28, SE = 0.09, z = −3.10, p = .002). The inspection of this interaction showed that priming was overall stronger in L1 (b = 0.57, SE = 0.07, z = 8.87, $p < .001$) than in L2 (b = 0.27, SE = 0.07, z = 3.93, $p < .001$). Mode further modified the prime–language interaction (three-way: b = −.48, SE = 0.18, z = −2.70, p = .007), such that the priming effects were parallel in L1 and L2 in reading (b = −0.04, SE = 0.12, z = −0.37, p = .713), whereas they differed between languages in listening (b = −0.52, SE = 0.21, z = −2.49, p = .013). This also led to a significant language–mode interaction (b = 0.24, SE = 0.08, z = 2.85, p = .004). The remaining interactions were not significant (all $p > .13$). In sum, Figure 5 shows the differential priming pattern with language-parallel, load-dependent homophone priming in reading and largely load-independent, L2-reduced priming in listening.

To further validate the priming effect and its moderation by language in listening, we merged the data from Study 2 (online) with the listening subset of Study 3 (lab). The data set included 352 participants with 88 (control, load-off), 95 (homophone, load-off), 85 (control, load-on), and 84 (homophone, load-on) in the groups. An ordinal mixed model reconfirmed the main effect of prime (b = 0.54, SE = 0.04, z = 12.44, $p < .001$), a trend toward a prime–load interaction (b = 0.16, SE = 0.07, z = 1.80, p = .072), and most

Figure 5

Study 3: Interaction Model Plots for Preference of the Homophone Target



Note. CIs = confidence interval; L1 = first language; L2 = second language. See the online article for the color version of this figure.

importantly, the prime-language interaction ($b = -0.60$, $SE = 0.08$, $z = -7.23$, $p < .001$).

Discussion

Study 3 used the same primed visual preference task as Study 2 in a combined reading and listening paradigm. Here, homophone primes induced a preference bias toward the contextually irrelevant target homophone meaning that was unsupported by the pictorial prime context. This bias was considerably stronger under incidental memory load replicating the load-moderated homophone priming hypothesis (Hypothesis 1). Further, a three-way interaction with mode suggested that the prime–load interaction mostly originated in the reading task while it was negligible in listening. The results also confirmed the second hypothesis about the size of the L1–L2 priming gap (Hypothesis 2), such that the priming difference between L1 and L2 increased when suppression got more difficult. More specifically, a significant prime–language–mode interaction indicated that language modulated the size of the priming effect and its interaction with incidental memory load mostly in listening and barely in reading. In other words, only with auditory stimuli, homophone priming was reliably stronger in L1 than L2, and we did not observe load to moderate priming. Most likely, we observed the mode interactions as (a) listening induces higher task-specific integral cognitive load because participants cannot perceive the prime at their own speed and (b) listeners cannot use orthography as an overt cue to suppress the contextually irrelevant homophone meaning.

Study 4. Priming Preferences at Low L2 Proficiency

The experiment had a 2 (Prime: control|homophone) × 2 (Language: L1 German|L2 English) factorial design with prime as a between-subjects factor and language as a within-subjects factor. The major aim here was to retest the reading condition from Study 3—where homophone priming occurred only under cognitive load but to a comparable degree in L1 and L2—with a sample of less proficient L2 English readers, namely secondary school students. In addition to replicating homophone priming with a different population (Hypothesis 1), a comparison of the school students' responses with those of the more proficient adult subsample from Study 3 allowed us to test statistically if reduced orthographic knowledge changes the language-dependent priming lag in L2 (Hypothesis 2). Due to practical restrictions with testing in public schools, we ran a reading-based primed visual preference task with memory load in all conditions.

Participants

Eighty-one (44 female, $M_{\text{age}} = 14.19$, $SD = 1.26$, range = 12–17 years) students participated in the experiment as part of a school activity. The data from another three participants were excluded because their L1 was Somalian, and they had just begun to learn German. All participants were students at a German secondary middle school in a rural area attending Grades 7, 8, or 9. They had started learning English in Grade 1 in primary school. Their self-assessed proficiency measured in a mean score based on their

6-point ratings (corresponding to school grades with 1 = *very good*, 6 = *fail*) of reading, writing, listening, speaking, vocabulary, and grammar was better in German (Cronbach's $\alpha = .72$; $M = 2.31$, $SD = 0.65$) than in English, Cronbach's $\alpha = .87$; $M = 2.65$, $SD = 0.83$; $t(80) = -3.51$, $p < .001$. However, their self-ratings most likely reflected their normally distributed school grades more than their actual proficiency. School grades were similar in German ($M = 3.09$, $SD = 0.83$) and English, $M = 3.12$, $SD = 0.93$; $t(80) = -0.28$, $p = .783$. In all, due to their age and education level, the participants were L1 German speakers with low–intermediate L2 English skills.

Method

The materials were adopted from the reading version of the primed visual preference task in Study 3 implemented in the same software. We prepared an information letter for parents and children about a study on "what do you like more" in combination with a follow-up exercise on "difficult orthography" in English. In collaboration with the principal of a secondary middle school, we distributed the letter and obtained parental consent. Students participated as part of an English lesson in seven groups (two from Grades 7 and 8 and three from Grade 9). Ten to 16 students went to the school's computer room for 45 min. There, they completed the experiment individually and quietly at a PC, while they were supervised by their teacher and the experimenter. Each group was assigned to the prime or control condition to avoid that students would recognize the manipulation. Group sizes varied for these two organizational reasons so that 32 students were in the control group and 49 in the homophone group. Language order was counterbalanced, such that students, that is, computer workstations, assigned to odd numbers started with L1 German ($n = 38$), students assigned to even numbers started with L2 English ($n = 43$). None of the students mentioned awareness of homophones, while some felt stressed by the memory task.

Results

For the sample of school students with low–intermediate L2 English proficiency, a cumulative link mixed model predicting preference yielded a significant main effect of prime ($b = 0.56$, $SE = 0.09$, $z = 6.36$, $p < .001$), with higher preferences for the homophone target picture after a homophone prime ($M = 3.63$, $SD = 2.20$) than after a control word ($M = 3.19$, $SD = 2.08$). Remember that all participants were under incidental cognitive load. Language had no significant main effect ($b = -0.21$, $SE = 0.36$, $z = -0.59$, $p = .552$), but it qualified the priming effect ($b = -0.53$, $SE = 0.17$, $z = -3.02$, $p = .002$). As the first plot in Figure 6 illustrates, priming was stronger in L1 ($b = 0.88$, $SE = 0.13$, $z = 6.95$, $p < .001$) than in L2 ($b = 0.23$, $SE = 0.12$, $z = 2.26$, $p = .024$).

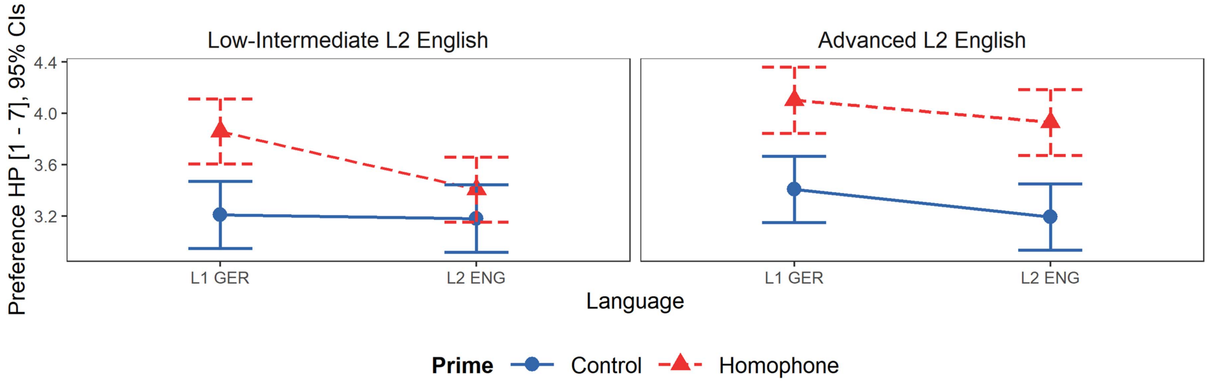
For a second analysis, we pooled the data from the 81 beginning learners of English in Study 4 with that from the 79 advanced English users from Study 3 who were in the equivalent subcondition, that is, reading with incidental cognitive load. The corresponding mixed model confirmed a main effect of prime ($b = 0.60$, $SE = 0.06$, $z = 10.02$, $p < .001$) modulated by language ($b = -0.26$, $SE = 0.12$, $z = -2.22$, $p = .026$). Interestingly, there was a main effect of proficiency (coded as low–intermediate = −0.5, advanced = 0.5), which can be explained by a significant three-way interaction of prime and language with proficiency ($b = 0.49$, $SE = 0.24$, $z = 2.05$, $p = .040$). Figure 6 also shows that written homophone primes biased the preferences of the low–intermediate English group substantially less in their L2 than L1, while priming was similar across languages for the advanced L2 readers. The main effect of language and the two-way interactions with proficiency were not significant (all $p > .36$).

Discussion

With respect to our replication hypothesis (Hypothesis 1), Study 4 found that homophone primes can also bias the preferences of teenagers, at least under incidental cognitive load. Whereas older participants with advanced L2 English proficiency showed similar priming in L1 and L2 in the identical experimental conditions of Study 3 when reading homophones under cognitive load, the secondary school students with low–intermediate English skills were primed less strongly in L2 than in L1. This supports the

Figure 6

Study 4: Interaction Model Plots for Preference of the Homophone Target in L1 and L2 Reading Under Cognitive Load for Beginning and Advanced L2 English Proficiency (Advanced Users From Subcondition in Study 3)



Note. L1 = first language; L2 = second language; CIs = confidence interval; HP = homophone; GER = German; ENG = English. See the online article for the color version of this figure.

hypothesis (Hypothesis 2) that the L1–L2 priming gap varies with orthographic knowledge and proficiency.

General Discussion

The present research had the methodological aim to replicate homophone priming of preference decisions in a multi-item design and with unbalanced bilinguals. Its theoretical–empirical aims were to show that homophone priming is indeed weaker in L2 than in L1 and, more importantly, to investigate if the L1–L2 priming gap narrows or widens if the task or individual skill make suppressing the contextually irrelevant meaning more difficult. We conducted four experiments testing our replication and a research hypothesis.

Table 1 presents a simplified summary of the results. Study 1 found that homophone priming under incidental cognitive load biased the decision process reflected in eye movements prior to choice in a reading-based visual choice task, but the priming effect did not transcend to the decision outcomes. Study 2 optimized the experimental design to detect a preference bias induced by homophone priming under cognitive load and in a listening task. The experiment increased the likelihood of finding a priming effect by (a) measuring a gradual preference bias for instead of a quaternary choice of the homophone target, (b) implementing additional integral cognitive load via listening, and (c) depriving listeners of orthography as a disambiguation cue for the heterographic homophones. Study 2 found that the presence of homophones primed participants' preferences without and, more so, with incidental cognitive load and that priming was significantly stronger in L1 than L2. Study 3 added a reading condition to the design of Study 2. It confirmed homophone priming that was (a) stronger in listening than in reading, (b) interacted with incidental load predominantly in reading, (c) was comparable in L1 and L2 in reading, but (d) stronger in L1 than L2 with auditory homophones. Finally, Study 4 targeted a population of substantially less proficient learners of L2 English to replicate the reading version of the visual preference task and to compare effects of low and advanced L2 proficiency. Parallel to the listening results from Studies 2 and 3 with advanced L2 English speakers, homophone priming biased the preferences of teenage learners of English more toward the homophone target meaning in L1 than L2. Compared to the advanced L2 speakers, the language-dependent priming difference between L1 and L2 was larger for the low–intermediate English speakers.

With respect to the replication aim, all three experiments that tested preference gradually—and were thereby very similar to prior research (Baxter et al., 2017; Davis & Herr, 2014; Ilicic et al., 2018; Kulczynski et al., 2017)—confirmed a main effect of homophone prime for written and auditory stimuli that increased under cognitive load. We could thus successfully replicate the postlinguistic influence of homophone priming in persuasive communication in a multi-item design for German and English primes in bilinguals' first and second language. Consistent with the theory that homophones initially coactivate all their meanings and then suppression resolves the ambiguity (Gernsbacher, 1993; Humphreys et al., 1982; Lukatela & Turvey, 1994; Swinney, 1979), incidental memory load increased the preference bias.

Taken together, our findings highlight two practical implications for using homophone priming in persuasive communication such as advertising. First, if priming effects occurred, they did so without additional cognitive load. Therefore, if consumers are cognitively busy because they must make multiple decisions in a row (as in our multi-item design) or can only listen once to a piece of information including the prime (instead of reading it at their own pace), homophone priming could work in naturalistic settings. Second, for bilingual audiences, homophone priming is generally more effective in their L1 and should be presented in written form in L2.

From a theoretical perspective, our findings provide the first empirical support for the prediction derived from the RHM (Kroll et al., 2010; Kroll & Stewart, 1994) and multilink model (Dijkstra et al., 2019) that homophone priming is weaker in L2 than in L1—at least in listening and when low–intermediate learners read heterographic homophones. Following activation–suppression theory alone, we further argued that the L1–L2 priming gap could narrow if hindering suppression strengthens L2 priming disproportionately, similarly than with less skilled readers in L1 (Gernsbacher, 1993; Gernsbacher & Faust, 1991; Ilicic et al., 2018). However, a more complex prediction following from the combination of the activation–suppression with the frequency lag hypothesis (Gollan et al., 2008, 2011) was that the gap would widen if the priming-diminishing subjective frequency lag of L2 homophones outweighs the priming-friendly suppression reduction in L2.

Table 1 summarizes that we observed significantly weaker priming in L2 in listening tasks with advanced L2 users (but not in reading) and when low–intermediate L2 users read homophones. This pattern was statistically supported by a prime–language–mode interaction in Study 3 and by a prime–language–proficiency interaction in the combined data set of Studies 4 and 3. Therefore, consistent with the combined prediction, the L1–L2 priming gap widened when listening

Table 1
Overview of Findings Across Studies

	Study (*N*)							
Sample/study	1 (76)		2 (207)	3 (304)		4 (81)	3 and 4 (160)	
Task	Read		Listen	Read	Listen	Read	Read	
L2 proficiency	High		High	High		Low	Low	High
Dependent variable	Choice	Eye data	Preference	Preference		Preference	Preference	
Priming	No	No	Yes	Yes	Yes	Yes	Yes	
Prime × Load	No	Yes	Yes	Yes	No	N.A.	N.A.	
Prime × Language	No	No	L1 > L2	L1 ≈ L2	L1 > L2	L1 > L2	L1 > L2	L1 ≈ L2

Note. N.A. = not applicable; L2 = second language; L1 = first language.

or poor orthographic knowledge hindered suppression so that the frequency lag of L2 primes became more decisive for the preference bias. This interpretation is supported by the finding that priming was stronger in listening than in reading within both languages, that is, in the task where the absence of orthography in perception and the increased incidental cognitive load of transient audio input impeded suppression. Given this similar pattern, the L2 frequency lag is the most likely explanation for why L2 fell behind in listening. This, of course, provokes the question if prime frequency differences within a language also become more relevant if the disambiguation process gets harder. With 12–16 homophones per language, we did not have enough item variation to test for frequency effects, but creating tasks with more homophones remains a challenge.

Despite its methodological focus, this study has limitations that open interesting further perspectives for future research. As for the language materials, we exclusively used heterographic homophones in German and English. It remains to be shown if homographs function like auditory heterographs, especially in languages with highly consistent grapheme–phoneme correspondence in their writing system, such as Italian.

As for individual differences, most claims about the coactivation of homophone meanings and suppression could be substantiated with data on lexical knowledge and cognitive control skills. However, it will be difficult to identify and measure moderators that are directly related to homophone priming. In a pretest to Study 2, for example, we designed a 30-item Hayling task (Burgess & Shallice, 1996), measuring inhibitory suppression skills via semantically (in)congruent sentence completion. The idea was to control for individual differences in homophone suppression, yet the task was laborious for participants and performance did not correlate with homophone priming. A homophone task similar to the one by Gernsbacher and Faust (1991) may be more appropriate. For the advanced L2 English users in Studies 2 and 3, we did also not expect their AoA of English or self-assessed L2 proficiency to correspond with the priming effect because these measures were very global. For individual difference effects, objective measures of proficiency should be used (Tomoschuk et al., 2019). Specific vocabulary tests of the knowledge and accessibility of the multiple meanings of the homophones in the experiment could be useful in this respect.

Finally, as for the dependent variables, we do not know how time persistent the priming effects are. It would be interesting to see if a repeated exposure to the primes reinforces the behavioral bias. A long-term repeated measures design may also allow to overcome the present limitation and manipulate priming as a within-subjects factor.

In conclusion, this research presents the first evidence that homophones can prime unbalanced bilinguals' preference formation processes and outcomes in general and more strongly so in their L1 than L2. This replicates findings from prior single-item experiments in monolingual settings and has practical implications for modulating consumer behavior in multilingual markets. The language-dependent priming differences were larger in listening than in reading and at low L2 proficiency. The widening of the L1–L2 priming gap suggests that the lower subjective frequency of L2 primes outweighs the support that L2 priming receives from less efficient suppression of contextually irrelevant meanings. While L2 homophone priming seems to be consistently weaker than in L1, the subjectively less frequent and thus less coactivating L2 primes cannot benefit as much from impeded suppression as the more frequent L1 primes. These findings showcase the intricate interplay between general processes of ambiguity resolution and specific characteristics of L2 knowledge in bilingual lexical processing.

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