

# **Gesture-speech coupling:**

A role of iconic gestures in predicting semantic content during  
sentence comprehension?

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July 2020

LET-TWM400: Master's Thesis

MA Linguistics: General Linguistics

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## Abstract

During natural conversations (i.e., face-to-face dialog), speakers convey information through visual and auditory signals, such as speech and manual gestures (e.g., McNeill, 1992). Semantic information provided by iconic gestures is tightly linked with that in speech. Gestures, however, often temporally precede their corresponding speech units by various degrees (4300 ms – 6 ms). On this basis, it has been argued that gestures may be used as cues during prediction processes (e.g., Schegloff, 1984; Ferré, 2010), which are thought of as the fundamental principle of natural language processing (Clark, 2013). The proposed study aims to investigate the role of gestures in predicting semantic contents during sentence comprehension. To answer this question, EEG data will be recorded from 80 Dutch speakers while they are watching videos of an actress speaking and gesturing. The stimuli will comprise of a target word (object/noun) at the end of the discourse that is depending on the preceding sentence context either predictable or non-predictable, as well as iconic gestures that will be presented such that the gesture stroke starts either 520 ms ("early" condition) or 130 ms ("late" condition) before target word onset. To test for differences in EEG activity in response to the early and late gesture presentation, cluster-based permutation analyses will be used. We hypothesize that gestures are especially relevant in semantically predictive discourses, where they might further facilitate lexico-semantic processing of the target noun. Specifically, we expect the facilitation to be more efficient (i.e., highly automatic) when gestures strongly precede target words compared to when they only slightly precede them.

**Keywords:** multimodal communication, comprehension, language prediction, iconic co-speech gestures, gesture-speech integration, temporal alignment

## Introduction

In recent years, cognitive scientists have extensively studied prediction. This work has led to the notion of predictive processing being a fundamental principle of human cognition and prediction "[offering] the best clue yet to the shape of a unified science of mind" (Clark, 2013). Therefore, prediction has become an integral part of a growing number of theories in the cognitive sciences. Theories of visual and auditory perception, for instance, propose that "the human brain is continuously busy generating predictions that approximate the relevant future" (Bar, 2007: 280) and that viewers and listeners engage in prediction to prepare for upcoming visual and acoustic events (e.g., Bar, 2009; Bendixen, Schroeger, & Winkler, 2009; Schroeger, 2007).

Language comprehension involves auditory and visual perception. Thus, it might not be surprising that the prediction of upcoming information has been assigned an equally important role during language comprehension (e.g., Altmann & Mirkovic, 2009; Dell & Chang, 2014; Ferreira & Chantavarin, 2018; Kuperberg & Jaeger, 2016; Pickering & Gambi, 2018). Importantly, while the overwhelming majority of studies has focused on unimodal settings (e.g., spoken or written language processing), few studies have investigated prediction during comprehension in multimodal contexts, which – arguably – is the most natural and most frequent form of human language use (Levinson & Holler, 2014). In multimodal settings (e.g., face-to-face dialog), speakers convey information through auditory and visual signals, such as speech and manual gestures (e.g., McNeill, 1992; Kendon, 2004; Bavelas & Chovil, 2000). Critically, manual gestures often precede the elements in the speech stream they correspond to (e.g., Schegloff, 1984; Chui, 2005; Ferré, 2010; Church, Kelly & Holcombe, 2014; Kok et al., 2016). Based on this observation, a recent framework has been proposed where recipients exploit the information conveyed by preceding gestures to aid in predicting upcoming semantic information (Holler & Levinson, 2019). The proposed study

aims to test this proposal with regard to the potential predictive function of iconic gestures, a frequently used form of manual gestures depicting semantic information tightly related to that in speech.

### *Prediction during language comprehension*

To date, most experimental support for predictive language comprehension comes from electroencephalogram (EEG) studies on modulations of the amplitude of the N400 component. The N400, frequently seen as an indicator of semantic processing, is a negative-going, centro-parietally distributed event-related brain potential (ERP) that occurs approximately 400 ms after target word onset (e.g., Kutas & Federmeier, 2011; Kutas & Hillyard, 1984). Importantly, the N400 is often interpreted as indexing the ease of processing of a target word given the context in which it is presented. For example, when embedded in a predictive context, the same target word generates a reduced (i.e., less negative) N400 component, compared to being embedded in a non-predictive context. In such a case, reductions of the N400 amplitude are assumed to reflect the (partial) pre-activation of the target word by the predictive context (e.g., Federmeier & Kutas, 1999; Kutas, DeLong & Smith, 2011; Kutas & Federmeier, 2011). Importantly, there has been a methodological debate concerning the interpretation of N400 effects as reflecting either prediction (i.e., pre-activation) of a given target word or the ease with which the target word can be integrated into the unfolding sentence context. The reason is that many previous EEG studies have measured the N400 on the target, making it difficult to distinguish between the two accounts (e.g., Mantegna et al., 2019; Nieuwland et al., 2018, for discussion).

There are a few exceptions: Van Berkum et al. (2005; see also Wicha et al., 2003, 2004), for instance, examined whether participants who listened to short Dutch stories would use the given discourse information to predict specific upcoming nouns. Importantly, Dutch nouns inflect for gender (common and neuter gender), and the gender-marking is also

expressed in adjectives that modify and typically precede a given noun. Van Berkum and colleagues observed that the neural response on encountering an adjective gender-marker that mismatched the gender of the predicted noun differed from processing a gender marker that was congruent with that of the predicted target noun. The authors interpreted the more negative ERP in the mismatch condition as an indication that participants had used the discourse information to predict the target noun, and that this prediction involved the pre-activation of morpho-syntactic knowledge about the target word (i.e., gender). As the ERP was recorded on a word preceding the target, the finding supports the view that listeners predict upcoming words during comprehension.

A similar pre-nominal manipulation was used by DeLong et al. (2005), who investigated the prediction of phonological form when reading predictable English sentences. DeLong et al. exploited the fact that the English indefinite article changes from 'a' to 'an' when the subsequent word, in their case a noun, starts with a vowel while maintaining the same meaning. In sentences such as "The day was breezy, so the boy went outside to fly a kite/an airplane," DeLong and colleagues recorded ERPs on the indefinite article preceding the noun and observed differences in N400 amplitude between the prediction-consistent form of the article ('a' in the example above) and the prediction-inconsistent form. Moreover, the authors found that the amplitude of the N400 component elicited by indefinite articles (and the target nouns) correlated negatively with the target words' predictability in the sentences, as assessed in an off-line cloze probability task (Taylor, 1956). DeLong et al. interpreted their results similarly as Van Berkum et al. (2005) such that readers used the predictive context to predict the upcoming target word and that this prediction included the pre-activation of the words' phonological form. It is important to note that even though this study is often cited as providing unequivocal evidence for prediction during sentence comprehension, a recent large-

scale multi-lab pre-registered study was unable to replicate the crucial condition difference on the articles (Nieuwland et al., 2018).

In sum, despite some mixed findings, the ERP literature offers support for the notion that language users do often predict upcoming information during language comprehension. However, to date, all of these studies have focused on unimodal language use. Whether, and to what extent, visual communicative signals that carry semantic information and accompany speech in face-to-face settings, such as iconic gestures, also play a role in predictive language processing is currently an open question.

### *The coupling of speech and co-speech gestures*

During multimodal face-to-face interaction, interlocutors use a multitude of visual communicative signals, including manual gestures. Iconic gestures, for example, are one of the main carriers of gestural semantic information and can depict actions and objects as well as their attributes and relations. Iconic gestures are closely coupled with the speech that they accompany in terms of semantic content and timing during production (e.g., McNeill, 1985, 1992). Crucially, the human brain appears to be highly sensitive to this coupling, as semantic information from iconic gestures and co-expressive speech is readily integrated and merged during comprehension.

Gesture comprehension and integration with speech have mostly been studied through mismatch paradigms, in which gesture and speech either convey the same information (match condition) or different information (mismatch condition). Several EEG studies reported a significantly larger (i.e., more negative) N400 in mismatch conditions, interpreting this interference effect as proof for attempted gesture-speech integration (e.g., Holle & Gunter, 2007; Kelly, Kravitz & Hopkins, 2004; Özyürek et al., 2007; Wu & Coulson, 2005, 2007, 2010; see Özyürek, 2014 for a review). Further evidence for the integration of semantic information from co-speech gestures during speech comprehension comes from behavioral

(e.g., Beattie & Shovelton, 1999; McNeill, Cassell & McCullough, 1994; Kelly et al., 1999, 2010; Hostetter, 2011; Silverman et al., 2010) as well as fMRI studies (e.g., Willems, Özyürek & Hagoort, 2007, 2009; Holle et al., 2008; Dick et al., 2009; Skipper et al., 2009).

A question resulting from this body of research in the context of the current study is whether these gestures may also play a role in prediction during spoken language comprehension. One prerequisite for the contribution of gestures to predictive processing is not only that semantic information of gestures is tightly linked with the information in the speech, but also that gestures temporally precede related semantic information in the speech stream. Evidence that this is indeed the case stems from qualitative, observational studies based on detailed examinations of individual gestures and their timing relative to speech (e.g., Kendon, 1980; Schegloff, 1984), as well as from quantitative evidence derived from multimodal language corpora and experimental studies (e.g., ter Bekke et al., in press; Bergmann et al., 2011; Butterworth & Beattie, 1978; Ferré, 2010; de Kok et al., 2016; Morrel-Samuels & Krauss, 1992). The recent study by ter Bekke et al. (in press) bears the most relevance to the present study since it, too, focused on Dutch. This analysis has revealed a varying extent to which co-speech gestures precede speech, ranging from 4300 ms to 6 ms. When measured in their entirety, gestures were shown to precede the onset of the lexical affiliate (i.e., the linguistic component their depiction is most closely related to semantically) by an average of 680 ms. When measured from the onset of the stroke phase (i.e., the most meaning-bearing component of a gesture), the gestural semantic depiction preceded the lexical affiliate on average by 215 ms.

In terms of multimodal utterance comprehension, researchers have addressed the variation in gesture-speech timing and have examined different time-windows for the integration of semantic information: Obermeier, Holle and Gunther (2011) first manipulated gesture-speech synchrony during sentence processing by using gesture fragments to avoid the

usual long temporal overlap of gestures with their corresponding speech. They concluded that when iconic gesture fragments and speech temporally overlap (i.e., were synchronized), their interaction is more or less automatized. Otherwise, more controlled, active memory processes are required for successful integration and disambiguation. Furthermore, Obermeier and Gunther (2014) investigated the specific time-window during which semantic integration seems least effortful. Their results suggest a temporal window ranging from at least 200 ms prior to 120 ms post-target word stimulus within which semantic gesture-speech integration happens automatically. Similarly, Habets et al. (2011) manipulated the time interval between the onset of iconic gestures and the onset of corresponding verbs using three different intervals: directly coinciding, gesture preceding by 160 ms, and 320 ms. The authors used a mismatch paradigm and observed the expected N400 effect for incongruent over congruent gesture-verb pairs for coinciding onsets and for gestures that preceded the verbs by 160 ms, but the effect was lost at asynchrony values of 320 ms.

Together, these studies suggest that iconic gestures and speech are successfully integrated even when gestures precede the corresponding speech items. However, it appears that there may be a limit on the size of the temporal window during which semantic information can be easily integrated. Further studies are needed to investigate this issue beyond the individual word level, and, regarding the sentence level, by going beyond gestures that disambiguate homonyms in the speech stream, to allow for more generalizable conclusions.

The above studies demonstrate another crucial prerequisite for gestures hypothesized to be playing a role in language prediction, namely that speech is integrated with gestural information even if the gestures do not occur in tight synchrony but slightly in advance. However, what remains unclear is whether gestures do play a role in predictive language processing, that is, whether the semantic information they encode contributes to the pre-

activation of concepts denoted by words that form part of the gesture-accompanying verbal utterances but which have not yet been uttered. Holler and Levinson (2019) proposed a situated framework for understanding human language processing, which is oriented at the various layers (from individual sounds and words to speech acts) and modalities of language. The authors argue that "the compositional and temporal architecture of multimodal utterances facilitates predictive coding on multiple levels, leading to a processing advantage over unimodal utterances" (Holler & Levinson, 2019: 645). This is in line with behavioral studies showing that responses tend to be faster when speech is presented together with gestures than when speech is presented alone (e.g., Holle et al., 2008; Kelly, Özyürek & Maris, 2010; Nagels et al., 2015; Wu & Coulson, 2015). They further argue that "prediction happens on different time scales, covering both shorter and longer time windows [and] different levels" (Holler & Levinson, 2019: 643), but hypothesizing a clear role of manual gestures and other co-speech visual signals in language prediction.

However, whether such a processing advantage may be linked to gestures facilitating prediction remains unknown. Moreover, if co-speech gestures do function in this way, the question is whether this effect is only present for very short gesture-speech time lags (thus resulting in a relatively limited benefit regarding the time-course of linguistic processing), or whether gestures may aid the prediction of linguistic items also in the context of longer lags. The studies mentioned above (Habets et al., 2011; Obermeier, Holle & Gunther, 2011; Obermeier & Gunther, 2014) have experimentally manipulated gesture-speech timing based on a lag of approximately 200 ms, claiming that semantic information provided by gestures may get lost over time or can only be integrated with effort at lags larger than this (cf. Holle, Obermeier & Gunther, 2011). However, recent research suggests that in natural conversation settings we can observe time lags that considerably exceed 200 ms: Ter Bekke et al. (in press) found that for almost a quarter of iconic gestures in the corpus (55 out of 258 gestures;

21.31%), the stroke onset preceded the lexical affiliate onset by 520 ms or more. Thus, an important next step is to design experimental paradigms that capture these longer distances between gesture stroke and lexical affiliate representative of a considerable proportion of iconic co-speech gestures in conversation. Recent frameworks nestling psycholinguistic processing within conversational situ (Holler & Levinson, 2019) have argued that visual communicative signals facilitating prediction would benefit the fast pace of conversational turn-taking, especially when these visual signals occur early on during the verbal utterance. Anticipating what the unfolding turn is about is beneficial since response planning can begin early, facilitating the timely launch of the next conversational contribution. Thus, a predictive effect of early iconic gestures would be in line with this account.

### *The present study*

The proposed study is based on the multimodal, situated psycholinguistic framework by Holler and Levinson (2019). We assume that accessing linguistic representations during language processing may be facilitated through the presence of gestures, and critically, that iconic gestures that precede corresponding semantic elements in the speech stream aid prediction during language comprehension.

To address our research question, we will conduct an EEG experiment similar to those conducted by Obermeier and colleagues. Our participants will be watching videos of an actress producing two-sentence discourses featuring a target word in the form of an object (noun) at the end of each discourse. While remaining still when uttering the preceding discourse, the actress will produce an iconic gesture depicting the target word. Importantly, the iconic gesture will either be presented such that the gesture stroke starts 520 ms before target word onset ("early" condition) or 130 ms before target word onset ("late" condition, see Figure 1, for a schematic of the trial structure). This manipulation was chosen to reflect the natural timing variation established by recent corpus analyses (ter Bekke et al., 2020, as seen

above). We will record participants' EEG throughout the presentation of each discourse. Our analyses will focus on the period spanning the gesture's visual presentation and the subsequent auditory presentation of the target word. Using cluster-based permutation analyses (Maris & Oostenveld, 2007), we will test for differences in EEG activity in response to the early and late gesture presentation.

Although previous studies have manipulated the gesture-speech time lags, the possible effects of iconic gestures on predictive sentence processing have yet to be tested in designs that specifically measure prediction. Thus, each target word will be embedded in a discourse that is predictive of the word in question, as assessed using a cloze task (Taylor, 1956), and in a non-predictive discourse. We hypothesize that gestures are especially relevant in semantically predictive discourses, where they might further facilitate lexico-semantic processing of the target noun. Specifically, we expect the facilitation to be more efficient (i.e., highly automatic) when gestures strongly precede target words compared to when they only slightly precede them. This facilitated integration effect due to prediction should occur before target word onset. Further, we expect an increased integration effort for early gestures, compared to late gestures, which can be easily embedded into the preceding sentence context. However, if the pre-activation of the target word is not possible as in the non-predictive discourses, it is unclear to which extent iconic gestures are integrated and used for semantic predictions no matter when they occur. Here, two outcomes are possible: First, we might see two main effects (of gesture-speech time lag and of semantic predictability) indicating that also in non-predictive discourses iconic gestures show some processing benefits when presented early but not slightly in advance, while overall facilitation should be less efficient than in predictive discourses. Alternatively, we might see an interaction between both factors meaning that in non-predictive discourses preceding gestures, no matter when they occur, cannot be integrated and used to form predictions. Finally, we hypothesize that the degree of

iconicity (as measured by the iconicity ratings in the pilot study) should be reflected in our EEG measures when gestures are used to form predictions to prune these further. We expect that gestures low in iconicity, which are embedded into a non-predictable sentence context, will be difficult to interpret in the absence of the linguistic information they relate to; thus, we might observe an increased integration effort for late gestures compared to early gestures.

## **Method**

### *Participants*

Eighty right-handed native Dutch speakers will be recruited through the participation database 'SONA' of Radboud University (Nijmegen, the Netherlands). This sample size was chosen based on the ones of previous studies by Obermeier and colleagues (2011, 2014). Since the present study involves two groups and a between-subject design, we doubled the amount of participants to ensure that an effect will be detected.

The recruited participants will range in age between 18 and 35. They will be screened for any neurologic impairments or trauma, neuroleptics, and any known hearing or language impairments, and only participants fitting these criteria will be tested. They will have normal or corrected to normal vision, and they will not be color-blind. Participants must not have taken part in any of the pre-tests (see below). Participants will give written, informed consent to take part in the experiment. The study was approved by the Ethics Committee of the Social Sciences Faculty at Radboud University in compliance with the Declaration of Helsinki. Participants will consent to share their anonymized experimental data for research purposes, and participation will be compensated with 15 Euros or 1.5 course credits.

### *Materials*

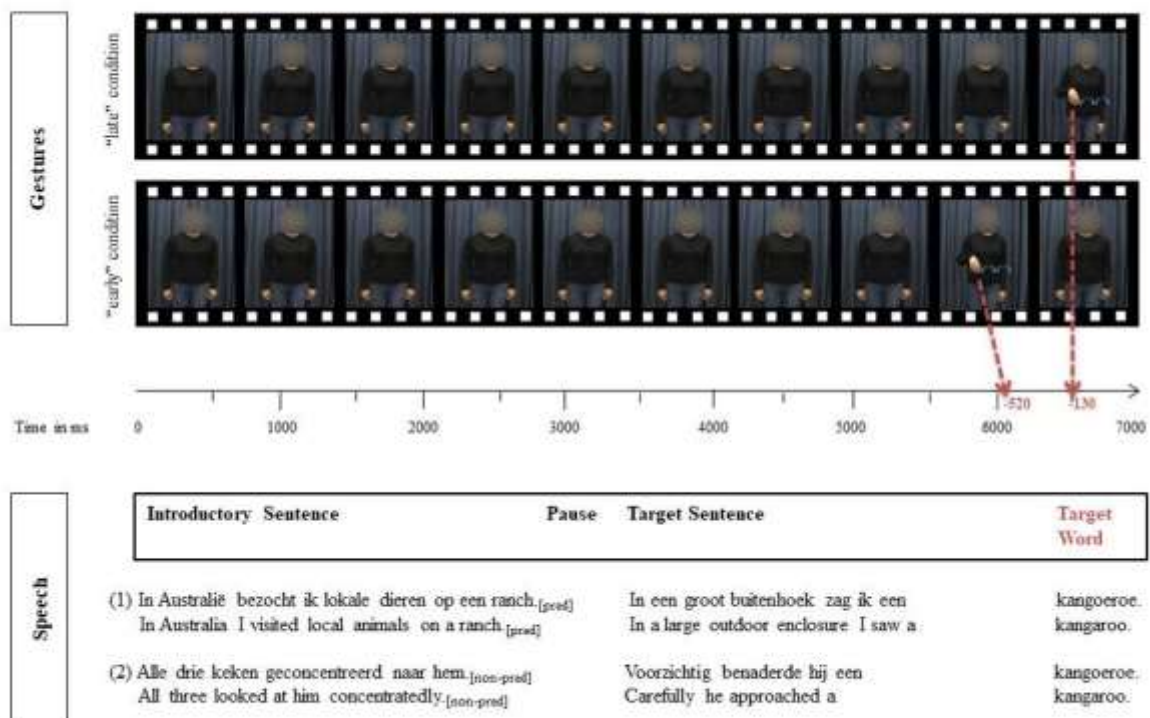
The stimuli of the proposed study are based on the materials developed by Khoe, Holler and Hintz (in prep). The stimulus set consists of 80 concrete target nouns (mean Zipf-

frequency = 3.92 , SD = 0.90, range = 2.06 – 6.47, Keuleers & Brysbaert, 2010; mean prevalence = 0.99, SD = 0.02, range = 0.91 - 1, Keuleers et al., 2015), which are either embedded in (1) a predictable or (2) a non-predictable context. The contexts comprise of Dutch mini-stories consisting of two sentences, ending in the target noun. In 80 mini-stories, the target word can be predicted; in the remaining 80 ones, the target word cannot be predicted. Each mini-story is paired with an iconic gesture, which is timed to have its stroke onset either 520 ms ("early" condition) or 130 ms ("late" condition) prior to the target word onset, yielding a total of 320 unique stimuli. Figure 1 displays one target word being embedded in a predictable and non-predictable context, as well as being presented with an early and a late preceding iconic gesture.

Recordings of the stimuli were made in the video recording laboratory of the Max Planck Institute for Psycholinguistics. A female native speaker of Dutch was videotaped, producing iconic gestures while speaking the stimulus sentences, using normal intonation and a regular speaking rate. The speaker wore clothes in a neutral dark color and stood in front of a unicolor curtain. The speaker was positioned in the center of the screen. At sentence onset, her arms were hanging casually by her sides. She produced the gesture at a point in time that felt natural to her, that is always close to the target word, but no specific instructions on the timing were given (i.e., the actress was blind to the goal of the present study). At least three versions of each stimulus were recorded. From these three versions, the best recording was selected based on the naturalness of speech and gesture, consistency of speech and gesture across different conditions, and quality of the recording (e.g., absence of background noise, video recording artifacts, etc.). We used ELAN (Version 4.1.2, Wittenburg et al., 2006) to annotate the onset and offset of several events in the video: the target words, each gesture phrase (i.e., from the first to the last frame in which manual movement could be observed that belonged to a gesture), and each gesture stroke phase (the most meaning-bearing part of the

gesture, Kita et al., 1998). The video recordings were further edited using Adobe After Effects© to add a mask blurring the speaker's face, such that facial movements and expressions were not visible. Finally, we used ffmpeg© to shift the video track of the stimuli recordings relative to the audio track such that the onset of the gesture stroke preceded the onset of the spoken target by either 520 ms or 130 ms in every stimulus video.

The 320 videos are on average 8302 ms long (SD = 1169, range = 6120 - 11952). Target word onset occurs on average after 6703 ms (SD = 1155, range = 4374 -10336) and is comparable across the predictable (M = 6715, SD = 1168, range = 4423-10336) and the non-predictable (M = 6693, SD = 1146, range = 4374-10010) sentence conditions.



**Figure 1:** Schematic of the trial structure. Gesture stroke onset preceded target word onset by either 520 ms ("early" condition) or by 130 ms ("late" condition). An example of a predictable context can be found in (1); a non-predictable context example can be found in (2).

### *Rating studies*

We conducted two web-based sentence completion studies to assess the cloze probability of the target words in the (1) predictive and (2) non-predictive mini-stories (Taylor, 1956). Moreover, a lab-based rating study was run to assess how well the iconic gestures embodied the target words.

Both sentence completion studies were implemented in LimeSurvey (LimeSurvey GmbH). The participants read the mini-stories up until and including the determiner preceding the target word, and were instructed to fill in the word they thought would be the most likely continuation of the running sentence. Thirty participants took part in the first rating study (involving predictive contexts, 22 female, M age = 26.2, SD = 3.5, range = 21 - 33); another thirty-one participants took part in the second rating study (involving non-predictive contexts, 18 female, M age = 24.0, SD = 4.0, range = 18 - 33). Participants' responses were coded as 'match' in case the word in question was provided. In the case of a non-target response, the pairwise semantic distance to the target word was calculated using the Dutch version of Snaut<sup>1</sup> (Mandera, Keuleers & Brysbaert, 2017). The semantic distance values were then converted to similarity values by subtracting them from 1. Finally, the cloze probability for each target word was calculated by summing up 'matches' (value of 1) and similarity values for non-target responses (value between 0 and 1) and by dividing the sum by the number of participants who responded. For the predictable contexts the average cloze probability was 0.85 (SD = 0.13, range = 0.51 – 1). For the non-predictable contexts, the average cloze probability was 0.17 (SD = 0.07, range = 0.04 – 0.32).

Thirty-two participants (23 female, M age = 23.0, SD = 2.9, range = 19 - 31) took part in the lab-based iconic gesture compatibility rating study, which was implemented in Presentation (version 20.0; Neurobehavioral Systemsec, Inc.). On each trial, the participants

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<sup>1</sup> Snaut was accessed through <http://meshugga.ugent.be/snaut-dutch/>.

first saw a video recording of one of the 80 iconic gestures without audio. They were then asked to provide a maximum of three words that best describe the gesture. Finally, they were asked to rate the compatibility of the just-seen gesture and the target word it depicts, using a scale ranging from 1 (incompatible) to 7 (fully compatible). On average, the probability of the target word being among the three words provided by participants was 0.41 (SD = 0.32, range = 0 – 1). The average compatibility rating was 5.16 (SD = 1.24, range = 1.75 – 7), indicating good compatibility.

### *Experimental design and lists*

The proposed study uses a 2 (gesture-speech time lag) x 2 (word predictability) mixed design, with repeated measures on the first factor. In other words, both factors are independent variables, whereas the gesture-speech lag will serve as within-subject manipulation and the semantic predictability of the target word as between-subject manipulation. This leaves us with four experimental conditions: predictable target word with an early preceding gesture, predictable target word with a slightly preceding gesture, non-predictable target word with an early preceding gesture and non-predictable target word with a slightly preceding gesture.

Two target word lists will be created, such that experimental conditions are counterbalanced across participants, meaning that half of the participants will hear the target words in the predictable and the other half only in the non-predictable condition. However, across the lists, each target word is heard in each prediction condition equally often.

Each of the target word lists comes in two stimulus list versions, each of which consists of 80 sentence stimuli embedding the target word: 40 sentences that are coupled with a strongly preceding gesture, 40 with a later gesture. A total of four stimulus lists will be pseudo-randomized independently for each of the 80 individual participants using Mix (van Casteren & Davis, 2006). Pseudo-randomization was constrained by allowing a maximum of

three repetitions of the same temporal alignment value ("early" or "late" gesture conditions). Every stimulus list started with two practice stimuli that were not accompanied by a comprehension question.

### *Procedure*

Following the general informed consent procedure, participants will be fitted with an EEG cap. During EEG recording, participants will be seated in front of a computer monitor, with speakers placed on either side. Participants will be seated in a sound-attenuating and electrically shielded booth. The stimuli will be presented full screen on a 23-inch monitor operating at a 1920 x 1080 native resolution, using Presentation software (version 20.0; Neurobehavioral Systemsec, Inc.). Participants will be assigned to either the predictable or the non-predictable context condition. Each participant will see two practice trials and a total of 80 experimental trials: 40 trials with an early preceding gesture and 40 with a slightly preceding gesture (130 ms, "late" condition). Twenty of these trials will be followed by a yes/no comprehension question on whether the participant has perceived a red star in the preceding trial, to ensure that the participant will be paying attention. They will, therefore, be instructed to respond by pressing the 'Y' key on the keyboard to answer with 'no,' and the 'M' key to answering with 'yes.' These comprehension questions will be spread over the experiment at irregular intervals. After every 20 trials, participants will be able to take a short, self-timed break before continuing the experiment.

### *EEG data recording*

The EEG signal will be recorded from 27 active scalp electrodes (Fz, FCz, Cz, Pz, Oz, F7/8, F3/4, FC5/6, FC1/2, T7/8, C3/4, CP5/6, CP1/2, P3/4, O1/2) which will be mounted in an elastic cap (ActiCAP), and will be placed according to the 10-20 convention. The EEG signal will be recorded relative to the left mastoid, along with activity at a right-mastoid

reference channel and four bipolar horizontal and vertical electrooculogram (EOG) channels. The ground electrode will be located on the forehead. The impedance for all active electrodes will be kept below 20k $\Omega$ , and triggers will be time-locked to both gesture stroke onset and target word onset. EEG signals will be recorded using BrainVision Recorder software (version 1.20.0401; Brain Products GmbH), at a sampling rate of 1000 Hz, using a time constant of 8 s (0.02 Hz) and high cut-off of 100 Hz in the hardware filter.

### *Data pre-processing*

The pre-processing of the data will be performed using BrainVision Analyzer (version 2.2) and will involve five main steps: re-referencing, filtering, segmentation, ocular correction and artifact rejection. First, the raw signal will be inspected to identify insufficient EEG signals (e.g., electrodes that show poor signal due to large-amplitude artifacts or deficient connectivity for at least half of the experiment), and interpolate these signals through spherical splines. A maximum of 4 EEG channels will be interpolated; a summary of the number of interpolated channels will be reported (Nieuwland & Arkhipova, 2018). Then, both mastoid channels will be combined, and the resulting new signal will get re-referenced over all remaining channels. Afterwards, the data will be filtered with a Butterworth IIR filter with a low cut-off of .01 Hz and a high cut-off of 30 Hz (Hintz, Meyer & Huettig, 2020).

In the next step, the continuous data will be segmented into epochs ranging from -1000 to 1000 ms relative to the target word onset. The segments will then be screened for eye movements, large muscle artifacts, electrode drifts, and amplifier blocking: First, ocular correction according to the method of Gratton and Coles (1983) will be used to detect and straighten out artifacts concerning the EOG channels, such as blinks and other eye movements. Further, a semiautomatic artifact rejection will be performed on all channels. Here, the BrainVision Analyzer highlights trials with channels whose values exceed +/-100  $\mu$ V, which will be manually filtered and rejected on an individual base. Participants who, on

average, have less than 68 remaining trials (85%) left from the initial 80 across the four conditions will be excluded from the statistical analysis and replaced by new participants who will view the same list of materials. The average number of removed trials per condition (and SD) will be reported. Next, the mastoid, as well as the EOG channels, will be excluded, and baseline correction will be performed on the remaining channels. Here, the average voltage of a relevant 200 ms (-1000 to -800 ms) interval will be subtracted from every segment. This time window was chosen as to this point no gestures or other stimuli will have occurred.

### *Statistical Analysis*

In order to systematically evaluate our hypotheses, we plan four major analyses. For all analyses, single-trial time-domain EEG data will be submitted to a multi-level statistics approach (for application to time-frequency data see, e.g., Strauß et al., 2014).

On the first level, the contrast of the within-subjects factor "gesture timing" will be calculated (i.e., for each individual separately), and an independent samples t-tests will be applied to compare single-trials with early preceding versus slightly preceding gestures. Then, uncorrected regression t-values will be obtained for all time-channel bins.

On the second level, four different analyses will be performed: First, to test the main effect of gesture timing independent of semantic predictability of the sentences, z-transformed t-values of all subjects will be compared against zero in a two-tailed dependent samples t-test. A Monte-Carlo non-parametrical permutation method (1000 randomizations), as implemented in Fieldtrip, will estimate type I-error controlled cluster significance probabilities ( $\alpha = 0.025$ ). If the hypothesis of the two-main effect confirms, we should obtain significant results here. It would be most likely to find effects on the N400 (and P600) component, peaking 400 ms (and 600 ms respectively) post target word onset. Subsequently, to test for gesture timing effects specific to only highly predictable discourses, z-transformed t-values of the group of subjects that have only listened to high cloze sentences will be compared against zero in a two-tailed

dependent samples t-test; again, by using the cluster-based permutation method. We will repeat the previous analysis on the group of subjects that have only listened to low cloze sentences to control for possible gesture timing effects that might be specific to non-predictable sentences. If the hypothesis of the two-main effect applies, converging results in both groups should be obtained. However, if the interaction hypothesis holds true, different times and regions in the two groups should be found, where, for instance, an early gesture timing matters in the high cloze but not in the low cloze group. Afterwards, to directly test for the interaction of gesture timing and semantic predictability, z-transformed t-values of the high cloze group will be compared to those of the low cloze group in a two-tailed, between-subjects independent samples t-test. If the interaction hypothesis confirms and facilitatory effects of early gesture timing will be found only in highly predictable discourses, the proposed study would provide initial evidence that there is no fixed time-window of audiovisual integration, but a context-dependent widening of such time windows. Finally, to show that semantic predictions are formed and pruned by the iconic gestures, we will correlate the amplitude of the EEG signal within times and regions of interest (determined by analysis 1 to 3) with the ratings of the gestures' degree of iconicity from one of the pilot studies.

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### Appendix: Material overview

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>In de dierentuin is het oude verblijf van Kiki omgetoverd tot een waar klimparadijs. Iedereen is namelijk dol op de</p> <p>(Kiki's old residence in the zoo has been transformed into a true climbing paradise. Everybody loves the)</p>	<p>Wendy is het populairste meisje van de klas. Ze heeft de coolste stickers van de</p> <p>(Wendy is the most popular girl in the class. She has the coolest stickers of the)</p>	<p>aap (monkey)</p>	0.67	0.59
<p>De dochters van de kermisexploitant vinden spannende attracties erg leuk. Het liefst spenderen ze de hele dag in de</p> <p>(The daughters of the fairground operator love exciting attractions. They prefer to spend the whole day in the)</p>	<p>Gerda is helderziend en heeft geregeld een visioen. Toen ze in de bus stapte zag ze ineens de</p> <p>(Gerda is a psychic and regularly has a vision. When she got on the bus she suddenly saw the)</p>	<p>achtbaan (rollercoaster)</p>	0.53	0.63
<p>Jos had het helemaal gehad om met de trein te reizen. Hij bedacht zich geen moment en kocht een</p> <p>(Jos had enough of travelling by train. He didn't hesitate for another moment and bought a)</p>	<p>Samen keken ze voor de 10e keer naar deze film. Hun favoriete scene was die met een</p> <p>(They watched this movie together for the 10th time. Their favorite scene was the one with a)</p>	<p>auto (car)</p>	0.93	0.88
<p>Pieter is op kraamvisite bij zijn beste vriendin. In zijn armen houdt hij de</p> <p>(Pieter is on a maternity visit with his best friend. In his arms he holds the)</p>	<p>Hij kon zijn aandacht niet bij de les houden. Al snel was hij aan het dagdromen over de</p> <p>(He couldn't focus his attention on the lesson. Soon he was daydreaming about the)</p>	<p>baby (baby)</p>	0.97	1.00

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>Het rommelhok was door een stylist omgetoverd tot een logeerkamer. In de hoek van de kamer stond nu een</p> <p>(The messy room had been turned into a guest room by a stylist. In the corner of the room was now a)</p>	<p>Iedereen weet dat uitstel leidt tot afstel. Patricia had dan ook eerder moeten beginnen aan haar verslag over een</p> <p>(Everyone knows that you shouldn't put off until tomorrow what you can do today. Patricia should have started earlier on her report about a)</p>	<p>bed</p> <p>(bed)</p>	0.8	0.97
<p>Als het warm weer is gaat Maarten graag naar het terras met zijn vrienden. Hij geniet dan nog meer van een</p> <p>(When the weather is warm Maarten likes to go to the café with his friends. There he enjoys a)</p>	<p>Het dagje uit van de familie Jansen ging niet helemaal zoals gedacht. Vader had alleen maar aandacht voor een</p> <p>(The day out of the Jansen family didn't go quite as planned. Father was only paying attention to a)</p>	<p>biertje</p> <p>(beer)</p>	0.83	0.53
<p>Het was een koude winter en er moest nieuw hout worden klaargemaakt voor de open haard. Vader ging naar de schuur en pakte de</p> <p>(It was a cold winter and new wood had to be prepared for the fireplace. Father went to the barn and grabbed the)</p>	<p>Maarten staat bij de kassa in de bouwmarkt. De mensen achter hem blijven het maar hebben over de</p> <p>(Maarten is at the checkout in the DIY store. The people behind him keep talking about the)</p>	<p>bijl</p> <p>(axe)</p>	0.8	0.31
<p>Het werd buiten steeds donkerder en het begon hard te waaien. Niet lang daarna zag Tom een</p> <p>(It was getting darker and darker outside and it started blowing hard. Not long after, Tom saw a)</p>	<p>Het werd helemaal stil in de volle kamer. Iedereen keek naar een</p> <p>(It got completely quiet in the crowded room. Everybody was looking at a)</p>	<p>bliksemschicht</p> <p>(lightning bolt)</p>	0.37	0.28

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
Nienke ziet in het park een grote struik in bloei staan. Glimlachend ruikt ze aan de (Nienke sees a large blooming bush in the park. Smiling she smells the)	Gelukkig had Arnold zijn camera meegenomen. Hij maakte meer dan tien foto's van de (Luckily Arnold had brought his camera. He took more than ten pictures of the)	bloem (flower)	0.77	0.03
Johan loopt 's ochtends de keuken in. Voor zijn ontbijt eet hij graag een (Johan walks into the kitchen in the morning. For his breakfast he likes to eat a)	Rudolf is een heel belangrijk examen aan het maken. Hij raakte in de war bij de vraag over een (Rudolf is taking a very important exam. He got confused when he was asked about a)	boterham (sandwich)	0.47	0.47
De laatste tijd heeft opa wat moeite met het lezen van kleine lettertjes. Gelukkig heeft hij nu een (Lately grandpa has been having some trouble reading small print. Luckily he now has)	Toen hij het tijdschrift weg wilde gooien, hield zijn vriendin hem tegen. Ze wilde nog het stuk lezen over een (When he wanted to throw away the magazine, his girlfriend stopped him. She still wanted to read the article about)	bril (glasses)	0.3	0.78
De familie Kuiper kwam verschillende planten tegen tijdens hun tocht door de woestijn. Toen ze even niet opletten, bezeerde hun dochter zich aan een (The Kuiper family came across several plants during their journey through the desert. When they didn't pay attention for a moment, their daughter hurt herself on a)	De buurman van Nadia is op excursie geweest. Ze luistert aandachtig als hij vertelt over een (Nadia's neighbor has been on an excursion. She listens attentively when he tells about a)	cactus (cactus)	0.97	0.00

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Op 1 januari vindt altijd een groot klassiek concert plaats in het centrum. Het orkest dat daar speelt wordt geleid door de</p> <p>(On the 1st of January there is always a big classical concert in the city centre. The orchestra that plays there is conducted by the)</p>	<p>Julia heeft nu langs alle zenders gezapt maar er is niets wat haar leuk lijkt. Uit verveling zet ze toch maar het programma op over de</p> <p>(Julia's been zapping all the stations now, but there's nothing she likes. Out of boredom she puts on the program about the)</p>	<p>dirigent (conductor)</p>	0.97	0.69
<p>Patricia wil de grote groep jongeren passeren. Om ze aan de kant te laten gaan gebruikt ze de</p> <p>(Patricia wants to pass the large group of young people. In order to make them move aside, she uses the)</p>	<p>Melanie werd 6 jaar en dat werd uitgebreid gevierd. Het eerste cadeau dat ze kreeg was de</p> <p>(Melanie turned 6 and that was extensively celebrated. The first gift she received was the)</p>	<p>fietsbel (bike bell)</p>	0.23	0.44
<p>Oma heeft de laatste tijd steeds meer moeite om de televisie te verstaan. De audicien raadde haar aan om gebruik te gaan maken van een</p> <p>(Grandma's been having more and more trouble understanding television lately. The Hearing Care Professional advised her to use a)</p>	<p>Over drie dagen is Huub jarig. Voor zijn verjaardag wil hij graag een</p> <p>(It's Huub's birthday in three days. For his birthday he would like a)</p>	<p>gehoorapparaat (hearing aid)</p>	0.83	0.25
<p>De postcodeloterij was afgelopen maand in onze straat gevallen. We besloten een mooie roadtrip door Amerika te gaan maken van het</p> <p>(The postcode lottery had fallen on our street last month. We decided to make a nice roadtrip through America from the)</p>	<p>Andre kan de slaap al uren niet vatten. Als hij zijn ogen sluit ziet hij steeds het</p> <p>(Andre hasn't been able to sleep for hours. When he closes his eyes, he always sees the)</p>	<p>geld (money)</p>	0.83	0.94

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>De man is achter het stuur gekropen, ook al had hij teveel gedronken. Hij bracht de nacht door in de</p> <p>(The man got behind the wheel, even though he'd had too much to drink. He spent the night in the)</p>	<p>Ondanks dat hij in de file stond, moest Richard toch lachen. Op de radio hoorde hij een grap over de</p> <p>(Even though he was stuck in traffic, Richard still had to laugh. He heard a joke on the radio about the)</p>	<p>gevangenis (prison)</p>	0.1	0.03
<p>Toen de jager omkeek stond er een hert achter hem. Snel pakte hij het</p> <p>(When the hunter turned around, there was a deer behind him. Quickly he grabbed the)</p>	<p>Na drie koppen koffie kon Vera zich eindelijk op haar werk concentreren. Niet langer bleef ze verwonderd kijken naar het</p> <p>(After three cups of coffee Vera could finally concentrate on her work. No longer did she keep looking in amazement at the)</p>	<p>geweer (weapon)</p>	0.87	0.91
<p>Jenny zag dat de plantjes water nodig hadden. Ze ging naar de kraan en vulde de</p> <p>(Jenny saw that the plants needed water. She went to the tap and filled up the)</p>	<p>Karel was zijn schuur aan het opruimen. In de hoek onder alle spullen vond hij de</p> <p>(Charles was cleaning out his barn. In the corner under all the stuff he found the)</p>	<p>gieter (watering can)</p>	0.93	0.22
<p>Op zaterdagavond ga ik graag naar een rockconcert. Ik ben dol op het geluid van de</p> <p>(I like to go to a rock concert on Saturday night. I love the sound of the)</p>	<p>Thomas at snel zijn bord leeg zodat hij niet bij zijn ouders aan tafel hoefde te blijven zitten. Hij wilde geen woord meer horen over de</p> <p>(Thomas finished his meal quickly so that he didn't have to sit at his parents' table. He didn't want to hear another word about the)</p>	<p>gitaar (guitar)</p>	0.47	0.97

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Rapunzel liet haar blonde lokken uit het raam van de toren vallen. De knappe prins ging vervolgens langzaam omhoog via het</p> <p>(Rapunzel dropped her blonde locks from the window of the tower. The handsome prince then slowly climbed up her)</p>	<p>In sommige gevallen slaat een hobby om naar een obsessie. Het liep dan ook uit de hand met Wilma's liefde voor het</p> <p>(In some cases, a hobby turns into an obsession. Things got out of hand with Wilma's love for the)</p>	<p>haar (hair)</p>	0.9	0.16
<p>Sam gleed bij het snowboarden zo de steile afgrond in. Gelukkig werd hij snel gered met een</p> <p>(Sam slipped into the steep abyss while snowboarding. Fortunately, he was quickly rescued with a)</p>	<p>Leo luistert naar een spannend audioboek. Hij is net bij het stuk over een</p> <p>(Leo is listening to an exciting audiobook. He's just at the piece about the)</p>	<p>helicopter (helicopter)</p>	0.8	0.41
<p>Hendrik ging vissen aan de waterkant. Toen zijn dobber onderging, pakte hij meteen de</p> <p>(Henry went fishing on the waterfront. When his float went down, he immediately grabbed the)</p>	<p>Bas heeft veel spullen die hij niet meer gebruikt. Naar de kringloopwinkel brengt hij de</p> <p>(Bas has a lot of stuff he doesn't use anymore. To the thrift store he brings the)</p>	<p>hengel (fishing rod)</p>	0.87	0.38
<p>Valerie heeft gisteren teveel gedronken en heeft nu een enorme kater. Het meeste last heeft ze van de</p> <p>(Valerie had too much to drink yesterday and now she's got a huge hangover. She's suffering most from a)</p>	<p>Grietje kwam helemaal chagrijnig thuis. Haar hele dag was verpest door de</p> <p>(Gretel was grumpy when she came home. Her whole day was ruined by a)</p>	<p>hoofdpijn (headache)</p>	0.7	0.19

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>Lucas wil altijd weten hoe laat het is. Voor zijn verjaardag kreeg hij van zijn vrienden een</p> <p>(Lucas always wants to know what time it is. For his birthday, his friends gave him a)</p>	<p>Harry heeft wel 30 verschillende t-shirts. Zijn nieuwste shirt heeft een plaatje van een</p> <p>(Harry's got 30 different t-shirts. His latest shirt has a picture of a)</p>	<p>horloge (watch)</p>	0.97	0.97
<p>Ze verveelden zich al de hele middag. Ineens sprong Karin op, ze had eindelijk een</p> <p>(They've been bored all afternoon. Suddenly Karin jumped up, she finally had an)</p>	<p>Moeder zegt de hele dag al geen woord tegen vader. Zij was nog steeds boos op hem vanwege zijn kritiek op een</p> <p>(Mother hasn't said a word to Father all day. She was still angry with him because he criticized her)</p>	<p>idee (idea)</p>	1	0.66
<p>In Australië bezocht ik lokale dieren op een ranch. In een groot buitenhok zag ik een</p> <p>(In Australia I visited the local animals on a ranch. In a large outdoor kennel I saw a)</p>	<p>Alle drie keken ze geconcentreerd naar hem. Voorzichtig benaderde hij een</p> <p>(All three of them looked at him with concentration. Carefully he approached the)</p>	<p>kangoeroe (kangaroo)</p>	0.77	0.03
<p>Juffrouw Jannie liet in de les over de herfst een paar stekelige groene bolsters zien. Voorzichtig opende ze er eentje en de kleuters keken verwonderd naar de</p> <p>(Miss Jannie showed some prickly green husks in the lesson about autumn. Carefully she opened one and the toddlers looked in amazement at the)</p>	<p>Nancy verzamelt graag dingen uit de natuur. Het mooist vindt ze de</p> <p>(Nancy enjoys collecting things from nature. What she likes best is the)</p>	<p>kastanje (chestnut)</p>	0.67	0.00

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Garfield, het huisdier van de familie Jansen, was weggelopen. Loesje hing overal in de buurt posters op met een foto van de</p> <p>(Garfield, the pet of the Jansen family, had run away. Loesje hung up posters all over the neighborhood with a picture of their)</p>	<p>Carolien bladert alle tijdschriften op tafel door. Ze is op zoek naar het artikel over de</p> <p>(Carolien flipped through all the magazines on the table. She is looking for the article about the)</p>	<p>kat (cat)</p>	0.93	0.03
<p>Nicole had maar een uur voor de moeilijke toets. Tijdens het invullen van de vragen keek ze daarom regelmatig op de</p> <p>(Nicole only had an hour before the difficult test. Whilst answering the questions she therefore regularly looked at the)</p>	<p>Beatrice weet op de housewarming niet zo goed waar ze over moet praten. Twijfelend begint ze een gesprek over de</p> <p>(Beatrice doesn't know what to talk about on the housewarming. Doubtfully she starts a conversation about the)</p>	<p>klok (clock)</p>	1	0.09
<p>Ik maakte een heerlijk kopje thee voor mezelf. Uit de trommel pakte ik een</p> <p>(I made myself a lovely cup of tea. From the tin I took a)</p>	<p>De kinderen waren buiten verstopperij aan het spelen. Susan kon de anderen niet vinden maar ze vond wel een</p> <p>(The kids were playing hide and seek outside. Susan couldn't find the others but she did find a)</p>	<p>koekje (cookie)</p>	0.73	0.06
<p>Justin was een uitstekende journalist. Om op de hoogte te blijven van de actualiteiten keek hij elke dag in de</p> <p>(Justin was an excellent journalist. To keep abreast of current affairs, every day he reads the)</p>	<p>Rianne speelde een spelletje op haar mobiel. Ineens verscheen er een reclame over de</p> <p>(Rianne played a game on her mobile. Suddenly an advertisement appeared about the)</p>	<p>krant (newspaper)</p>	1	0.16

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>De klaar-overs stonden elke ochtend klaar om de kinderen te helpen. Zo kwamen zij zonder problemen over het</p> <p>(The lollipop men and women were ready to help the children every morning. Without problems they crossed the)</p>	<p>De familie was bijeengekomen om te spreken over de situatie. Ze waren het erover eens dat er iets gedaan moest worden aan het</p> <p>(The family had gathered to discuss the situation. They agreed that something had to be done at the)</p>	<p>kruispunt (intersection)</p>	0.23	0.56
<p>Roel wilde een fles wijn open maken voor bij het diner. Uit de keukenlade haalde hij de</p> <p>(Roel wanted to open a bottle of wine for dinner. From the kitchen drawer he took the)</p>	<p>Quinten was een cryptogram puzzel aan het maken. Hij wist niet wat er bedoeld werd met de cryptische beschrijving van de</p> <p>(Quinten was making a cryptogram puzzle. He didn't know what was meant by the cryptic description of the)</p>	<p>kurkentrekker (corkscrew)</p>	0.73	0.34
<p>De meeste kleuters doe je een groot plezier met een bezoekje aan de dierentuin. Maar soms schrikken ze van het gebrul van de</p> <p>(Most toddlers give you lots of happiness during a visit to the zoo. But sometimes they are frightened by the roar of the)</p>	<p>Nerveus stond de kleine jongen voor de groep. Hij haalde diep adem en begon zijn spreekbeurt over de</p> <p>(The nervous little boy stood up in front of the group. He took a deep breath and started his talk about the)</p>	<p>leeuw (lion)</p>	0.83	0.69
<p>Ivo houdt van wat extra room in zijn koffie. Hij deed er melk in en gebruikte een</p> <p>(Ivo likes some extra cream in his coffee. He put milk in it and used a)</p>	<p>Norbert kreeg een onvoldoende tijdens zijn beoordelingsgesprek. Zijn baas vond dat hij teveel bezig was met een</p> <p>(Norbert got a fail at his appraisal interview. His boss thought he was too preoccupied with an)</p>	<p>lepeltje (spoon)</p>	0.8	0.59

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>Anna moest op de twintigste verdieping zijn voor een vergadering. Ze ging meteen naar de</p> <p>(Anna had to be on the 20th floor for a meeting. She went straight to the)</p>	<p>Marjolein is de hele dag druk bezig geweest op haar werk. Ze is vergeten de reparateur te bellen voor de</p> <p>(Marjolein has been busy at work all day. She forgot to call the repairman for the)</p>	<p>lift (elevator)</p>	1	0.00
<p>Op bijna elke middelbare school wordt er een eindejaarsgala georganiseerd. Perfect opgedofte leerlingen worden graag naar de feestlocatie gebracht met een</p> <p>(At almost every secondary school there is an end-of-year gala. Perfectly dressed up pupils are brought to the party location with a)</p>	<p>Paula ging naar de bibliotheek in het dorp. Voor de ingang stond een</p> <p>(Paula went to the library in the village. In front of the entrance there was a)</p>	<p>limousine (limousine)</p>	0.8	0.00
<p>Mieke wilde een paar sfeervolle kaarsjes aansteken. Daarvoor gebruikte ze een</p> <p>(Mieke wanted to light some decorative candles. To do so she used a)</p>	<p>Alle kinderen uit de straat waren aan het stoepkrijten. De grappigste tekening was die van een</p> <p>(All the kids in the street were drawing chalk on the pavement. The funniest drawing was that of a)</p>	<p>lucifer (match)</p>	0.3	0.22
<p>De kok ging de verse zalm snijden. Hij nam de vis uit de koelkast en pakte een</p> <p>(The cook was going to cut the fresh salmon. He took the fish out of the fridge and grabbed a)</p>	<p>In een sloppenwijk is het meestal een grote smeerboel. Tussen alle rommel vond Pablo een</p> <p>(A slum is usually a big mess. Among all the rubbish Pablo found a)</p>	<p>mes (knife)</p>	0.87	0.81

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>De zangeres betrad het podium van de concertzaal. Zij zwaaide naar het publiek en ging staan bij de</p> <p>(The singer entered the stage of the concert hall. She waved to the audience and stood up behind the)</p>	<p>Ijverig maakte Dave de spellingstoets. Hij twijfelt over de zin met de</p> <p>(Dave took the spelling test diligently. He had doubts about the sentence with the)</p>	<p>microfoon (microphone)</p>	0.73	0.53
<p>Voor jongeren is het tegenwoordig heel belangrijk dat ze altijd hun vrienden kunnen bereiken. Elke puber zeurt daarom bij zijn ouders om een</p> <p>(Nowadays, it is very important for young people to always be able to reach their friends. That is why every adolescent is nagging their parents for a)</p>	<p>Nu Theo even zonder werk zit, kan hij niet meer zomaar alles kopen. Hij heeft dan ook geen geld voor een</p> <p>(Now that Theo is out of work for a while, he can't just buy everything anymore. He doesn't have the money for a)</p>	<p>mobieltje (mobile phone)</p>	0.47	0.38
<p>Met mooi weer gaat Jos in het weekend graag touren met de vriendengroep. Ook doordeweekst gebruikt hij graag de</p> <p>(With nice weather Jos likes to ride during the weekend with his group of friends. During the week he also likes to use his)</p>	<p>Julius kijkt al de hele week uit naar het weekend. Zaterdag krijgt hij eindelijk de</p> <p>(Julius has been looking forward to the weekend all week. On Saturday, he will finally get the)</p>	<p>motor (motorbike)</p>	0.57	0.84
<p>Het water in de gootsteen kan niet weglopen door alle etensresten in de afvoerbuis. Gelukkig kwamen deze los toen Willem gebruik maakte van de</p> <p>(The water in the sink cannot drain all the food residues in the drainpipe. Luckily, it came loose when Willem used the)</p>	<p>Rita zette de boodschappen op het aanrecht. Het enige wat ze is vergeten te halen is de</p> <p>(Rita put the groceries on the sink. The only thing she forgot to pick up is the)</p>	<p>ontstopper (plunger)</p>	0.7	0.22

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Paul is heel muzikaal. Op zondag gaat hij altijd naar de kerkdienst en speelt hij op het</p> <p>(Paul is very musical. On Sunday, he always goes to church and plays the)</p>	<p>Hugo werkt zes dagen in de week. Zijn vrije dag brengt hij het liefste door achter het</p> <p>(Hugo works six days a week. He prefers to spend his day off behind the)</p>	<p>orgel (organ)</p>	0.83	0.00
<p>Er dreigden grote grijze wolken net toen ik naar de markt wilde lopen. Ik durfde het huis niet uit te gaan zonder een</p> <p>(There were big grey clouds just as I was about to walk to the market. I didn't dare leave the house without a)</p>	<p>De kinderen waren verwikkeld in een hevige discussie. Ze maakten elkaar goed duidelijk wat ze nu vonden van een</p> <p>(The children were engaged in a fierce discussion. They made it very clear to each other what they now thought of the)</p>	<p>paraplu (umbrella)</p>	1	0.31
<p>Max was de hele morgen bezig geweest met het versieren van de kerstboom. Nu miste op de top van de boom alleen nog de</p> <p>(Max had been decorating the Christmas tree all morning. Now all that was missing on top of the tree was the)</p>	<p>Trudy kon haar aandacht niet bij het gesprek houden. Ze werd afgeleid door de</p> <p>(Trudy couldn't keep her attention on the conversation. She was distracted by the)</p>	<p>piek (peak)</p>	0.97	0.00
<p>Op de zuidpool leven grote groepen dieren. Mijn favoriet is de</p> <p>(The South Pole is home to large groups of animals. My favorite is the)</p>	<p>Ze verslikte zich toen ze het nieuws op de televisie zag. Vol verbazing keek ze naar het bericht over de</p> <p>(She choked when she saw the news on television. In amazement, she watched the news about the)</p>	<p>pinguïn (penguin)</p>	0.73	0.50

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
Het jonge stel ging op huwelijksreis naar Egypte. Daar bezochten ze als eerste de (The young couple went on their honeymoon to Egypt. There they visited the)	De kinderen in de klas hielden een kringgesprek. Erik vertelde enthousiast over de (The children in the class had a discussion in a circle. Erik told enthusiastically about the)	piramiden (pyramids)	0.93	0.09
Voordat ik de bioscoopzaal in ga haal ik altijd iets lekkers. Er is niets zo leuk als een film kijken terwijl je geniet van de (Before I go into the cinema, I always get something nice. There's nothing like watching a movie while you're enjoying the)	Ze stonden al tien minuten op haar te wachten. Uiteindelijk arriveerde ze met de (They had been waiting for her for ten minutes. Eventually she arrived with the)	popcorn (popcorn)	0.8	0.03
Annette vond het muf ruiken in haar kamer. Om frisse lucht te krijgen opende ze het (Annette thought her room smelled stale. To get some fresh air, she opened the)	Het was boekenweek op de basisschool. Sarah nam een griezelboek mee over het (It was book week in elementary school. Sarah brought a horror book about the)	raam (window)	0.9	0.03
De verstrooide leerling was al zijn sportspullen vergeten. Hij leende bij zijn tennisleraar een (The absent-minded student had forgotten all of his sports gear. From his tennis coach he borrowed a)	Mensen met autisme hebben vaak een obsessie voor een bepaald voorwerp of onderwerp. Daniel heeft dat met een (People with autism often have an obsession with a certain object or subject. Daniel has that with a)	racket (racket)	0.6	0.22

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>De deelnemer aan het televisiespelprogramma keek gespannen naar de presentatrice. Op haar teken mocht hij draaien aan het</p> <p>(The participant in the television game show looked tensely at the presenter. On her signal he was allowed to spin the)</p>	<p>Olivier dreigt een burn-out te krijgen als hij op deze manier doorgaat. Hij draagt teveel verantwoordelijkheid met zich mee, waaronder die over het</p> <p>(Olivier is in danger of getting burned out if he goes on like this. He takes on too much responsibility, including for the)</p>	<p>rad (wheel)</p>	0.9	0.06
<p>In de zomermaanden is het een natte boel in de tropen. Je kan dan nergens schuilen voor de</p> <p>(In the summer months the tropics are a wet place. There's nowhere to hide from the)</p>	<p>Peuters kunnen de hele dag door hetzelfde zeggen. Kleine Lucas heeft het nu al een uur over de</p> <p>(Toddlers can say the same thing all day long. For an hour now, little Lucas has been talking about the)</p>	<p>regen (rain)</p>	0.83	0.94
<p>De zon scheen fel aan de hemel toen het plotseling in de verte begon te regenen. Toen we in verwondering omhoog keken zagen we een</p> <p>(The sun was shining brightly in the sky when it suddenly started raining in the distance. When we looked up in amazement we saw a)</p>	<p>Hij werd verrast toen hij de bladzijde omsloeg. Daar stond op twee pagina's groot een</p> <p>(He was surprised when he turned the page. Spread out over two pages there was a large)</p>	<p>regenboog (rainbow)</p>	0.7	0.69
<p>Nora moest een aantal moeilijke rekensommen maken. Daarom pakte ze meteen de</p> <p>(Nora had to make some difficult calculations. That's why she immediately grabbed the)</p>	<p>Annebel vindt het leuk om te tekenen. Ze is bijna klaar met het tekenen van de</p> <p>(Annebel likes to draw. She's almost done drawing the)</p>	<p>rekenmachine (calculator)</p>	0.97	0.22

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Mariska vertelde enthousiast over het huwelijksaanzoek van haar verloofde. Iedereen keek vol verwondering naar de</p> <p>(Mariska talked enthusiastically about her fiancé's marriage proposal. Everyone looked amazed at the)</p>	<p>Fiona heeft altijd veel geluk. In de garage vond ze vanochtend de</p> <p>(Fiona is always very lucky. This morning in the garage she found the)</p>	ring (ring)	0.83	0.97
<p>Het lint hing klaar voor de opening van de nieuwe school. De burgemeester pakte hiervoor een</p> <p>(The ribbon hung ready for the opening of the new school. The mayor grabbed)</p>	<p>Tina komt thuis van werk en hangt haar jas op. Op de tafel ziet ze een</p> <p>(Tina comes home from work and hangs up her coat. On the table she sees)</p>	schaar (scissors)	1	1.00
<p>De kinderen vermaakten zich kostelijk op het strand. Stijn maakte een diepe gracht met de</p> <p>(The children had a great time on the beach. Stijn made a deep moat with the)</p>	<p>Hij zat al twee uur op internet, op zoek naar het perfecte cadeau. Uiteindelijk koos hij voor de</p> <p>(He had been on the internet for two hours, looking for the perfect gift. In the end he chose the)</p>	schep (shovel)	0.97	0.50
<p>De inbreker had geen moeite om de geheime familiekluis te vinden. Deze bevond zich namelijk achter het</p> <p>(The burglar had no trouble finding the secret family safe. It was behind the)</p>	<p>Muziek kan sterke herinneringen oproepen. Bij dit nummer denkt Karel meteen aan het</p> <p>(Music can evoke strong memories. With this song Karel immediately thinks of the)</p>	schilderij (painting)	0.83	0.06

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>In het bezoekerscentrum is een grote vijver met verschillende dieren aangelegd. Op de steen onder de warmtelamp ziet Hans een</p> <p>(A large pond with various animals has been dug in the visitor centre. On the stone under the heat lamp Hans sees a)</p>	<p>Richard begon zich zorgen te maken om Simone. Ze staarde al 10 minuten strak naar een</p> <p>(Richard started to worry about Simone. For 10 minutes, she had been staring at a)</p>	<p>schildpad (turtle)</p>	0.4	0.13
<p>Caroline heeft al meerdere pogingen gedaan om te stoppen, maar ze vindt het moeilijk haar slechte gewoonte af te leren. Uiteindelijk pakte ze toch een</p> <p>(Caroline has tried to stop several times, but she finds it difficult to get rid of her bad habit. Eventually, she picked up a)</p>	<p>Toen ik wakker werd kon ik me mijn droom nog levendig herinneren. Het was niet de eerste keer dat ik droomde over een</p> <p>(When I woke up, I could still vividly remember my dream. It wasn't the first time I dreamt about a)</p>	<p>sigaret (cigarette)</p>	0.9	0.53
<p>Kleine Tony kon nog niet goed met mes en vork eten en knoeide. Hij kreeg daarom van zijn moeder een</p> <p>(Little Tony couldn't eat with knife and fork yet and messed around. That's why his mother gave him a)</p>	<p>Voor het buurtfeest mocht de vierjarige Michael een muurschildering maken. Ze hadden niet verwacht dat hij een tekening zou maken van een</p> <p>(Four-year-old Michael was allowed to make a mural for the neighbourhood party. They didn't expect him to draw a)</p>	<p>slabbetje (bib)</p>	0.37	0.00
<p>Simone is altijd alles kwijt. Toen ze vanochtend naar haar werk wilde rijden, moest ze een uur zoeken naar de</p> <p>(Simone always loses everything. When she wanted to drive to work this morning, she had to spend an hour looking for the)</p>	<p>Marta werd verrast toen ze door het oude boek bladerde. Er zat namelijk een foto tussen van de</p> <p>(Marta was surprised when she flipped through the old book. There was a photo of the)</p>	<p>sleutel (key)</p>	0.53	0.78

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>Moeder maande de tienjarige Tobias de computer nu echt uit te zetten. Hij leek wel verslaafd aan het</p> <p>(Mother urged ten-year-old Tobias to turn off the computer for real. He seemed addicted to the)</p>	<p>Christa kon haar ogen niet geloven toen Chiel in een t-shirt naar buiten kwam. Op zijn onderarm had hij een tatoeage van het</p> <p>(Christa couldn't believe her eyes when Chiel came out in a t-shirt. On his forearm he had a tattoo of the)</p>	<p>spelletje (game)</p>	0.4	0.44
<p>Het vuilnis in het zomerse Napels was al een week niet opgehaald. Alle inwoners van de stad klaagden over de</p> <p>(The garbage in summery Naples hadn't been collected for a week. All of the city's inhabitants complained about the)</p>	<p>Het was al drie uur 's nachts maar hij kon nog steeds niet slapen. Hij bleef maar piekeren over de</p> <p>(It was three o'clock in the morning but he still couldn't sleep. He kept worrying about the)</p>	<p>stank (smell)</p>	0.93	0.16
<p>Mijn vrienden en ik hebben dit weekend een wedstrijdje hockey gespeeld. Jan had nog nooit eerder gespeeld en had veel moeite met het vasthouden van de</p> <p>(My friends and I played a game of hockey this weekend. Jan had never played before and had a lot of trouble holding the)</p>	<p>Midden in de nacht werd Susan wakker omdat ze naar de wc moest. Onderweg naar de badkamer struikelde ze over de</p> <p>(In the middle of the night Susan woke up because she had to go to the toilet. On the way to the bathroom she tripped on the)</p>	<p>stick (stick)</p>	0.67	0.50
<p>Het tapijt in de huiskamer lag na het kinderfeestje vol met kruimels en confetti. Martijn besloot om snel de rommel op te ruimen met de</p> <p>(The carpet in the living room was full of crumbs and confetti after the children's party. Martijn decided to quickly clean up the mess with the)</p>	<p>De gegijzelde man had zo lang niets gegeten of gedronken dat hij begon te hallucineren. Toen hij knipperde met zijn ogen zag hij de</p> <p>(The hostage hadn't eaten or drunk for so long that he started to hallucinate. When he blinked he saw a)</p>	<p>stofzuiger (vacuum cleaner)</p>	0.87	0.22

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(\text{target-present, rating variables})} = 0.90$
<p>Maria kreeg het niet voor elkaar om de computer aan te zetten. Blijkbaar zat de stekker niet in het</p> <p>(Maria didn't manage to turn on the computer. Apparently the plug wasn't in the)</p>	<p>Ze wist niet wat ze kon verwachten in de andere kamer. Toen ze de deur opendeed was het eerste wat ze zag het</p> <p>(She didn't know what to expect in the other room. When she opened the door, the first thing she saw was the)</p>	<p>stopcontact (socket)</p>	1	0.03
<p>Mijn blouses kwamen helemaal gekreukt uit de was. Om ze weer glad te krijgen gebruikte ik het</p> <p>(My blouses came out of the wash all wrinkled. To get them smooth again, I used the)</p>	<p>Katy stond met haar vrienden op de jaarlijkse rommelmarkt. Het eerste wat ze verkocht was het</p> <p>(Katy was at the annual flea market with her friends. The first thing she sold was)</p>	<p>strijkijzer (iron)</p>	1	0.28
<p>Het hele dorp werkte samen om het kleine meisje uit de waterput te redden. Met z'n allen trokken ze aan het</p> <p>(The whole village worked together to save the little girl from the well. Together they pulled the)</p>	<p>Guus liep wel 200 treden omhoog. Boven in de toren pakte hij het</p> <p>(Guus walked up 200 steps. At the top of the tower he grabbed the)</p>	<p>touw (rope)</p>	0.9	0.72
<p>De oude kerk heeft een hoge toren vanwaar je een mooi uitzicht hebt. Om boven te komen moest Stefan met de</p> <p>(The old church has a high tower from where you have a nice view. To get upstairs Stefan had to take the)</p>	<p>Toen ze naar het restaurant liep, wist ze niet wat ze zag. Op het raam hing een poster van de</p> <p>(When she walked to the restaurant, she couldn't believe what she saw. On the window hung a poster of)</p>	<p>trap (stairs)</p>	0.87	0.88

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Hans en Lydia hebben vorige week de Kilimanjaro beklommen. Toen ze de top bereikten waren ze onder de indruk van het</p> <p>(Hans and Lydia climbed Kilimanjaro last week. When they reached the top they were impressed by the)</p>	<p>Vader besloot oude foto's te laten digitaliseren. Helaas miste de foto van het</p> <p>(Dad decided to have old photos digitized. Unfortunately, one was missing: the photo of the)</p>	<p>uitzicht (view)</p>	1	0.22
<p>Hanneke trakteert zichzelf op een manicure. De schoonheidsspecialiste haalt de scherpe punten weg met een</p> <p>(Hanneke treats herself to a manicure. The beautician removes the sharp edges with a)</p>	<p>De muur is bezaaid met foto's en plaatjes. Franks favoriet is die van een</p> <p>(The wall is littered with photos and pictures. Frank's favorite is one of a)</p>	<p>vijl (file)</p>	0.87	0.41
<p>Jos moest naar Engeland voor een conferentie. Omdat hij snel zeeziek wordt, kocht hij een ticket voor het</p> <p>(Jos had to go to England for a conference. Because he gets seasick quickly, he bought a ticket for the)</p>	<p>Een duur merk zegt niet altijd iets over de kwaliteit. Dat merkten ze duidelijk op bij het</p> <p>(An expensive brand doesn't always say something about quality. They clearly noticed that at the)</p>	<p>vliegtuig (airplane)</p>	1	0.69
<p>Jan zag dat hij de planken korter moest maken. Hij liep naar de gereedschapskist en pakte de</p> <p>(Jan saw that he had to shorten the boards. He walked to the toolbox and grabbed the)</p>	<p>Ankie begon wat vergeetachtig te worden. Ze wist niet meer wat ze had gedaan met de</p> <p>(Ankie started to get a little forgetful. She didn't know what she'd done with the)</p>	<p>zaag (saw)</p>	0.97	0.63

Predictive sentence context	Non-predictive sentence context	Target word	Cloze probability	Iconicity rating $Cov_{(target-present, rating\ variables)} = 0.90$
<p>Voor ieders veiligheid is het belangrijk dat de verkeersregels worden nageleefd. Zo moeten mijn kinderen altijd oversteken bij een</p> <p>(It is important for everyone's safety that the traffic rules are observed. For example, my children must always cross at a)</p>	<p>Elke week hebben ze in de kleuterklas een ander thema. Deze week gaat het thema over een</p> <p>(Every week in kindergarden they have a different theme. This week the theme is about a)</p>	<p>zebrapad (zebra crossing)</p>	0.87	0.09
<p>Na een uitgebreide restauratie was het schip klaar om de zee op te gaan. De matroos maakte de trossen los en hees het</p> <p>(After an extensive restoration the ship was ready to go to sea. The sailor loosened the mooring lines and hoovered up the)</p>	<p>Iedereen is al op het feestje, behalve Gerda. Zij is nog bezig met het repareren van het</p> <p>(Everyone's already at the party, except Gerda. She's still repairing the)</p>	<p>zeil (sail)</p>	0.73	0.00
<p>De dappere ridder zag dat de draak de tovenaars bedreigde. Uit zijn schede pakte hij snel het</p> <p>(The brave knight saw that the dragon threatened the sorcerer. From his scabbard he quickly grabbed the)</p>	<p>De drie broertjes keken erg schuldig toen moeder thuiskwam. Ze wisten heel goed dat ze niet hadden mogen komen aan het</p> <p>(The three brothers looked very guilty when Mother came home. They knew very well that they shouldn't have touched the)</p>	<p>zwaard (sword)</p>	1	0.44
<p>Kelly ging voor het eerst kajakken in Frankrijk. Toen haar kajak omsloeg op de wilde rivier was ze blij met het</p> <p>(Kelly went kayaking in France for the first time. When her kayak tipped over on the wild river she was happy with the)</p>	<p>Toen ze elkaar tegenkwamen op de gang bleven ze even staan om te kletsen. Het gesprek ging al snel over het</p> <p>(When they bumped into each other in the hallway, they stopped to chat. Soon, the conversation was about the)</p>	<p>zwemvest (life jacket)</p>	0.23	0.44