

UNIVERSITEIT TWENTE

How context repetition influences the N400 and reaction times – A metaphor study

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Abstract

In cognitive metaphor research a lot of different variables can exert their influence on the results. To control for all these variables limits the set of possible stimuli used. However, previous studies have already indicated that it may be possible to work with single word repetitions in psycholinguistic studies of language to broaden the set of possible stimuli. The effects of repeating stem sentences on the processing of language are less known. This study aims at expanding existing findings by examining the effect of repeating stem sentences on the processing of metaphorical, literal and anomalous expressions. Participants had to judge whether an expression was metaphorical, literal or anomalous, while N400 ERP responses were recorded. Repetition of stem sentences had no effect on the N400 amplitude. Reaction times were longest for first presentations of the stem sentences compared to second or third presentations. Unexpectedly, faster reaction times for anomalous sentences were found compared to metaphorical and literal sentences, which may be explained by task design. The findings from this study suggest, that it may be possible to work with repetition of stem sentences in psycholinguistic research, without compromising the validity of results.

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Introduction

Human language is complex. Many different factors are thought to influence how it is processed in the human brain: Aspects such as word frequency, concreteness, predictability, novelty, word length,, figurativeness and interpretability are frequently used constructs in contemporary linguistic research (e.g. Lai, Curran and Menn, 2009; Gullick, Mitra and Coch, 2013; Renoult, Wang, Calcagno, Prévost and Debrulle, 2012; Grainger, Lopez, Eddy, Dufau and Holcomb, 2012; Diependaele, Lemhöfer and Brysbaert,2013). A lot of time and effort is spent on holding these variables constant, because of their possible confounding effects on research results (Cardillo, Schmidt, Kranjec and Chatterjee, 2010). This ultimately limits the amount of stimuli that can be used to study the processing of language in individuals. Moreover, item pools are even more limited if research is done in a specific category of expressions such as metaphor research. The question arises, if it may or may not be possible to work with repetitions to broaden the set of stimuli used in a specific category. Some researchers have already explored this issue by studying the effects of repeating single words (Renoult et al., 2012; Grainger et al., 2012; Van Strien, Verkoeijen, Van der Meer and Franken, 2007). In this study, whole sentences will be used to examine the effect of repeating the context instead of single target words on the N400, reaction times and on response patterns.

Neurobiological Research – ERPs and N400

EEG (electroencephalographic) research has proven to be one of the most promising contemporary approaches to study how language is processed in the human brain. From the EEG, event-related potentials (ERPs) can be extracted, which are time-locked recordings of activity that can be attributed to specific cognitive events (Purves et al., 2008, p.81). Hence, ERPs can be used to study the cognitive responses to single stimuli. One specific EEG component that receives a lot of attention in neuropsychological research of language is the N400. The N400 consists of a negative deflection in the EEG, 200-500ms after stimulus onset (Renoult et al, 2012). It is thought to be related to semantic processing (Purves et al., 2008; Davenport & Coulson, 2011; Gullick et al., 2013; Grainger et al. 2012; Renoult et al., 2012). More specifically, it is thought to index the integration of semantic features into a meaningful whole (Renoult et al., 2012). In this context, the amplitude of the N400 reflects the ease of the semantic processing (Davenport & Coulson, 2011). A related interpretation of the N400 is the

notion of “unexpectedness”: It indicates a mismatch between the expected semantic flow and the actual stimulus (Purves et al., 2008, p.542). If the stimulus does not fit into the context provided, it has to be reprocessed, which demands higher order semantic processing (Kutas & Hillyard, 1980; Purves et al., 2008).

Repetition effect

Several studies have focused on repeating target words to examine whether the N400 effect decreases with repetition. The assumption is that repetition of a stimulus increasingly activates the semantic representation of that stimulus in the brain, which in turn facilitates its processing (Renoult et al., 2012). In a study with 15 repetitions per target word, Renoult et al. (2012) found that the N400 effect indeed decreases with repeated exposure to the stimulus. Hereby, the latency of the N400 linearly decreased with repeated exposure, while the N400 amplitude only decreased after the second presentation and thereafter remained constant. So repetition only had considerable effect on the timing of the semantic processing, but not on the ease of semantic processing. This implies that the same words may indeed be presented several times in a single study, without compromising the validity of the results.

Van Strien et al. (2007) applied a continuous recognition memory task with massed and spaced repetition. Massed repetition implies that words are repeated immediately, whereas during spaced repetition six intervening words were used. They found that the N400 repetition effect is greater for massed than for spaced repetition. This effect was explained by priming: The semantic representation of the stimulus that was activated during the first exposure was thought to be still activated when the stimulus was presented for the second time. As only twice-presented words were used in this study nothing can be said about the stabilization of the N400 after the second presentation, as found by Renoult et al. (2012).

Grainger et al.(2012) added another variable to repetition research: They found that repetition priming effects are larger for high-frequency words than for low-frequency words. To study the effect of repetition on the processing of language the frequency of the words used thus needs to be controlled to rule out word frequency as alternative explanation.

The present study expands existing findings by investigating whether the repetition of stem sentences, thus repetition of the context, influences the N400 amplitude. If the repetition of stem

sentences had no considerable effect on the semantic processing of the target words, stem sentences could be presented several times with different endings. Hence, different types of expressions could be created while using the same context several times to study semantic processing of language. This would broaden the set of possible stimuli used in linguistic research.

Types of Expression and Mapping Theory

A main method to study the processing of language in the human brain is to compare the ERPs linked to different types of expressions, such as for example metaphoric expressions and literal expressions. In this study three different types of expressions are used: Literal expressions, metaphoric expressions and anomalous expressions. Literal meanings are quite straightforward: “My friend is a man” indicates that the friend is a male human being. “My friend is a harbor” on the other hand cannot be taken literally, because the expression would not make sense. If we say that our friend is a harbor, a meaning has to be retrieved by interpretation. We could for example mean that our friend is someone we always come back to. This type of metaphor, which has the form of “A is a B” is referred to as structural metaphor by George Lakoff and Mark Johnson in their book “Metaphors we live by” (Lakoff and Johnson, 2003) or as “nominal metaphor” as referred to by Cardillo et al. (2010). One concept is replaced by another dissimilar concept. If we talk about metaphoric expressions in this study, we refer to this specific form. An anomalous expression, as the name indicates, makes no sense if taken literally but does not provide a metaphorical meaning either. “My friend is a table” can hardly be interpreted in a meaningful way, nor can it be taken literally. Admittedly, there are possibilities to interpret almost every sentence in a highly creative manner, such that one ultimately arrives at a meaningful explanation. To differentiate anomalous from metaphorical expressions, we refer to anomalous expressions if a meaningful interpretation does not spontaneously come to mind and if much effort is needed to link the one concept to the other.

Mapping theory provides a useful framework in cognitive metaphor research: Meaning is attached to an expression by semantically connecting the two conceptual domains of the sentence (Davenport & Coulson, 2011). In the example given earlier, the concept “friend” is semantically mapped to the concept “harbor”. The more semantically distinct the words of such a sentence are, the more effortful processing is needed to integrate them into a meaningful

whole. Consequently, processing should be most effortful for anomalous sentences, as the two concepts that need to be linked are semantically more distant than for metaphors or literal sentences, and more effortful for metaphors than for literal sentences. Accordingly, the N400 should be largest for anomalous expressions and smallest for literal sentences. This is supported by contemporary research (e.g. Davenport & Coulson, 2011; Chwilla, Kolk & Vissers, 2007; Baumgaertner, Weiller & Büchel, 2001; Yang, Bradley, Huq, Wu, & Krawczyk, 2013).

Factors that influence the N400

A lot of different properties of words are found to influence the N400 effect. For example, Gullick et al. (2013) have investigated the effect of abstractness and concreteness of words on the N400. They found that the N400 effect was larger for concrete than for abstract words in a single word processing paradigm. These findings were attributed to the amount of activation in semantic memory, which are thought to be larger for concrete words than for abstract words. Abstract words, on the other hand, are thought to lead to less activation in the semantic system, which should result in a decrease in the N400 effect. Another study points to the effects of predictability and novelty in language comprehension, which again can be derived from the N400 component (Davenport & Coulson, 2011). Larger N400 effects were found for sentence final words that were less predictable, while no effects were found for conventionality of the sentences. There are other studies, however, which did find that new stimuli elicit somewhat larger N400 effects than more conventional stimuli. In addition, metaphoric endings elicited somewhat larger effects than literal endings (Coulson & van Petten, 2002).

The task is to investigate the extent to which repetition can help building up broader sets of matched stimuli in different conditions, while controlling for confounding variables such as word frequency. For this purpose, a lexical judgment task with spaced repetition of stem sentences in three conditions will be used: metaphorical, literal and anomalous. If the N400 is interpreted as an index of semantic integration, the amplitude of the N400 should be largest for anomalous expressions, intermediate for metaphorical expressions and smallest for literal expressions. As only stem sentences will be repeated while the last words differs for each presentation of the stem sentences, for each presentation of the stimuli another pair of concepts will be needed to be mapped. Thus, the N400 for each condition is expected to remain stable with repetition. Reaction times on the other hand should decrease with repetition, as the processing of each stem sentence should be facilitated through earlier presentations. In addition,

the effects of expression condition on the judgments people make during the task will also be investigated to see whether they match the experimental conditions assigned to the expressions. Moreover possible effects of repetition on response patterns will be analyzed.

Methods

Participants

Thirty-six participants participated in the experiment, whereof eighteen were native Dutch speakers and eighteen non-native Dutch speakers. Of the non-native Dutch speakers 61.2% learned the Dutch language at the age of 19, only one participant indicated age 22 as the age of acquisition. All non-native speakers passed the NT2 language exam, which allowed them to enroll for a Dutch university. Most of the participants were students of the University of Twente or Hogeschool Saxion Enschede, with the exception of one employee of the University of Twente. Twenty-seven of the thirty-five students received study credits for their participations; they were all majors of the behavioral science faculty and subscribed to the study via Sona Systems. The remaining eight participants were selected by convenience sampling. The mean age was 22.4, with a standard deviation of 5.3 years. 72.2% of the participants were female, 27.8 % were male. All but two participants were right-handed, as assessed by the Annett's Handedness Inventory (Annett, 1970). All participants had correct or corrected-to-normal vision with no history of neurological insult or language disability.

Task and Stimuli

Participants were divided into two groups: native Dutch speakers and non- native Dutch speakers. The non-native Dutch group completed the DIALANG test of language proficiency (Lancaster University, 2003) in Dutch before starting with the main experiment. The native speakers group skipped this part of the procedure. Two subtests of the DIALANG test of language proficiency were used, which were relevant to the following EEG experiment: a vocabulary test which assessed the participant's treasury of words and a test for reading proficiency. The former subtest was divided into two parts: A placement test and the main

vocabulary test. At the end of the tests language levels were automatically computed which classified the participants language skills into six ordinal levels (A1 as the lowest and C2 as the highest level of proficiency). The main experimental task had to be completed by both groups. It contained a stimuli set of 93 stem sentences. Each stem sentence was presented three times with varying last words. The last word, which was always a noun, defined whether the expression was to be classified as metaphorical, literal or anomalous. Some of the metaphorical expressions were adopted from Hoorn (1997). This resulted in a total set of 279 (93x3) items that were presented to the participants in random order. The last words did not differ significantly in word frequency ($F(2, 276) = 2.316; p > 0.05$), which was assessed from the Dutch SUBTLEX database (<http://crr.ugent.be/isubtlex/>). In addition items were matched on word length. The task was to judge the word condition of the expressions by pressing one of three arrow keys with the right index finger. One key represented the metaphorical condition, one the literal condition and the third key represented the anomalous condition. The assignment of the arrow keys to the conditions was randomized over participants to avoid possible order effects. For the non-native group the space balk could be pressed if an expression was not understood because of unknown words.

Procedure

Before the start of the experiment, the participants filled in a written informed consent form and a questionnaire that assessed demographical variables as well as handedness, possible neurological diseases, dyslexia and drug use. Participants in the non-native Dutch group were subsequently seated in a comfortable chair in a separate sound attenuated lit room next to the laboratory, approximately 60cm in front of a laptop screen. They were asked to complete the Dialang language test. After giving a short instruction, the researcher left the room. The completion of the DIALANG language test took the participants 45 minutes on average. Native Dutch speakers skipped this part of the procedure. The main experiment was conducted with both groups. The native Dutch speakers filled in the form of consent before the beginning of the main experiment. The participants were subsequently placed in a comfortable chair in the laboratory. After having prepared the electrodes and giving written instructions to the participants, the light was turned off. The participants sat approximately 60cm in front of a computer monitor. Before the onset of the main experiment a one minute control measurement was carried out. Next, a written introduction was presented on the screen, which also included the assignment of arrow keys to the word conditions. In addition, an example of a stem sentence

with three alternative word endings in three different categories was presented. Participants were asked to respond as fast and accurate as possible. All stimuli were presented as black letters on a white background in the centre of the screen. Each trial began with a fixation point in the middle of the screen, which appeared for 500ms. After that, the stem sentence was presented for 1800ms, followed by a 500ms white default display and by the target word which was presented for 300ms. After that, a white default display appeared until one of the response keys was pressed by the participant. The following trial was initiated by the participant's response to the target stimulus. The order of the 279 experimental trials was randomized over all participants, with the restriction that a stem sentence was not repeated within five subsequent trials. Completion of the task took approximately 35 minutes, including a short break after 15 minutes. After completion of the task another control measurement of one minute was carried out. At the end of the experiment participants were debriefed and all their questions were answered.

Apparatus and EEG procedure

Stimuli were presented by using Presentation software 16.3 (Neurobehavioral Systems, Inc., 2012) installed on a separate experimental computer with a 17"-CRT-monitor and a standard QWERTY keyboard. Passive Ag/AgCl ring-electrodes were placed on 61 locations on a elastic cap (Braincap, Brainproducts GmbH) according to the extended 10-20 system. Figure 1 provides an overview over the electrodes used in the experiment. The horizontal and vertical electro-oculogram (hEOG and vEOG) were applied above and below the left eye, at both sides of the face by using bipolar electrodes.. To assess an electromyogram (EMG), another bipolar electrode was positioned at the string muscles at the outer right forearm and at the ulnar styloid process of the same arm. Electrode gel and standard procedures were used to establish adequate conductivity, electrode resistance was kept under 10 k Ω for all 61 electrodes. The EEG, EOGs and EMG were amplified by a 72-channels QuickAmp (Brain Products GmbH) amplifier, which had a built in average reference. The signals were transmitted to a separate computer that had BrainVision Recorder (BrainProducts GmbH) installed. The time-locked signals of the EEG were samples at a rate of 500Hz.

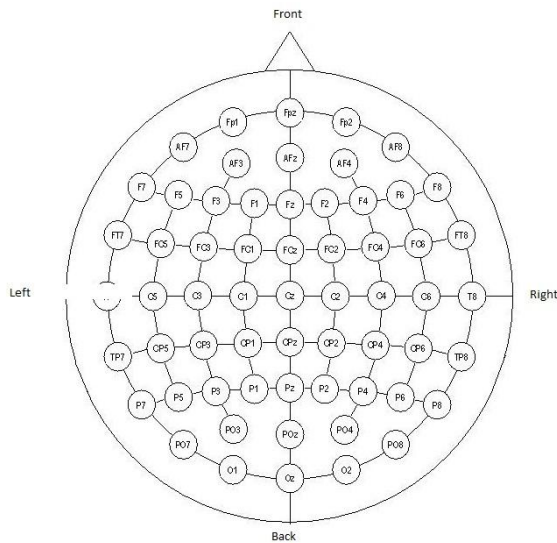


Figure 1. An overview of the 61 electrodes used for the experiment.

Data processing

BrainVision Analyser 2.0 (Brain Products GmbH, 2012) was used to process the raw EEG data. ERPs to target sentences were computed from -200ms before target word onset to 800ms after target word onset, using a baseline of -200 to 0 before target onset. Ocular correction was used to correct for eye blinking and other interfering signals in the EEG. All following data analyses were based on data sampled within the 380ms-420ms time frame, derived from the CZ electrode. Only data from Dutch native speakers was used for analysis, to eliminate possible effects of language proficiency on the results. In addition, trials with eye movements within 0-200 ms after stimulus onset were excluded from the analysis (>150 microV on the vEOG). The mean amplitudes of the N400 per type of expression were computed and submitted to a repeated-measures ANOVA. To investigate the effect of repetition on the N400, mean N400 amplitudes were computed per number of presentation (1st, 2nd, 3rd) of the stem sentences for each condition (metaphorical, literal, anomalous). Repeated measures ANOVAs were applied for each type of expression separately with time of presentation as within-subject factor. Mean reaction times per condition and per number of presentation of the stem sentences were also computed and submitted to repeated-measures ANOVAs with number of presentation as within-subject factor. For each condition, a separate ANOVA was applied. The influence of repetition on response patterns was analyzed by separate repeated-measures ANOVAs per response choice (choice metaphorical, choice literal and choice anomalous) with repetition and condition as within-subject factors. Where the Mauchly's Test of Sphericity yielded a significant result, the

Greenhouse-Geisser corrected degrees of freedom and the related F-value are reported.

Results

Repetition and Reaction times

Mean reaction times differed significantly between conditions ($F(2, 34) = 54.787, p < 0.01$). Reaction times were longest for metaphorical expressions, intermediate for literal expressions and shortest for anomalous expressions. Pairwise comparisons confirmed that each of the differences reached significance with $p < 0.001$. Table 1 shows mean reaction times per condition.

Table 1. *Mean Reaction Times*

	Mean	Std. Deviation	N
Metaphorica 1	1338.7	287.9	18
Literal	1191.2	271.5	18
Anomalous	1042.7	215.9	18

A separate repeated-measures analysis for each type of expression was conducted to investigate the effect of repetition on mean reaction times per condition. With regard to metaphorical expressions, the differences in reaction times between the 1st, 2nd and 3rd presentation of the sentences differed significantly ($F(2, 34) = 6.580, p < 0.01$). Pairwise comparisons revealed that reaction times were longer for the first presentation of a stem sentence compared to the second ($p < 0.05$) or third presentations of a stem sentence ($p < 0.05$). The difference in reaction time between the second and third presentation failed to reach significance ($p > 0.05$). For literal expressions only the difference between the first and the third presentation was statistically significant ($p < 0.05$): Reaction times were longer for first

presentations of stem sentences than for third presentations.¹ For anomalous expressions only, patterns resembled the results found for metaphorical expressions: The difference in reaction time between the first and the second presentation of stem sentences and the difference between the first and the third presentation reached significance, while reaction times for the second and third presentations did not differ significantly from each other. Reaction times for first presentations of stem sentences were significantly longer than reaction times for second presentations of stem sentences ($p < 0.05$). Reaction times were also longer for first presentations compared to third presentations ($p < 0.01$). Table 2 shows mean differences in reaction times per condition.

Table 2. *Mean Differences in Reaction Times per Condition*

Number of Presentation	Metaphoric	Literal	Anomalous
1-2	97.7ms*	44.8ms	47.9ms*
1-3	135.7ms*	76.6ms*	85.1ms*
2-3	37.9ms	31.8ms	37.2ms

* *The mean difference is significant at the 0.05 level*

Type of expression and N400

Regarding the N400 amplitude, anomalous expressions led to the most negative amplitude, the N400 amplitude of metaphoric expressions was intermediate and literal expressions resulted in the least negative amplitude, all with regard to the base line. The repeated-measures ANOVA revealed that these differences in N400 amplitude were significant ($F(2, 34) = 32.241, p < 0.01$). Pairwise comparisons confirmed that all differences reached significance at the 0.01 significance level. Table 3 shows the mean N400 amplitudes for each condition.

¹ The original set of participants contained additional 18 German students, which were excluded for this analysis on the basis of interaction effects with language. If all cases were included, reaction times to first presentations were significantly longer than for than for second representations, as found in the other conditions.

Table 3. *Mean N400 Amplitudes in MicroV*

	Mean	Std. Deviation	N
metaphorical	-1,5	2.0	18
literal	-0.7	1.5	18
anomalous	-2.5	1.7	18

Repetition and N400

The effect of repeating stem sentences on the N400 amplitude was assessed for each condition separately. None of the differences between the first, second or third presentation of a stem sentence was significant. In the anomalous condition, there was a trend towards a larger N400 if the second presentation of a stem sentence was anomalous, compared to anomalies at first presentations of a stem sentence ($p > 0.05$). Figure 2 provides an overview of the effects of repetition and condition on the N400.

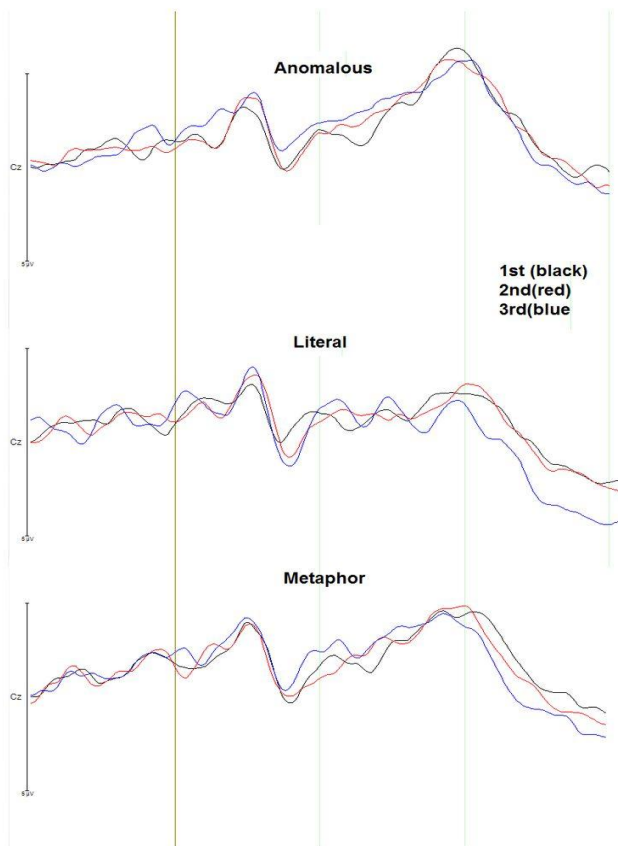


Figure 2. Illustration of the mean N400 amplitude within the -200ms to 800ms time frame as derived from the CZ electrode. Amplitudes are presented per condition (anomalous, literal, metaphorical) and per number of presentation of the stem sentences (black, red and blue lines). The N400 was largest for anomalous sentences and smallest for literal expressions. No repetition effect per condition was found.

Repetition and Response Patterns

First, the expressions that were rated by participants as metaphorical were analyzed. A main effect of condition was found ($F(1.472, 25.028) = 112.237, p < 0.01$). Metaphors were most likely to be classified as metaphorical by the participants (46.7%), anomalous sentences were least likely to be classified as metaphorical (7.9%) while literal sentences were intermediate (17.5%). Classification of the expressions differed significantly between all categories of expressions ($P < 0.01$ for each pair). In addition, a significant interaction effect between condition and repetition was found ($F(4, 68) = 2.606, p < 0.05$). Pairwise comparisons revealed that anomalous expressions were more frequently classified as metaphorical if the stem sentence was presented for the first than for the third time ($p < 0.05$). Literal expressions were more often classified as metaphorical if the stem sentence was

presented for the third than for the second time ($p < 0.05$). No other significant differences were found. Figure 3 shows the effects of repetition on metaphor judgments per condition.

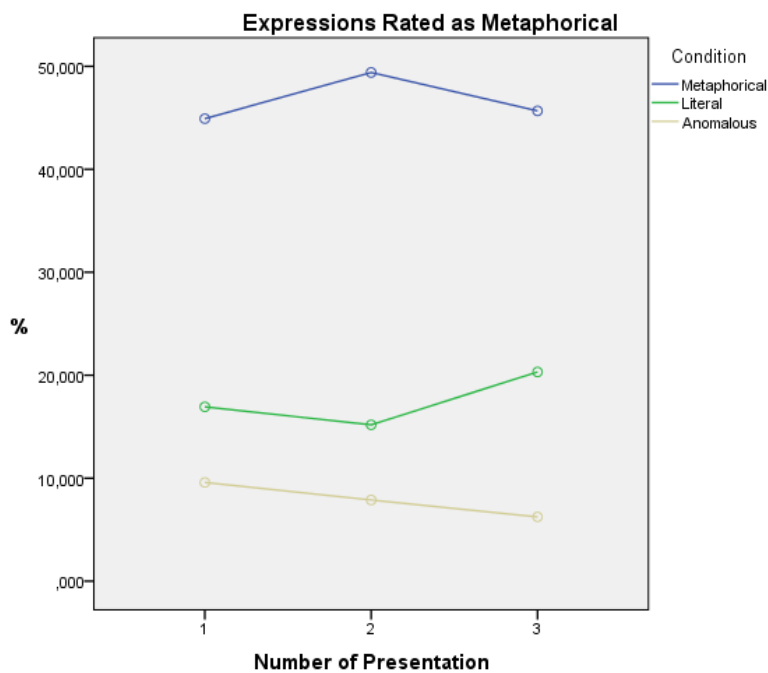


Figure 3. Mean percentages of the expressions that were rated as metaphorical by the participants. Most of the expressions rated as metaphorical were metaphorical expressions, least of them were anomalous expressions. A main effect of condition as well as a interaction effect between condition and repetition were found.

Second, all expressions that were rated as literal by the participants were analyzed. Main effects of condition ($F(1.282, 21.793) = 532.523, p < 0.01$) and repetition ($F(2, 34) = 3.770, p < 0.05$) were found. On average 69.1% of the literal expressions were rated as literal, while only 5.6% of the metaphorical expressions were rated as literal and only 1.9% of the anomalous expressions were rated as literal by the participants. Pairwise comparisons confirmed that all the differences in categorization reached significance. In addition, expressions were more likely to be classified as literal if a sentence was represented for the second time than if the sentence was presented for the third time ($p < 0.05$). No significant interaction of condition and repetition was found. Figure 4 shows the effects of repetition on literal judgments per condition.

How context repetition influences the N400 and reaction times

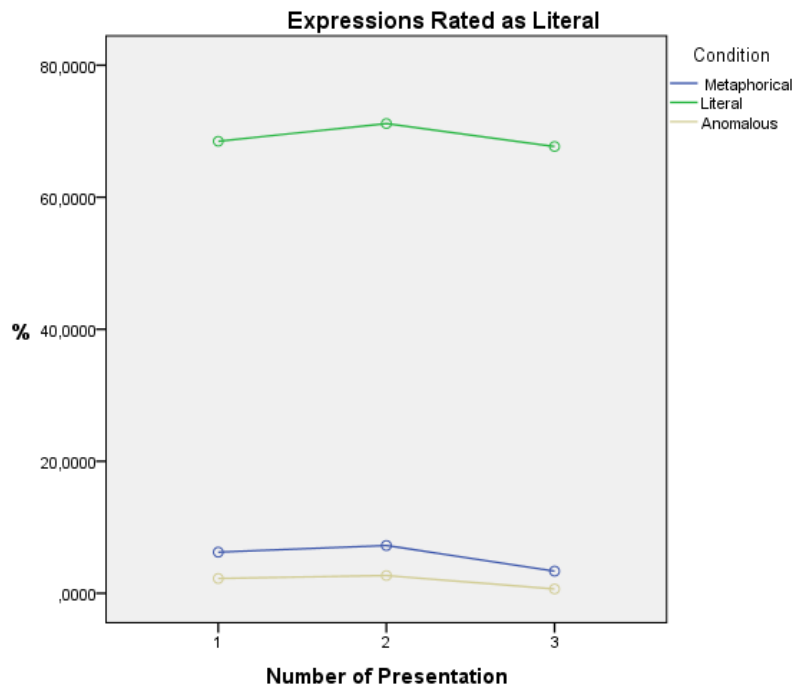


Figure 4. Mean percentages of the expressions that were rated as literal by the participants. Main effects were found for condition and for repetition. Most sentences rated as literal were literal expressions, least were anomalous expressions. Third presentations of a stem sentences had a lower chance of being rated as literal than first or second presentations.

Third, an analysis of all expressions that were rated as anomalous by the participants was conducted. A main effect of condition was found ($F(2, 34) = 476.574, p < 0.01$): Averaged over all presentations of the stem sentence, 89% of the anomalous expressions were rated as anomalous. Still, 45% of the metaphorical expressions were rated as anomalous by the participants. Literal sentences were least frequently classified as anomalous (10.8% of the literal expressions on average). Paired comparisons confirmed that each of the differences in categorization yielded significance at the 0.05 level. In addition, the interaction between condition and repetition was significant ($F(2.046, 34.790) = 3.581, p < 0.05$). Follow up analysis revealed that metaphorical expressions had a significantly higher chance of being classified as anomalous if the stem sentence was presented for the third compared to the second time ($p < 0.05$). Anomalous expressions were more often classified as anomalous if the stem sentence was presented for the third compared to the first time ($p < 0.05$). Figure 5 shows the effects of repetition on anomalous judgments per condition.

How context repetition influences the N400 and reaction times

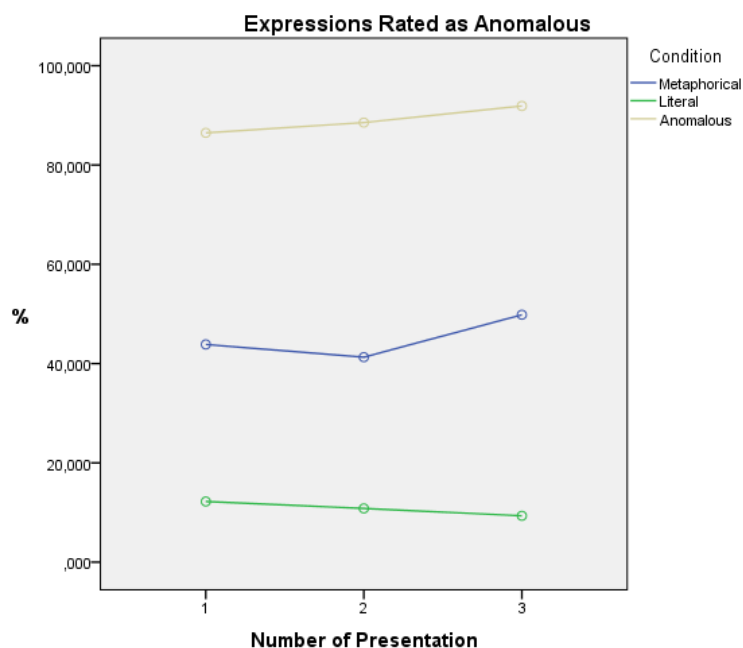


Figure 5. Mean percentages of the expressions that were rated as anomalous by the participants. A main effect of condition and an interaction effect between condition and repetition were found. Most sentences rated as anomalous were anomalous expressions, but a big part of the metaphorical expressions was also classified as anomalous by participants. For both condition, the chance of being classified as anomalous rose if the stm sentence was presented for the third time. Literal expressions were least often considered anomalous.

Discussion

The goal of this study was to examine in how far repetition of context affects the processing of target sentences, especially the N400 and reaction times. In addition, the effect of repetition on participant's lexical judgments was to be examined. Therefore, a set of matched stimuli that resulted in three within-subject conditions was generated: metaphorical expressions, literal expressions and anomalous expressions. For each trio of expressions, only the last word differed and thus determined the type of expression. The main findings will briefly be summarized and discussed in detail in the following sections.

A general comparison of the three conditions showed that the N400 is largest for anomalous expressions and smallest for literal expressions. This is in line with the interpretation of the N400 given earlier: Anomalous expressions contain last words that do not fit into the context provided by the first part of the sentence. As Kutas and Hillyard (1980) put it, the

sentence needs to be semantically reprocessed. The integration of the semantic features into a meaningful whole takes more effort for anomalous expressions than the processing of metaphorical expressions, where a meaning can be more easily derived by focusing on the figurative meaning. Literal sentences on the other hand should need less effort than the other two types of expressions to be processed, because the words of the sentence can more easily be integrated into a meaningful whole. These results can be explained in the context of mapping theory: The metaphors used in this study were mainly novel metaphors, which set up novel mappings between two concepts. Regarding anomalous expressions, the connection between the two concepts at hand is even more unexpected and less plausible (Davenport & Coulson, 2011). Hence, for mapping the two concepts of an anomalous expression more intensive semantic processing is needed.

No statistically significant differences in N400 amplitude between the first, second or third presentation of the sentences were found for any category (metaphorical, literal or anomalous). This suggests that the ease of semantic processing is not affected by repetition. If we consider mapping to take place between the first noun word of the sentence and the last noun word this makes perfect sense. As the last word is different for each presentation of the sentence, each presentation provides the respondent with a new pair of stimuli (the noun word of the stem sentence and the varying target word). Consequently, the semantic processing of the expressions should not be affected by repetition.

Second, the effect of repetition on reaction times was analyzed. The main finding was that reaction times tended to be longer for first presentations than for second or third presentations. This finding is in line with results of contemporary research. For example, Renault et al. (2012) found that reaction times decrease rapidly for the first numbers of presentations, a process that slows down for later repetitions. The fact that our study failed to find significant differences after the second presentation could be due to task design: Some participants indicated after the experiment that they had noticed that stem sentences were used several times. When presented with a stem sentence they remembered, they were reflecting on which buttons they already had pressed in response to the stem sentence. If for example participants remembered to have pressed “metaphorical” when the stem sentence was presented before, they considered pressing one of the other two buttons instead. This engagement in memory and conscious deliberation may have resulted in delayed responses.

Additionally, an unexpected effect of expression condition was found: Reaction times were shortest for anomalous expressions and longest for metaphorical expressions. This is partly in

contrast to other studies like Lai et al. (2009), who report longer reaction times to anomalous sentences and novel metaphors than to literal expressions. Findings like these can be explained in the context of semantic integration: Anomalous sentences are more difficult to process, because the last word does not fit into context and thus is more difficult to integrate. Mapping the words of which the expression is made of hence requires more intense semantic processing, which results in slower reaction times. This is a pattern that is supported by our analysis of the N400, which was largest for anomalous expressions, but not by our analysis of reaction times. The reaction times to anomalous expressions found here are difficult to explain in the context of existing theories. At least two other recent studies have found a similar pattern of reaction times: Responses were faster for implausible than for plausible sentences (Kolk, Chwilla, Van Herten & Oor, 2003; Vissers, Chwilla & Kolk, 2007). The explanation given in these studies were as followed: The anomalous sentences used in both studies were characterized by verb forms from which the anomaly of the sentence could be derived before reading to the last word of the sentence. Participants may have prepared their response before processing the whole sentence. In the present study, however, participants had to read through the whole sentence before making their judgments, because only the last word of each sentence indicated the type of expression. Thus far, it is uncertain whether the same phenomenon underlies the results found by Kolk et al. and the results found here.

The analysis of the judgments themselves and how they are influenced by repetition may shed light on these results. Expression condition accounted for a big part of the choices participants made: Anomalous expressions were mostly rated as anomalous and literal expressions were mostly rated as literal by the participants. The classification of metaphorical expressions was more problematic: On average only half of the metaphorical expressions were indeed rated as metaphorical, while the other half was rated as anomalous by the participants. In addition, for third presentations of sentences, metaphorical as well as anomalous sentences had an increased chance of being rated as anomalous. These findings suggest that to participants a huge proportion of the sentences in the experiment appeared to be anomalous, which may have shaped their expectations. This top-down approach to processing the sentences in this experiment may in turn account for the faster reaction times to anomalous expressions. Literal sentences on the other hand were least often rated as anomalous, so reaction times may have been prolonged because this type of expression was less compatible with participant's expectations and with their prepared motoric response of pressing the "anomalous-key". If we take this perspective, the question why the N400 was still significantly larger for anomalous

sentences remains. Still, the N400 is mainly a marker of semantic integration. Even if the response of pressing the “anomalous-key” may have been facilitated, which could have resulted in enhanced reaction times, the semantic integration of the anomalous word endings of each anomalous expression still requires more processing effort than the integration of literal word endings. More research is needed to examine the effect of expectations on the N400 and to investigate under which circumstances anomalous sentences can be processed faster than literal and metaphorical sentences. Another implication of these findings is that the meaning of the metaphoric expressions was not easily derived by the participants during the experiment. Consequently, the metaphorical stimuli used in this study were ambiguous and may need to be revised. We do not know, however, in which ways the judgments made by the participants influence the semantic processing of the stimulus. In addition, reaction times were only enhanced for anomalous sentences and not for metaphorical sentences rated as anomalous. This could be due to the ambiguity of the metaphorical stimuli. Our results also suggest that the N400 amplitude was dependant solely on the type of the expressions and not on the subjective judgments of the participants, as the differences in N400 amplitude between metaphorical and anomalous expressions still reached significance. A follow-up analysis could investigate this issue by comparing the N400 amplitudes and reaction times for stimuli where the judgments of participants were compatible (e.g. metaphorical expressions rated as metaphorical) with the category of the expression with the N400 amplitudes elicited by stimuli where participant’s judgments and the category of expression were incompatible (e.g. metaphorical expressions rated as anomalous). This would have further implications on whether incompatible judgments in sentence studies should or should not be excluded for data analysis. Due to time constraints, these analyses lay beyond the scope of this paper.

Note that other studies have found several different inherent properties of words, such as abstractedness and concreteness (Gullick et al., 2013) or predictability and novelty (Davenport & Coulson, 2011) which can affect the processing of words and sentences. Validating the stimuli used and matching the target words as well as the noun words of the stem sentences on all these dimensions was beyond the scope of this study. Only word frequency and word length were controlled here. Consequently, other word properties could have had confounding effects on the reported results. In addition, some of the target words were used several times and have been used as word endings as well as as part of the stem sentences. Therefore, the results of this study need to be interpreted with caution.

One other remark is to be made here: In this study, as well as in related studies, effects have been found (or have not been found) that occurred over a relatively long period of time. Consequently, the repetition effects found here and elsewhere could also be influenced by this “time on task”, which consists of more than half an hour in this case. Fatigue, dry eyes and a loss of concentration are all factors that can occur in an experiment over time, especially if it takes place in a darkened room. To examine whether the effects found (or not found) in such experiments truly stem from repetition, future studies could add a control group to their experiments, for which repetition is excluded from the task. If the variations in N400 amplitudes, reaction times and lexical judgments differ significantly from the results found in the experimental group, these variations could more reliably be ascribed to the effect of repetition.

Conclusion

In sum, our results suggest that the ease of processing metaphorical, literal and anomalous expressions is not affected by context repetition. Consequently, repetition of stem sentences could be applied to broaden the datasets in psycholinguistic research. An advantage of this approach would be that different types of expressions could be compared without dealing with interfering variables that stem from stimulus design. By varying only the last words, matched pairs or groups of stimuli could be created to be used in studying language. Taken together, the findings of Renoult et al. (2012) and of the present study suggest that it should be possible to work with a limited set of stem sentences and words which are in turn combined differently to form different task conditions. In this way, standardized stem sentences as well as target words could be repeated to study the processing of different kinds of expressions in the human brain. However, the findings of this study have to be interpreted with caution. The stimuli used in this study were not validated beforehand, which led to ambiguity in the expressions used and possible confounding effects of word and sentence properties. In addition, the effect of repetition on reaction times led to unexpected results with regard to anomalous expressions. The nature of these deviations from other research is not yet clear. Further research has to show if these findings can be replicated or if they were due to interfering variables in task design. Furthermore, future studies may control for effects of explicit memory and conscious considerations while making lexical judgments, for example by using masked priming, as well as for possible effects of time on task.

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Appendix

Stimuli

type 1 = metaphor; 2 = literal; 3 = anomalous								
nr	type	deel1	woord	expr				
				27	3	Mijn schoonmoeder is een stoel	9	
				28	1	Mijn moeder is een kip	10	
				29	2	Mijn moeder is een vrouw	10	
				30	3	Mijn moeder is een schoen	10	
1	1	Een hond is een	vriend	1	31	1	Mijn broer is een beest	11
2	2	Een hond is een	dier	1	32	2	Mijn broer is een man	11
3	3	Een hond is een	tuin	1	33	3	Mijn broer is een duik	11
4	1	De tuin is een	droom	2	34	1	Mijn zus is een draak	12
5	2	De tuin is een	plek	2	35	2	Mijn zus is een vrouw	12
6	3	De tuin is een	mes	2	36	3	Mijn zus is een boom	12
7	1	De hemel is een	huis	3	37	1	Tijd is een deur	13
8	2	De hemel is de	lucht	3	38	2	Tijd is een duur	13
9	3	De hemel is een	doek	3	39	3	Tijd is een vaas	13
10	1	De aarde is een	school	4	40	1	Liefde is een spel	14
11	2	De aarde is een	ding	4	41	2	Liefde is een staat	14
12	3	De aarde is een	pan	4	42	3	Liefde is een kip	14
13	1	Vakantie is een	feest	5	43	1	Mijn huisdier is een ster	15
14	2	Vakantie is een	tijd	5	44	2	Mijn huisdier is een hond	15
15	3	Vakantie is een	dier	5	45	3	Mijn huisdier is een bord	15
16	1	Ziekte is een	straf	6	46	1	Mijn vriend is een kei	16
17	2	Ziekte is een	staat	6	47	2	Mijn vriend is een man	16
18	3	Ziekte is een	fiets	6	48	3	Mijn vriend is een stoel	16
19	1	Een boek is een	vriend	7	49	1	Oorlog is een hel	17
20	2	Een boek is een	ding	7	50	2	Oorlog is een staat	17
21	3	Een boek is een	aap	7	51	3	Oorlog is een voet	17
22	1	Mijn baas is een	aap	8	52	1	Vrede is een kind	18
23	2	Mijn baas is een	mens	8	53	2	Vrede is een staat	18
24	3	Mijn baas is een	zaag	8	54	3	Vrede is een want	18
25	1	Mijn schoonmoeder is een	heks	9	55	1	Water is een recht	19
26	2	Mijn schoonmoeder is een	vrouw	9	56	2	Water is een stof	19

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57 3	Water is een	lamp	19	93 3	Het vak is een	kind	31
58 1	Mijn hart is een	kuil	20	94 1	Het gerecht was een	droom	32
59 2	Mijn hart is een	spier	20	95 2	Het gerecht was een	gans	32
60 3	Mijn hart is een	tas	20	96 3	Het gerecht was een	wind	32
61 1	Muziek is een	taal	21	97 1	De weg is een	boek	33
62 2	Muziek is een	klank	21	98 2	De weg is een	straat	33
63 3	Muziek is een	voet	21	99 3	De weg is een	gans	33
64 1	De dood is een	reis	22	100 1	De arbeider is een	mier	34
65 2	De dood is een	eind	22	101 2	De arbeider is een	knecht	34
66 3	De dood is een	bord	22	102 3	De arbeider is een	boek	34
67 1	De ochtend is een	droom	23	103 1	De lerares is een	slang	35
68 2	De ochtend is een	start	23	104 2	De lerares is een	mens	35
69 3	De ochtend is een	darm	23	105 3	De lerares is een	reeks	35
70 1	De avond is een	man	24	106 1	De zangeres is een	lied	36
71 2	De avond is een	eind	24	107 2	De zangeres is een	vrouw	36
72 3	De avond is een	kuil	24	108 3	De zangeres is een	kuil	36
73 1	De vrouw is een	gans	25	109 1	Het gevoel is een	kleur	37
74 2	De vrouw is een	mens	25	110 2	Het gevoel is een	raad	37
75 3	De vrouw is een	duur	25	111 3	Het gevoel is een	kuil	37
76 1	Mijn broer is een	rots	26	112 1	Liefde is een	beest	38
77 2	Mijn broer is een	man	26	113 2	Liefde is een	staat	38
78 3	Mijn broer is een	dag	26	114 3	Liefde is een	baard	38
79 1	De zon is een	vriend	27	115 1	Het leven is een	reis	39
80 2	De zon is een	ster	27	116 2	Het leven is een	tijd	39
81 3	De zon is een	reis	27	117 3	Het leven is een	voet	39
82 1	De man is een	vos	28	118 1	De held is een	vuur	40
83 2	De man is een	vent	28	119 2	De held is een	man	40
84 3	De man is een	vork	28	120 3	De held is een	roest	40
85 1	Het verhaal is een	mes	29	121 1	Woede is	gif	41
86 2	Het verhaal is een	boek	29	122 2	Woede is	drift	41
87 3	Het verhaal is een	gans	29	123 3	Woede is	tijd	41
88 1	De storm is een	kind	30	124 1	Het hart is een	ster	42
89 2	De storm is een	wind	30	125 2	Het hart is een	spier	42
90 3	De storm is een	tekst	30	126 3	Het hart is een	rest	42
91 1	Het vak is een	hel	31	127 1	Het gesprek is een	dans	43
92 2	Het vak is een	deel	31	128 2	Het gesprek is een	zaak	43

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129 3	Het gesprek is een	ster	43	165 3	De dood is een	kien	55
130 1	Het geheugen is een	zeef	44	166 1	Ons hart is ons	park	56
131 2	Het geheugen is een	plaat	44	167 2	Ons hart is ons	spier	56
132 3	Het geheugen is een	spier	44	168 3	Ons hart is ons	zier	56
133 1	Vertrouwen is een	brug	45	169 1	De haven is een	mond	57
134 2	Vertrouwen is een	wens	45	170 2	De haven is een	oord	57
135 3	Vertrouwen is een	kip	45	171 3	De haven is een	snars	57
136 1	Mijn dochter is een	lied	46	172 1	De haven is een	tuin	58
137 2	Mijn dochter is een	kind	46	173 2	De haven is een	plek	58
138 3	Mijn dochter is een	zeef	46	174 3	De haven is een	plop	58
139 1	Mijn werk is een	trog	47	175 1	Ons hoofd is een	berg	59
140 2	Mijn werk is een	taak	47	176 2	Ons hoofd is een	ding	59
141 3	Mijn werk is een	tros	47	177 3	Ons hoofd is een	gooi	59
142 1	Mijn opa is een	eik	48	178 1	Mijn hoofd is een	haan	60
143 2	Mijn opa is een	knar	48	179 2	Mijn hoofd is een	deel	60
144 3	Mijn opa is een	kans	48	180 3	Mijn hoofd is een	trant	60
145 1	Het leven is een	kans	49	181 1	De huid is een	vrouw	61
146 2	Het leven is een	duur	49	182 2	De huid is een	laag	61
147 3	Het leven is een	knar	49	183 3	De huid is een	taks	61
148 1	Het strand is een	vloek	50	184 1	Hun huis is een	graf	62
149 2	Het strand is een	plek	50	185 2	Hun huis is een	pand	62
150 3	Het strand is een	vlok	50	186 3	Hun huis is een	wrik	62
151 1	Het bos is een	val	51	187 1	Het kind is een	maan	63
152 2	Het bos is een	woud	51	188 2	Het kind is een	mens	63
153 3	Het bos is een	zaak	51	189 3	Het kind is een	slip	63
154 1	De oase is een	drank	52	190 1	Zijn lach is een	lied	64
155 2	De oase is een	bron	52	191 2	Zijn lach is een	klank	64
156 3	De oase is een	kramp	52	192 3	Zijn lach is een	plaat	64
157 1	De motie is een	dag	53	193 1	Het leven is een	brood	65
158 2	De motie is een	wet	53	194 2	Het leven is een	feit	65
159 3	De motie is een	boom	53	195 3	Het leven is een	haan	65
160 1	De dichter is een	koe	54	196 1	De maan is een	dier	66
161 2	De dichter is een	mens	54	197 2	De maan is een	ding	66
162 3	De dichter is een	kies	54	198 3	De maan is een	piel	66
163 1	De dood is een	muur	55	199 1	De mens is een	steen	67
164 2	De dood is een	eind	55	200 2	De mens is een	soort	67

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201 3	De mens is een	snap	67	237 3	Woede is	stoel	79
202 1	Deze middag is een	mand	68	238 1	Liefde is een	roos	80
203 2	Deze middag is een	tijd	68	239 2	Liefde is een	staat	80
204 3	Deze middag is een	stoel	68	240 3	Liefde is een	drop	80
205 1	Je mond is een	huis	69	241 1	De dood is een	nacht	81
206 2	Je mond is een	plek	69	242 2	De dood is een	eind	81
207 3	Je mond is een	tijd	69	243 3	De dood is een	schoen	81
208 1	De nacht is een	vrouw	70	244 1	De kerk is een	vlucht	82
209 2	De nacht is een	tijd	70	245 2	De kerk is een	huis	82
210 3	De nacht is een	soort	70	246 3	De kerk is een	dans	82
211 1	De poezie is een	mens	71	247 1	Mijn werk is een	hel	83
212 2	De poezie is een	tekst	71	248 2	Mijn werk is een	taak	83
213 3	De poezie is een	brui	71	249 3	Mijn werk is een	kast	83
214 1	De stilte is een	brug	72	250 1	De koran is een	last	84
215 2	De stilte is een	feit	72	251 2	De koran is een	boek	84
216 3	De stilte is een	baard	72	252 3	De koran is een	stal	84
217 1	Mijn toekomst is een	hart	73	253 1	Sport is een	plaag	85
218 2	Mijn toekomst is een	feit	73	254 2	Sport is een	spel	85
219 3	Mijn toekomst is een	kluts	73	255 3	Sport is een	druif	85
220 1	Onze vrede is een	huid	74	256 1	Ziekte is een	worm	86
221 2	Onze vrede is een	recht	74	257 2	Ziekte is een	plaag	86
222 3	Onze vrede is een	pats	74	258 3	Ziekte is een	spel	86
223 1	De woede is een	slang	75	259 1	Geboorte is een	licht	87
224 2	De woede is een	drift	75	260 2	Geboorte is een	start	87
225 3	De woede is een	zwik	75	261 3	Geboorte is een	plek	87
226 1	De zanger is een	lied	76	262 1	Oorlog is een	nacht	88
227 2	De zanger is een	mens	76	263 2	Oorlog is een	schijf	88
228 3	De zanger is een	keer	76	264 3	Oorlog is een	stoel	88
229 1	De zee is een	buik	77	265 1	Vriendschap is een	ster	89
230 2	De zee is een	plek	77	266 2	Vriendschap is een	band	89
231 3	De zee is een	gros	77	267 3	Vriendschap is een	druif	89
232 1	De zon is een	druif	78	268 1	Eten is een	drug	90
233 2	De zon is een	ster	78	269 2	Eten is een	maal	90
234 3	De zon is een	droom	78	270 3	Eten is een	park	90
235 1	Woede is	vuur	79	271 1	Voetbal is een	boek	91
236 2	Woede is	drift	79	272 2	Voetbal is	spel	91

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273 3	Voetbal is een	ster	91
274 1	Het brein is een	spons	92
275 2	Het brein is een	feit	92
276 3	Het brein is een	doek	92
277 1	Mijn hoofd is een	huis	93
278 2	Mijn hoofd is een	kop	93
279 3	Mijn hoofd is een	balk	93

