Does the Processing of Metaphors Depend on Language Proficiency in Non-Native Speakers?

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Bachelor Thesis

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Abstract

The current study examined the relation between second language proficiency and neural processing in the context of metaphor processing. Subjects, a group of 18 German students at a Dutch university, had to judge sentences as metaphorical, literal or anomalous while their EEG activity was recorded. Language proficiency was defined as a combination of the score on a proficiency test, reaction times and by the accuracy with which subjects differentiated between the sentence conditions (d'). N400 negativity served as an indicator for the cognitive effort to semantically integrate the stimuli. The obtained results revealed that sentences in the metaphorical and anomalous conditions elicited more N400 negativity than the literal expressions. Reaction times were longest and choice accuracy the poorest in the metaphorical condition. The expectation that less proficient subjects displayed a delayed peak and decreased negativity of the N400 was not supported by the results; there was no statistical relation between language proficiency and N400 activity. The deployed language proficiency measures failed to capture the individual differences regarding language skills of the subject group. The results implicate that figurative and anomalous expressions are processed with increased effort and that metaphors take more time and are more difficult to identify than literal and anomalous expressions.

Mastering a new language requires a lot of effort, especially in adulthood. Some studies suggested that second language processing differed fundamentally from the processing of one's mother tongue (Bley-Vroman, 1990; Hahne, 2001). Other studies claimed that highly proficient second language speakers processed linguistic information similarly to native speakers (Johnson & Rosano, 1993; Ibañez, Manes, Escobar, et. al., 2009; Weber-Fox & Neville, 1996; Kotz & Elston-Güttler, 2004). However, how and to what extent second language processing differs from that of native speakers is not fully clear yet.

The present study examined the relationship between second language proficiency and neural activity in the context of metaphor comprehension. Metaphors are a natural part of our everyday language. Figurative language takes an exceptional place in linguistics and was of special interest to this study. One reason being that it elicits quantifiable neural activity, the so-called N400 response. A second reason is its assumed sensitivity to language proficiency. Feature-matching models suggest that metaphors operate by importing features and relational structures from one domain to another; e.g. in "ideas are food", the notion of satisfying one's appetite is assigned to intellectual activity, resulting in the statement that having good ideas satisfies the intellectual appetite (Bowdle & Gentner, 2005; Boroditsky, 2000). A metaphor is suggested to integrate overlapping features between the source domain (e.g. "food") and the target domain ("ideas") and create cross-domain feature mappings (Bowdle & Gentner, 2005). Low proficient second language speakers have a smaller word store for second language words (Kotz & Elston-Güttler, 2004); consequently, they have a smaller amount of word features stored. This presumably makes it harder to recognize feature overlap between base- and target domain and to make sense of figurative language in their second language. Thus, it is assumed that second language proficiency modulates the processing of metaphors.

Figurative language

"Metaphoric expressions are neither true nor false", but move in a grey zone between 'probable' and 'improbable' (Hoorn, 1997). This is because figurative language activates conceptual mapping so that, in the example of "ideas are food", "ideas" can be described in terms of "food" (Lai, Curran & Menn, 2009). According to feature-matching models, metaphors import features and relational structures from one domain to another. In that, they integrate overlapping features of two domains to create meaning, as in the above-mentioned example of "ideas are food", in which cross-domain conceptual mapping results in the sense that a good idea satisfies the intellectual appetite (Boroditsky, 2000).

Processing of figurative language

A frequently used method to examine the cognitive processing of information is the analysis of Event-Related Potentials (ERPs). ERPs are measured using EEG; they reflect the postsynaptic activity in response to a new sensory, motor or cognitive stimulus. The method has a high temporal resolution so that specific brain activities can be mapped accurately to certain experimental stimuli. ERP research has shown a centro-parietal negative wave peaking 350-450 ms after the onset of linguistic stimuli called the N400 (Hahne, 2001; Lai, Curran & Menn, 2009). Researchers on the topic reached consensus in that the N400 component plays an important role in the semantic integration of linguistic information (Lai, Curran & Menn, 2009). It has been found to be sensitive to semantically incongruent information as well as to meaningful input. The N400 activity was one of the key variables in the present study and served as an indicator for the effort that was needed to semantically integrate the presented stimuli.

Lai et al. (2009) had participants judge how much sense different conditions of sentences make, while they collected their EEG data. The amplitude of the N400 in reaction to metaphoric and anomalous (i.e. non-sense) expressions showed more negativity in contrast to

literal expressions. The pattern of N400 activity suggests that figurative language and semantically incongruent information require an increased cognitive effort in order to be integrated. In the current study the N400 was expected to be more negative in the metaphoric and anomalous word condition than in the literal word condition. In order to evaluate this prediction, the studies of Lai et al. (2009) and Hoorn (1997) were partly replicated in that sentences were presented in an either metaphoric, anomalous, or literal word condition and compared regarding the N400 activity they elicit. In fact, this assumption was one of the preconditions for the current study to be valid, because if metaphors and anomalous expressions elicited more negativity than literal sentences, the experimental conditions of the stimuli differed sufficiently to ensure a certain degree of criterion validity and reliability.

Language proficiency

The key variable of the current study was language proficiency in the non-native Dutch speakers' group. An early study by Johnson and Rosano (1993) examined how second language proficiency, cognitive style and metaphor comprehension are related to each other. Interestingly, they found no effect of language proficiency on the level of metaphor interpretation and suggested that the interpretation of figurative language was more a conceptual than a linguistic task. It has been found that "proficiency (variously defined) affects the strength of connections between concepts and words" of the second language (Bijeljac-Babic, Biardeau & Grainger, 1997; Kotz & Elston-Güttler, 2004). This implies that, in metaphors, cross-domain conceptual mapping is affected by language proficiency because concepts are recognized and activated with less ease.

Hahne (2001) conducted an ERP study about second-language processing in semantically and syntactically correct or incorrect sentences. She examined the N400 in reaction to the stimuli in both native German speakers and bilingual Russians. The study found language

proficiency to be highly influential. Though the qualitative interpretation of the stimuli was not affected by language skills, the variable seemed to modulate latency and a less pronounced N400 effect in second language speakers. These findings were supported by a more recent study by Ibañez et al. (2009), who concluded that "semantic processing is robust in the learning of a second language", which means that there were no qualitative differences in the processing of figurative language between natives and L2 learners. Their study, too, has found a relationship between language proficiency and the amplitude and latency of the N400. Highly proficient speakers showed neuronal activity similar to that of native speakers, whereas the low proficient group's brain activation time was delayed and the amplitude of the N400 was decreased. This suggests that semantic processing in low proficient second language speakers is a weaker and slower mechanism than in highly proficient and native speakers.

In 1996, Weber-Fox and Neville have found similar effects, but referred to a different underlying cause for it than language proficiency alone. They studied the influence of L2 age of acquisition on language processing. Bilinguals who have obtained L2 between 11 and 13 or after 16 years of age demonstrated slower processing than early learners and native speakers. Kotz and Elston-Güttler (2004) suggested: "the factor of proficiency – not only age of acquisition – is likely to affect the efficiency of semantic processing in the L2 […]". It can be assumed that age of acquisition and second language proficiency interact and affect N400 peak modulation and timing. The current study exclusively examined L2 speakers that acquired Dutch after the age of 18. This implies that the subject group presumably tended to process the linguistic information less efficiently than a group of early learners would have done. However, these theoretical implications could not be validated, because the current study did not modulate this variable. In the present context, language proficiency was the prominent variable and was expected to influence the N400 effect. Lower language

proficiency was assumed to correlate with larger N400 peak latency and a decreased N400 negativity. In order to evaluate this prediction, the study of Hahne (2001) was partly replicated. The respondents' individual language proficiency was assessed by means of a language proficiency test, and then correlated with N400 activity.

Apart from the direct way of measuring language proficiency, the current study additionally deployed indirect ways to measure the variable in a broader sense. The behavioral measures reaction time and choice accuracy served as an indicator of how efficiently subjects processed and acted upon the offered stimuli. Various studies found that low language proficiency corresponded with extended reaction times in subjects (Weber-Fox & Neville, 1996; Chee, Hon, Lee & Soon, 2000; Hahne, 2001; Kotz & Elston-Güttler, 2004). Thus, it was expected that less proficient subjects would tend to produce longer reaction times. Conversely, extended reaction time might indicate low language proficiency. This inversion of the argument is to be treated with caution, because there might have been other factors that caused the high reaction time. As reaction time partly served as an indicator for language proficiency, it was expected that subjects with extended reaction times showed a less pronounced N400 negativity. Another behavioral variable that was of interest in this study was choice accuracy. It was expressed in d' values. D' is a variable that can be computed by applying the Signal Detection Theory (Macmillan & Creelman, 2004) and is calculated by subtracting the standard values of the 'false alarms' from the 'hit-rates' per subject and condition. This study deployed three word conditions, which participants had to act upon: metaphorical, literal and anomalous. For example, in a subject's d' of the metaphorical word condition, the 'false alarms' were the cases in which the subject judged literal or anomalous sentences as 'metaphorical', and the 'hit rates' were the cases in which the subject judged a metaphorical expression as such. A high d' stood for an accurate discrimination between the word conditions. It was assumed that highly proficient second

language speakers were able to discriminate more accurately between metaphorical, literal and anomalous expressions. Therefore, high language proficiency was expected to correlate with high d' values. Further, low d' values were assumed to correlate with a less pronounced N400 activity.

In summary, the current study expected lower language proficiency to correlate with larger N400 peak latency, a decreased N400 negativity, longer reaction times and lower d' values. Further, it was assumed that the N400 was more negative in the metaphoric and anomalous word condition than in the literal word condition.

The present study contributed to the knowledge about the N400 and its role in second language processing and metaphor comprehension. Understanding the processing of figurative language in non-native speakers is useful for the development of language courses, language proficiency assessment tools, and for entities that frequently deal with non-native speakers, such as universities, governmental institutions or schools.

Method

Participants

Thirty-six subjects took part in the experiment, partially in exchange for credit points. The participants were students of the University of Twente or Hogeschool Saxion, in addition to one university employee. With the exception of two left-handed attendees, all participants were right-handed, which was assessed by Annett's Handedness Inventory (Annett, 1970). All subjects had normal or corrected-to-normal vision; none of them had dyslexia or a history of neurological or psychological diseases. Subjects were divided into two groups. Native Dutch speakers (50 % of all participants) were assigned to one group and non-native Dutch speakers were allotted to another. The current study focused on second language speakers

only. Therefore, the Dutch participants will be left out of account in the following. All non-native Dutch speakers were Germans who began to acquire Dutch after the age of 18. The language proficiency of the bilingual speakers was sufficient to be admitted to a Dutch-language university. The mean age of the German subjects was 21 with a standard deviation of 1.53 years, and 83.3 % were female. Those participants that subscribed for the study to receive credit points (27 out of 36 in the total sample) were a random selection of bachelor and master students of the behavioral science faculty. The remaining subjects were acquired by convenience sampling and did not exclusively study behavioral sciences. Students with dyslexia and epilepsy were excluded from the study. Each subject provided written informed consent before participation. The ethics committee of the Faculty of Behavioral Sciences approved the experimental procedure.

Task and stimuli

Preceding the experiment, participants of all groups signed informed consent forms and filled in questionnaires that assessed demographic information, possible impairments (dyslexia, neurological or psychological diseases), medication or drug-use, handedness (Annett's Handedness Inventory; Annett, 1970) and, in the non-Dutch group, the age of acquisition of Dutch.

The group of non-native Dutch speakers completed a language proficiency test at the beginning of the experimental session. The study used two sub-tests of the DIALANG test of language proficiency (Council of Europe, Common European Framework of Reference for Languages: Learning, Teaching, Assessment, 2002) in Dutch, assessing vocabulary and reading skills. These abilities were relevant to the task the subjects had to execute in the succeeding EEG study. The sub-tests categorized a respondent's performance into six ordinal levels (A1 as the lowest and C2 as the highest level of proficiency), according to the Common European Framework of Reference for Languages (Council of Europe, 2002). The

subjects' levels in the sub-tests served as main indicator for the independent variable language proficiency. The participants were seated in an isolated, small room in front of a laptop that had the DIALANG software installed. After giving an informed consent form and instructions to the subjects, the researcher initiated the program and left the room. The language proficiency test took the participants forty-five minutes on average. After completing the DIALANG, the subjects were guided to the laboratory and the EEG procedure was carried out.

The main experimental task was given to both groups and contained 279 expressions, which were validated as metaphorical (met), literal (lit) or anomalous (ano) by an online survey that was conducted separately. The stimuli pool consisted of 93 stem sentences with three alternative endings, which marked the word condition of the expressions (e.g. Dutch equivalent of "A book is a" - "friend" (met) / "thing" (lit) / "monkey" (ano)). The study replicated the experiment of Hoorn (1997) by using its experimental stimuli in addition to self-generated stimuli. The stem sentences were presented to the subjects in random orders and in all word conditions. Participants were instructed to judge the word condition of the expressions by pressing the arrow keys (right, left or up) with their right index finger. The assignment of word conditions to the arrow keys was randomized for every participant of a group in order to minimize order effects. After subjects were seated at 60 cm in front of the computer, the screen presented a written introduction to the experiment and a demonstration of the task. The default display of the experiment was a black fixation point in the center of a light grey background. Participants were held to direct their attention towards the fixation point. After 500 ms, the fixation point disappeared and a stem sentence was presented for 1800 ms, being followed by a 500 ms default display, and by the target stimuli (300 ms), which was the final word of the expression. Subjects had to respond as fast and accurately as possible. The subject's response to a target stimulus initiated the onset of the following trial.

Duration of the whole task amounted to approximately 30 minutes, including a short break after 15 minutes. Before the start of the main experimental procedure and after its completion, control EEG measurements of a minute each were carried out.

Apparatus and EEG recordings

The subjects were seated in a dark room, at approximately 60 cm in front of a 17''-CRT-monitor and a standard QWERTY keyboard. The experimental procedure deployed Presentation software 16.3 (Neurobehavioral Systems, Inc., 2012). According to the extended 10-20 system, passive Ag/AgCl ring-electrodes were attached at 61 locations in an elastic cap (Braincap, Brain Products GmbH; see Figure 1). Horizontal and vertical electro-oculograms (hEOG and vEOG) were measured by placing bipolar ring-electrodes at the outer canthi of the eyes and above and below the left eye, respectively. Bipolar electrodes at the protruding distal end of the right forearm (styloid process of the ulna) and at the string of muscles that runs along the outer right forearm (dorsal interossei) were used to assess an electromyogram (EMG). Electrode gel was applied to attain adequate conductivity and electrode resistance was consistently kept below 10 kΩ. The EEG, EOG, and EMG electrodes were connected to a 72 channels QuickAmp (Brain Products GmbH) amplifier that was linked to a separate computer. The electrode signals and the task-related output of the Presentation software were transferred to the second PC at a rate of 500 Hz and computed with the BrainVision Recorder (Brain Products GmbH) program.

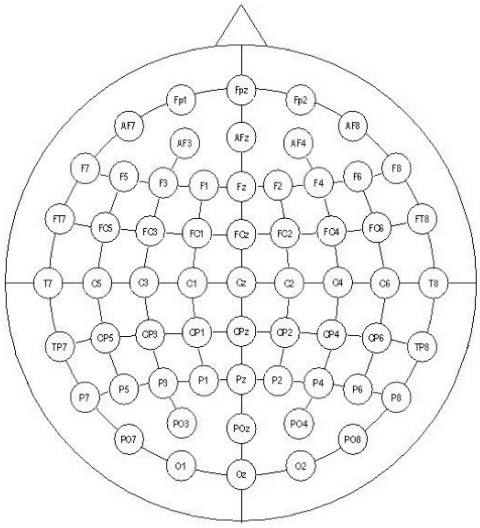
Data analysis

The collective data was processed with BrainVision Analyser 2.0 (Brain Products GmbH, 2012). First, the data set was segmented to show neural activity response to the experimental stimuli. The EEG data of each condition was averaged stimulus-locked. A baseline was set at -200 to 0. The ERPs included were timelocked -200 – +800 ms with regard to the onset of the

target stimulus words. ERPs displayed the mean amplitude of EEG activity of the Cz electrode at 320 – 380 ms, 380 – 420 ms, 420 – 460 ms and 480 – 520 ms after target stimulus onset. Reaction times (RT) and d' scores were identified on an individual level. Together with target-related N400 activity and language proficiency scores, these data were analyzed with SPSS Statistics 20 (IBM, 2011) software. The mean differences of neural activity between conditions were computed – MetLit equaled the difference of the mean neural activity in the metaphorical and literal condition, while AnoLit equaled the difference between mean activity in the anomalous and literal condition. The mean difference scores indicated how thorough a subject made a neural distinction between the word conditions. The negativity of the mean difference values showed how clearly a subject made a neural distinction between the conditions. In addition to the above-mentioned variables, the mean N400 activity of the word conditions was analyzed. Thus, statistical analyses were conducted with the following variables: EEG activity at 320 – 380 ms, 380 – 420 ms, 420 – 480 ms and 480 – 520 ms after target stimulus onset and per word condition, mean difference scores (MetLit, AnoLit), DIALANG proficiency scores, reaction times (RT) and d' values.

Figure 1

The 61 electrodes that were mounted at the BrainCap



The neural activity in the four time frames after stimulus onset (320 – 380 ms, 380 – 420 ms, 420 – 480 ms, 480 – 520 ms) was compared by Repeated Measures analyses. Language proficiency scores on the DIALANG test were analyzed with Repeated Measures ANOVAs regarding their effect on N400 activity. Initially, behavioral data consisted of reaction times and choice of word condition. The variable 'choice of word condition' proved imprecise, so it was replaced by the more accurate variable of d'. The effect of the behavioral variables on neural activity was examined by analyses of variance between N400 values and mean difference scores on the one hand and reaction times and d' scores on the other. Correlational analyses were conducted to reveal the relation between reaction times and neural activity and their relation to the mean difference scores and the relation between d' and neural activity. The mean neural activity per word condition was analyzed by Repeated Measure Analyses.

Results

Language proficiency

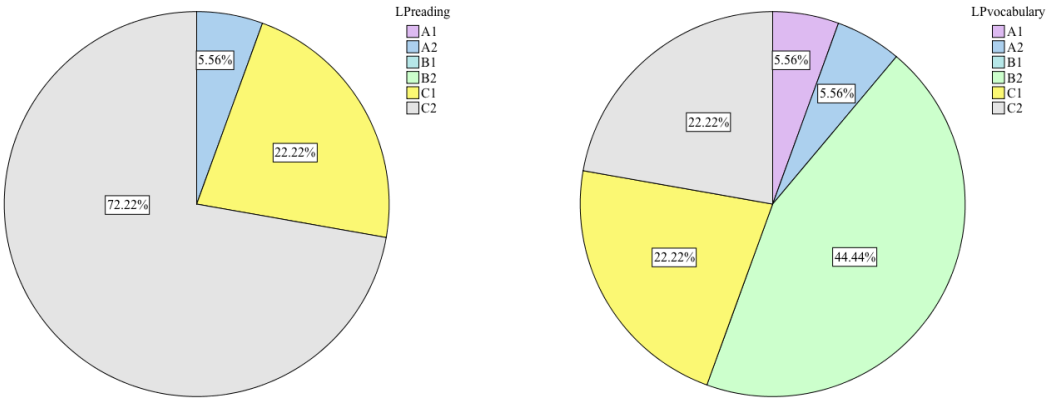
The subjects' results at the DIALANG served as an indicator for language proficiency (LP). Subjects have been tested in reading and vocabulary. The spreading of the scores in LP reading and vocabulary are displayed in Figure 2.

Behavioral data

This study used reaction times and d' scores as relevant behavioral variables. D' values were created by computing the difference between hit-rates and false alarms of the word conditions. It was observed that the mean hit-rates and false alarms of the subjects have been highest in the anomalous condition ($M_{\text{hit-rate}}$ = .73, $M_{\text{falsealarm}}$ = .30) and lowest in the metaphorical condition ($M_{\text{hit-rate}}$ = .40, $M_{\text{falsealarm}}$ = .12), while the hit-rates and false alarms of

Figure 2

Distributions of the subjects' scores in the subcategories 'reading' and 'vocabulary' of the DIALANG



the literal condition showed high hit-rates and few false alarms ($M_{\text{hit-rate}}$ = .57, $M_{\text{falsealarm}}$ = .04). An analysis has been conducted to compute the descriptive statistics of the d' and RT values per word condition (see Table 1). Subjects showed an overall high in-group variance, as expressed in the standard deviations and ranges between minima and maxima. The greatest range and standard deviation of RT as displayed in the anomalous word condition, whereas d' showed the greatest in-group variance in the literal word condition. Repeated Measures analyses have been conducted to compare the mean reaction times and the mean d' per word condition. There was a significant effect of word condition on mean RT ($F(2, 34) = 18.87$, $p < .0005$). Paired Samples T-Tests showed that RT was significantly higher in the metaphorical in contrast to the literal and anomalous condition, but did not differ between the

Table 1

Descriptive statistics of the behavioral data.

	RT			d'		
	Met	Lit	Ano	Met	Lit	Ano
Mean	1583.21	1414.08	1416.71	.95	2.12	1.22
Std. Deviaton	310.99	296.86	321.02	.26	.59	.32
Minimum	898.08	763.42	659.00	.16	.65	.47
Maximum	2026.27	1981.33	1948.43	1.22	3.24	1.71
Range	1128.19	1217.91	1289.43	1.06	2.59	1.24

two latter (RT_{met} vs. RT_{lit}: $t(17) = 5.74$, $p < .0005$; RT_{met} vs. RT_{ano}: $t(17) = 434$, $p < .0005$; RT_{lit} vs. RT_{ano}: $t(17) = -.06$, *ns*). Mean d' values differed significantly per word condition ($F(2, 34) = 55.2$, $p < .0005$). Separate T-Tests revealed that the mean d' of each condition was different from all others, with the highest d' values in the literal word condition and the smallest in the metaphorical condition (d_{met} vs. d_{lit}: $t(17) = -8.6$, $p < .0005$; d_{met} vs. d_{ano}: $t(17) = -2.9$, $p < .05$; d_{lit} vs. d_{ano}: $t(17) = 7.7$, $p < .0005$).

A Repeated Measures ANOVA between RT and language proficiency scores revealed no significant effects. A Repeated Measures ANOVA between the mean d' values and DIALANG scores did not produce significant effects. A correlational analysis has been conducted to examine whether reaction times and d' values were related. The resulting effects did not yield any significance.

Table 2

Behavioral data: Individual LP scores, RT per word condition and d' values per word condition

Subject	LP		RT			d'		
	Read.	Voca.	Met	Lit	Ano	Met	Lit	Ano
1	C1	B2	1,723.6	1,311.1	1,482.5	1.07	2.28	1.47
2	C2	B2	1,849.6	1,568.9	1,636.5	1.03	2.44	.78
3	C1	B2	1,706.2	1,492.6	1,654.9	.81	1.80	1.07
4	C2	C2	975.0	912.2	975.4	1.05	2.06	.89
5	C2	C1	898.1	763.4	659.0	.51	1.91	1.20
6	C2	C2	1,565.3	1,216.4	1,265.2	1.20	2.30	1.58
7	C1	B2	1,696.3	1,648.6	1,498.5	1.11	3.23	1.71
8	C2	B2	1,665.2	1,623.6	1,481.3	1.03	2.12	1.33
9	C2	B2	1,598.5	1,560.3	1,852.0	.88	1.68	1.07
10	C2	C1	1,457.3	1,444.2	1,466.5	1.12	2.35	1.29
11	C2	C2	1,662.2	1,449.1	1,235.6	1.22	3.24	1.11
12	C2	C1	1,934.5	1,562.7	1,948.4	1.11	1.90	1.35
13	C2	C2	1,278.3	1,110.9	1,149.6	1.13	2.46	1.63
14	C2	C1	2,026.3	1,981.3	1,655.7	1.14	.65	.47
15	A2	A1	1,326.4	1,235.4	1,094.7	.16	1.93	1.18
16	C1	A2	1,478.2	1,354.2	1,327.1	.89	2.32	1.56
17	C2	B2	1,981.6	1,800.5	1,719.6	.90	2.06	1.01
18	C2	B2	1,675.3	1,418.0	1,398.3	.82	1.42	1.31

ERPs

The four time frames were compared by conducting separate Repeated Measures ANOVAs for each time window per word condition. Across all conditions, mean ERPs differed per time frame (met: $F(1, 17) = 7.2$, $p < .05$; lit: $F(1, 17) = 7.6$, $p < .05$, ano: $F(1, 17) = 8.5$, $p < .05$). Paired Samples T-Tests showed that, in all word conditions, neural activity differed only significantly between the time frames 380 – 420 ms and 480 – 520 ms (met: $N400_{380\text{-}420}$ vs. $N400_{480\text{-}520}$: $t(17) = -8.5$, $p < .0005$; lit: $N400_{380\text{-}420}$ vs. $N400_{480\text{-}520}$: $t(17) = -10.1$, $p < .0005$; ano: $N400_{380\text{-}420}$ vs. $N400_{480\text{-}520}$: $t(17) = -8.5$, $p < .0005$), while there was no significant difference between all other time frames. Means and standard deviations of neural activity per condition and time frame are displayed in Table 3. In all conditions, the greatest negativity occurred at 380 – 420 ms after stimulus onset. This time frame can presumably be assigned to the N400 effect that earlier studies have found. As all other time frames were either not significantly different to the 380 – 420 ms frame or displayed significantly less negativity, those other time windows will be left out of account in the following analyses.

Descriptive analyses have been conducted to get a better understanding of the individual differences with regard to the N400. There have been found wide ranges of N400 values in all word conditions ($range_{met} = 11.64$; $range_{lit} = 12.31$; $range_{ano} = 12.08$), with the widest

Table 3

Descriptive statistics of ERPs per time frame and word condition

	Met		Lit		Ano	
	M	SD	M	SD	M	SD
320-380 ms	-1.73	2.5	-.84	2.42	-2.19	2.35
380-420 ms	-2.05	2.96	-1.52	3.13	-2.24	3.16
420-480 ms	-1.25	3.08	-.64	3.13	-1.77	2.66
480-520 ms	-.01	3.38	.86	3.42	-.33	3.12

range occurring in the literal condition. In order to compare the mean N400 activity across the word conditions, Repeated Measures ANOVAs were conducted with the neural activity at 380 – 420 ms after stimulus onset per word condition. Word condition showed a significant relation to N400 activity ($F(2, 34) = 5.4$, $p < .05$).

Paired Samples T-Tests showed that N400's differed significantly between the metaphorical and literal word condition and between the literal and anomalous condition, but not between metaphorical and anomalous condition ($N400_{met}$ vs. $N400_{lit}$: $t(17) = -3.4$, $p < .005$; $N400_{lit}$ vs. $N400_{ano}$: $t(17) = 2.5$, $p < .05$; $N400_{met}$ vs. $N400_{ano}$: $t(17) = .8$, *ns*). Figure 3 shows the mean neural activity across the conditions in the main time frame. Figure 4 shows grand average waveforms of neural activity, with separate lines for each word condition.

In addition to the N400 values, mean difference scores have been computed. "MetLit" stood for the difference between mean N400 activity of metaphorical and literal condition and "AnoLit" was the difference between anomalous and literal word condition. Means and standard deviations have been calculated ($M_{MetLit} = -.54$, $SD_{MetLit} = .68$; $M_{AnoLit} = -.72$, $SD_{AnoLit} = 1.24$). DIALANG scores and behavioral variables were separately analyzed with regard to their effects on the N400 and the mean difference scores between the word conditions. Correlational analyses did not find a significant interaction between LP reading

Figure 3

Mean neural activity per condition at 380 – 420 ms

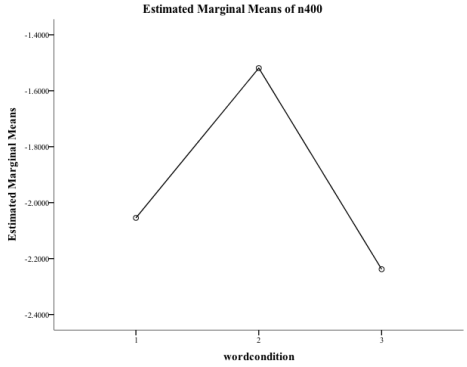


Figure 4

Neural activity per word condition at the Cz electrode

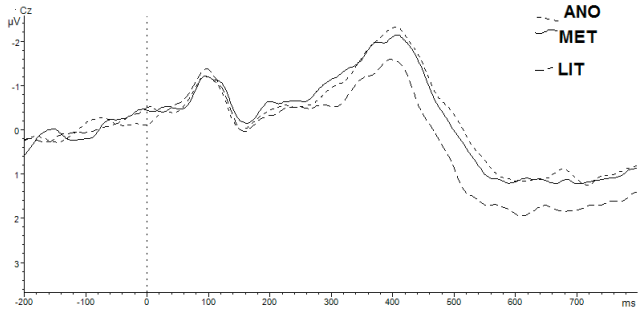


Table 4

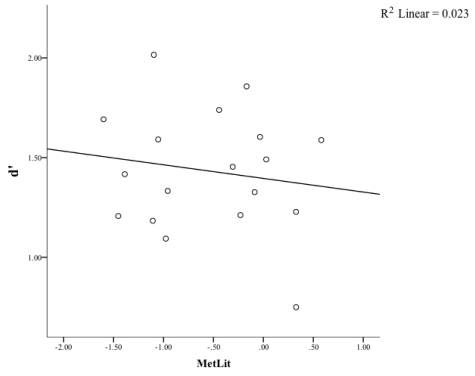
ERP data: Individual N400 per word condition and mean difference scores

Subject	N400			MetLit	AnoLit
	Met	Lit	Ano		
1	.07	.10	.46	-.03	.36
2	-4.30	-2.91	-5.14	-1.39	-2.23
3	-2.94	-3.27	-2.35	.33	.92
4	-.48	.48	-3.49	-.96	-3.96
5	-4.13	-2.67	-4.84	-1.45	-2.17
6	-1.35	.25	-1.53	-1.60	-1.78
7	1.01	2.11	1.28	-1.10	-.83
8	-5.42	-5.45	-5.63	.03	-.18
9	-3.14	-2.91	-4.07	-.23	-1.16
10	-8.14	-8.72	-8.37	.58	.34
11	-3.69	-3.52	-4.19	-.17	-.67
12	-1.22	-.91	-1.54	-.31	-.63
13	2.07	2.51	2.90	-.44	.40
14	-1.93	-2.26	-2.48	.33	-.22
15	1.09	2.07	1.26	-.98	-.81
16	-5.35	-4.30	-3.49	-1.05	.81
17	3.50	3.59	3.71	-.09	.11
18	-2.63	-1.53	-2.77	-1.11	-1.24

LP reading and ERPs or the mean difference scores MetLit and AnoLit. Repeated Measures ANOVAs were conducted to measure neural activity with LP vocabulary as an in-between-subjects-factor and word condition as within-subject factor. No significant effects between LP vocabulary and neural activity or with regard to MetLit and AnoLit were found.

Figure 5

Relation between the average d' (all conditions taken together) and MetLit



Regression analyses were conducted to examine the effect of reaction times on EEG activity across the three word conditions and on the mean difference values. No significant effects have been found between RT and neural activity. Regression analyses of the d' scores as independent variable and N400 activity and mean differences of N400 between the conditions as dependent variables did not result in statistically significant effects. Figure 5 shows the relation between MetLit and the average d' of all conditions taken together, functioning as an overall measure of accuracy of subjects.

Individual raw data is displayed in Table 2 (behavioral data) and Table 4 (ERP data).

Discussion

It was expected that language proficiency modulates N400 activity insofar as low language proficiency correlated with N400 peak latency, decreased negativity, longer reaction times and low d' values. In addition to that, the metaphorical and anomalous word conditions were expected to elicit more N400 negativity than the literal word condition. The original hypotheses of this study have partly been supported by the obtained results. Significant influences of direct or indirect second language proficiency on the processing of figurative language have not been found. The results corresponded with the assumption that the N400 in response to the anomalous and metaphorical word condition was more negative than to the literal condition. In addition to that, RT and d' values were found to differ significantly between the word conditions. Reaction times were significantly longer in metaphorical expressions in contrast to the literal and anomalous conditions. The d' values of each word condition differed from all others, with the highest d' in the literal expressions and the lowest in the metaphors.

Language proficiency measures

This study used the subjects' scores on the DIALANG test, reaction times and choice accuracy (d') as indicators for their second language skills. A noticeable aspect of the variable language proficiency is that the distribution of the subjects' scores on the DIALANG test was very narrow (see Figure 2). This circumstance is a threat to the variable's content validity, because it reduced the modulation of it and could not stand representative for various language proficiency levels. Thus, the validity of the DIALANG scores can be questioned because of methodological shortcomings in the distribution of the scores. In contrast to the distribution of the DIALANG scores, reaction times and d' values showed considerable in-group variances, with fairly high standard deviations and quite big differences between minima and maxima (see Table 1).

According to the obtained data, reaction times and language proficiency scores were not related. These results contrast other studies, which found that language proficiency modulates reaction time (Weber-Fox & Neville, 1996; Chee, Hon, Lee & Soon, 2000; Hahne, 2001; Kotz & Elston-Güttler, 2004). The study found no relation of d' and DIALANG scores and no interaction between RT and d'. This lack of inter-correlation is likely to be a result of the methodological weakness of the DIALANG scores.

A possible source of methodological problems could have arisen from the experimental stimuli that this study used. The majority of the metaphors in the stimuli pool were not conventional, which means they were less easy to spot, because they were unknown to the subjects. A conventional metaphor like "His love is warm", is likely to be identified more readily as a metaphor than an unknown one, like "Love is a rose", as it was used in the current study. Unconventional metaphors have been chosen, because they were found to elicit more negative N400 responses in contrast to conventional metaphors (Lai, Curran & Menn, 2009). Additionally, the identification of stimuli as metaphorical, literal and anomalous has

been very subjective, especially in the distinction between metaphorical and anomalous condition, which corresponded with the observed d' values. Subject B could judge an expression that was readily identified as a metaphor by subject A, as non-sense. In fact, subjects perceived the expression types quite differently, which can be seen in the wide range of d' values. The circumstance that there was little right or wrong in the choices of the subjects affects the power of the variable d'. Though d' can serve as an indication of how adequate the choices of a subject have been, this indication cannot be equated with the d' of a study that worked with sharply distinguishable right or wrong responses. Rather than a variable that unambiguously represents choice accuracy, the d' of the present study can ideally be regarded as an indication of choice accuracy.

ERPs

The N400 served as an indicator for the cognitive effort subjects needed to process the stimuli. The absence of an effect of language proficiency on N400 activity and the fact that the non-native speakers showed no delay in the N400 peak does not match earlier studies, which consistently found that language proficiency influences the latency and peak modulation of the N400 (Weber-Fox & Neville, 1996; Chee, Hon, Lee & Soon, 2000; Hahne, 2001; Kotz & Elston-Güttler, 2004; Ibañez et al., 2009). There was also no effect of language proficiency on MetLit and AnoLit. Again, it is reasonable to assume that this can be ascribed to the low validity of the assessment tool DIALANG in this context.

How much time subjects needed to choose a response to the stimuli (RT) did not correlate with their N400 activity or the mean difference scores MetLit and AnoLit. Also, the proficiency with which subjects discriminated between the word conditions (d') was not related to their N400 activity or the mean difference scores MetLit and AnoLit. Thus, how accurately and fast a subject discriminated between the word conditions did not influence

how he or she processed the stimuli. It can thus be assumed that a combination of reaction time and d' cannot hold for an indirect measure of language proficiency in the context of the current study, because the measures did not correlate and no relation was found between the N400 and the behavioral measures.

The study's objection was to find out to what extent language proficiency as measured by the DIALANG test and as expressed indirectly by choice accuracy (d') and reaction time, accounted for the differing neural activity in the word conditions. The findings suggest that subjects made neural distinctions between the word conditions, but none of the independent variables of this study (LP, RT, d') seemed to act upon these differences in neural activity.

Individual differences in the subject group

The group that this study examined showed very little diversity with regard to their scores in the DIALANG test, which leads to the assumption that their language proficiency levels were fairly homogenous. It is problematic to look for an effect of language proficiency on neural activity when the subjects do not show in-group variance regarding their proficiency levels. The spreading of the DIALANG scores was poor – not all language proficiency levels have been scored and there is an accumulation on C2 in reading and B2 in the vocabulary category.

This homogeneity of language proficiency could be a result of a combination of two factors. First, there is a high probability that the students performed 'too well' in the test, because they live in the Netherlands and have been forced to acquire a high proficiency level in order to be able to attend lectures and pass their exams in Dutch. The majority of the German students acquired Dutch in the summer vacation before the start of their bachelor program. However, the current experiment was conducted in April and May, which means that even the first-year German students had at least seven months to improve their language

skills after passing the language exam that is required to get admission to enroll at the university. This created an overall high proficiency level, which made it difficult to modulate the variable sufficiently. For future studies, a possible solution to this problem could be to conduct the experiment earlier in the academic year. This may create more spreading in language proficiency, as first-year German students in their first months at the university are likely to be less proficient at Dutch in comparison to subjects of higher academic years.

Second, it is reasonable to assume that the DIALANG test of language proficiency was not appropriate for measuring LP in the context of our study. As mentioned earlier, language proficiency levels at Dutch have been fairly high. The DIALANG was not designed to distinguish LP at a high base level of proficiency. In order to assess the differences in LP at such a high level, future research would require a proficiency test that is specialized to discriminate between highly proficient subjects. In sum, improvement of the experimental results would possibly result from altering both the spreading of language proficiency in the subject group and the deployed language test.

Though the distribution of the DIALANG scores was narrow, the behavioral measures RT and d' showed considerable in-group variance. It is possible that reaction times and d' were able to capture more subtle LP differences than the DIALANG. Nevertheless, as the two variables show no inter-correlation and no relation to N400 activity, the variables proved unable to represent language proficiency appropriately.

Word condition

Based on the findings of Lai et al. (2009), it was expected that word condition modulated reaction times as well as N400 activity. Their study found reaction times to be significantly longer in the conventional and literal expressions in contrast to the anomalous and novel metaphor conditions. In the current study, the reaction times of the metaphorical word

condition (containing novel metaphors) were considerably higher than those of the literal and anomalous conditions. Literal and anomalous expressions did not differ with regard to RT. The reason for the fast reactions to anomalous sentences is not fully clear. In the computing of d', it was observed that subjects displayed the highest hit- and false alarm rates in the anomalous condition and the lowest in the metaphorical. In other words, participants tended to respond 'anomalous' very frequently, whereas they regarded comparatively few expressions as metaphorical. It is possible that subjects had a general bias to judge expressions as anomalous, which could have facilitated the response – and correspondingly, shortened the reaction time of the response. Subjects have not been told whether the amount of metaphorical, literal and anomalous sentences was balanced, and maybe they got the impression that the stimuli pool consisted of relatively more anomalous sentences than metaphorical and literal ones. The expectation could have been a cause for the bias for anomalous responses and the short reaction times.

The d' values in the metaphorical condition were the smallest, which corresponds with the low hit- and false alarm rates and long reaction times of the condition. Taken together, subjects needed the longest time to think about metaphors and spotted them least accurately, which suggests that they had great difficulty in dealing with this particular word condition.

The effects of word condition on neural activity partly replicated the study of Lai et al. (2009). They found the N400 to be consistently more negative in the metaphorical and anomalous word condition in contrast to the literal one. In the current study, all word conditions elicited different N400 negativity, with the most negativity in the anomalous and the fewest in the literal expressions. This suggests that anomalous expressions cost the subjects the greatest effort to cognitively integrate. Metaphors elicited a slightly less negative neural response; presumably because subjects could 'solve' the semantic incongruence of the

expression by identifying it as a metaphor and integrating the relevant aspects of two domains to create meaning (Bowdle & Gentner, 2005).

An extended N400 negativity in the metaphorical word condition in contrast to the literal one was a fundamental condition for the experiment's criterion validity and reliability, because it showed that the experimental conditions differed sufficiently and it corresponded with the outcome of other studies (Lai, Curran & Menn, 2009, Hahne, 2001). The effect of word condition on N400 activity corresponded well with the finding that d' and RT were influenced by the word condition. It can be concluded that subjects reacted most hesitantly to metaphors, spotted them least effectively and required considerably more cognitive effort to process them in contrast to literal sentences.

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Appendix

Stimuli

type 1 = metaphor; 2 = literal; 3 = anomalous

nr	type	deel1	woord	expr
1	1	Een hond is een	vriend	1
2	2	Een hond is een	dier	1
3	3	Een hond is een	tuin	1
4	1	De tuin is een	droom	2
5	2	De tuin is een	plek	2
6	3	De tuin is een	mes	2
7	1	De hemel is een	huis	3
8	2	De hemel is de	lucht	3
9	3	De hemel is een	doek	3
10	1	De aarde is een	school	4
11	2	De aarde is een	ding	4
12	3	De aarde is een	pan	4
13	1	Vakantie is een	feest	5
14	2	Vakantie is een	tijd	5
15	3	Vakantie is een	dier	5
16	1	Ziekte is een	straf	6
17	2	Ziekte is een	staat	6
18	3	Ziekte is een	fiets	6
19	1	Een boek is een	vriend	7
20	2	Een boek is een	ding	7
21	3	Een boek is een	aap	7
22	1	Mijn baas is een	aap	8
23	2	Mijn baas is een	mens	8
24	3	Mijn baas is een	zaag	8
25	1	Mijn schoonmoederis een	heks	9
26	2	Mijn schoonmoederis een	vrouw	9
27	3	Mijn schoonmoederis 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
31	1	Mijn broer is een	beest	11
32	2	Mijn broer is een	man	11
33	3	Mijn broer is een	duik	11
34	1	Mijn zus is een	draak	12
35	2	Mijn zus is een	vrouw	12
36	3	Mijn zus is een	boom	12
37	1	Tijd is een	deur	13
38	2	Tijd is een	duur	13
39	3	Tijd is een	vaas	13
40	1	Liefde is een	spel	14
41	2	Liefde is een	staat	14
42	3	Liefde is een	kip	14
43	1	Mijn huisdier is een	ster	15
44	2	Mijn huisdier is een	hond	15
45	3	Mijn huisdier is een	bord	15
46	1	Mijn vriend is een	kei	16
47	2	Mijn vriend is een	man	16
48	3	Mijn vriend is een	stoel	16
49	1	Oorlog is een	hel	17
50	2	Oorlog is een	staat	17
51	3	Oorlog is een	voet	17
52	1	Vrede is een	kind	18
53	2	Vrede is een	staat	18
54	3	Vrede is een	want	18
55	1	Water is een	recht	19
56	2	Water is een	stof	19
57	3	Water is een	lamp	19
58	1	Mijn hart is een	kuil	20
59	2	Mijn hart is een	spier	20
60	3	Mijn hart is een	tas	20
61	1	Muziek is een	taal	21
62	2	Muziek is een	klank	21
63	3	Muziek is een	voet	21
64	1	De dood is een	reis	22
65	2	De dood is een	eind	22
66	3	De dood is een	bord	22
67	1	De ochtend is een	droom	23
68	2	De ochtend is een	start	23
69	3	De ochtend is een	darm	23
70	1	De avond is een	man	24
71	2	De avond is een	eind	24
72	3	De avond is een	kuil	24
73	1	De vrouw is een	gans	25
74	2	De vrouw is een	mens	25
75	3	De vrouw is een	duur	25
76	1	Mijn broer is een	rots	26
77	2	Mijn broer is een	man	26
78	3	Mijn broer is een	dag	26
79	1	De zon is een	vriend	27
80	2	De zon is een	ster	27
81	3	De zon is een	reis	27
82	1	De man is een	vos	28
83	2	De man is een	vent	28
84	3	De man is een	vork	28
85	1	Het verhaal is een	mes	29
86	2	Het verhaal is een	boek	29
87	3	Het verhaal is een	gans	29
88	1	De storm is een	kind	30
89	2	De storm is een	wind	30
90	3	De storm is een	tekst	30
91	1	Het vak is een	hel	31
92	2	Het vak is een	deel	31
93	3	Het vak is een	kind	31
94	1	Het gerecht was een	droom	32
95	2	Het gerecht was een	gans	32
96	3	Het gerecht was een	wind	32
97	1	De weg is een	boek	33
98	2	De weg is een	straat	33
99	3	De weg is een	gans	33
100	1	De arbeider is een	mier	34
101	2	De arbeider is een	knecht	34
102	3	De arbeider is een	boek	34
103	1	De lerares is een	slang	35
104	2	De lerares is een	mens	35
105	3	De lerares is een	reeks	35
106	1	De zangeres is een	lied	36
107	2	De zangeres is een	vrouw	36
108	3	De zangeres is een	kuil	36
109	1	Het gevoel is een	kleur	37
110	2	Het gevoel is een	raad	37
111	3	Het gevoel is een	kuil	37
112	1	Liefde is een	beest	38
113	2	Liefde is een	staat	38
114	3	Liefde is een	baard	38
115	1	Het leven is een	reis	39
116	2	Het leven is een	tijd	39
117	3	Het leven is een	voet	39
118	1	De held is een	vuur	40
119	2	De held is een	man	40
120	3	De held is een	roest	40
121	1	Woede is	gif	41
122	2	Woede is	drift	41
123	3	Woede is	tijd	41
124	1	Het hart is een	ster	42
125	2	Het hart is een	spier	42
126	3	Het hart is een	rest	42
127	1	Het gesprek is een	dans	43
128	2	Het gesprek is een	zaak	43
129	3	Het gesprek is een	ster	43
130	1	Het geheugen is een	zeef	44
131	2	Het geheugen is een	plaat	44
132	3	Het geheugen is een	spier	44
133	1	Vertrouwen is een	brug	45
134	2	Vertrouwen is een	wens	45
135	3	Vertrouwen is een	kip	45
136	1	Mijn dochter is een	lied	46
137	2	Mijn dochter is een	kind	46
138	3	Mijn dochter is een	zeef	46
139	1	Mijn werk is een	trog	47
140	2	Mijn werk is een	taak	47
141	3	Mijn werk is een	tros	47
142	1	Mijn opa is een	eik	48
143	2	Mijn opa is een	knar	48
144	3	Mijn opa is een	kans	48
145	1	Het leven is een	kans	49
146	2	Het leven is een	duur	49
147	3	Het leven is een	knar	49
148	1	Het strand is een	vloek	50

149 2	Het strand is een	plek	50	215 2	De stilte is een	feit	72
150 3	Het strand is een	vlok	50	216 3	De stilte is een	baard	72
151 1	Het bos is een	val	51	217 1	Mijn toekomst is een	hart	73
152 2	Het bos is een	woud	51	218 2	Mijn toekomst is een	feit	73
153 3	Het bos is een	zaak	51	219 3	Mijn toekomst is een	kluts	73
154 1	De oase is een	drank	52	220 1	Onze vrede is een	huid	74
155 2	De oase is een	bron	52	221 2	Onze vrede is een	recht	74
156 3	De oase is een	kramp	52	222 3	Onze vrede is een	pats	74
157 1	De motie is een	dag	53	223 1	De woede is een	slang	75
158 2	De motie is een	wet	53	224 2	De woede is een	drift	75
159 3	De motie is een	boom	53	225 3	De woede is een	zwik	75
160 1	De dichter is een	koe	54	226 1	De zanger is een	lied	76
161 2	De dichter is een	mens	54	227 2	De zanger is een	mens	76
162 3	De dichter is een	kies	54	228 3	De zanger is een	keer	76
163 1	De dood is een	muur	55	229 1	De zee is een	buik	77
164 2	De dood is een	eind	55	230 2	De zee is een	plek	77
165 3	De dood is een	kien	55	231 3	De zee is een	gros	77
166 1	Ons hart is ons	park	56	232 1	De zon is een	druif	78
167 2	Ons hart is ons	spier	56	233 2	De zon is een	ster	78
168 3	Ons hart is ons	zier	56	234 3	De zon is een	droom	78
169 1	De haven is een	mond	57	235 1	Woede is	vuur	79
170 2	De haven is een	oord	57	236 2	Woede is	drift	79
171 3	De haven is een	snars	57	237 3	Woede is	stoel	79
172 1	De haven is een	tuin	58	238 1	Liefde is een	roos	80
173 2	De haven is een	plek	58	239 2	Liefde is een	staat	80
174 3	De haven is een	plop	58	240 3	Liefde is een	drop	80
175 1	Ons hoofd is een	berg	59	241 1	De dood is een	nacht	81
176 2	Ons hoofd is een	ding	59	242 2	De dood is een	eind	81
177 3	Ons hoofd is een	gooi	59	243 3	De dood is een	schoen	81
178 1	Mijn hoofd is een	haan	60	244 1	De kerk is een	vlucht	82
179 2	Mijn hoofd is een	deel	60	245 2	De kerk is een	huis	82
180 3	Mijn hoofd is een	trant	60	246 3	De kerk is een	dans	82
181 1	De huid is een	vrouw	61	247 1	Mijn werk is een	hel	83
182 2	De huid is een	laag	61	248 2	Mijn werk is een	taak	83
183 3	De huid is een	taks	61	249 3	Mijn werk is een	kast	83
184 1	Hun huis is een	graf	62	250 1	De koran is een	last	84
185 2	Hun huis is een	pand	62	251 2	De koran is een	boek	84
186 3	Hun huis is een	wrik	62	252 3	De koran is een	stal	84
187 1	Het kind is een	maan	63	253 1	Sport is een	plaag	85
188 2	Het kind is een	mens	63	254 2	Sport is een	spel	85
189 3	Het kind is een	slip	63	255 3	Sport is een	druif	85
190 1	Zijn lach is een	lied	64	256 1	Ziekte is een	worm	86
191 2	Zijn lach is een	klank	64	257 2	Ziekte is een	plaag	86
192 3	Zijn lach is een	plaat	64	258 3	Ziekte is een	spel	86
193 1	Het leven is een	brood	65	259 1	Geboorte is een	licht	87
194 2	Het leven is een	feit	65	260 2	Geboorte is een	start	87
195 3	Het leven is een	haan	65	261 3	Geboorte is een	plek	87
196 1	De maan is een	dier	66	262 1	Oorlog is een	nacht	88
197 2	De maan is een	ding	66	263 2	Oorlog is een	schijf	88
198 3	De maan is een	piel	66	264 3	Oorlog is een	stoel	88
199 1	De mens is een	steen	67	265 1	Vriendschap is een	ster	89
200 2	De mens is een	soort	67	266 2	Vriendschap is een	band	89
201 3	De mens is een	snap	67	267 3	Vriendschap is een	druif	89
202 1	Deze middag is een	mand	68	268 1	Eten is een	drug	90
203 2	Deze middag is een	tijd	68	269 2	Eten is een	maal	90
204 3	Deze middag is een	stoel	68	270 3	Eten is een	park	90
205 1	Je mond is een	huis	69	271 1	Voetbal is een	boek	91
206 2	Je mond is een	plek	69	272 2	Voetbal is	spel	91
207 3	Je mond is een	tijd	69	273 3	Voetbal is een	ster	91
208 1	De nacht is een	vrouw	70	274 1	Het brein is een	spons	92
209 2	De nacht is een	tijd	70	275 2	Het brein is een	feit	92
210 3	De nacht is een	soort	70	276 3	Het brein is een	doek	92
211 1	De poezie is een	mens	71	277 1	Mijn hoofd is een	huis	93
212 2	De poezie is een	tekst	71	278 2	Mijn hoofd is een	kop	93
213 3	De poezie is een	brui	71	279 3	Mijn hoofd is een	balk	93
214 1	De stilte is een	brug	72				