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Was there an error?
Self-monitoring and language comprehension

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Contents

Dankwoord

Dankwoord

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Els,
Lètste daag van de vasteloavend 2008,
Gent

chapter 1

Biased internal self-monitoring: An overview

Biased internal self-monitoring: An overview

Language use is an extremely important form of human cognition. We talk, listen, read, and write to convey our thoughts to other human beings and we are extremely good at doing this. Even though we can produce on an average two to three words per second, we misspeak only about once per thousand words (Garnham, Shillcock, Brown, Mill, & Cutler, 1981). When we do misspeak, this seems to be bounded to certain rules (Fromkin, 1971). By studying different kinds of error patterns and the rules that seem to be influencing the error patterns we can learn how language is generated and, importantly for the present dissertation, how we detect errors in our speech.

When we are talking we somehow check if what we are saying is correct and if we are saying what we want to say. It is thought that we 'monitor' our internal speech plan (Levelt, 1983, 1989). This is a prearticulatory speech plan, which is checked for errors. When an error is detected, speech is immediately interrupted and the error is corrected. This is referred to as the main interruption rule (Nooteboom, 1980). On some accounts, this can happen completely covert, for example when there is a hesitation it is thought that speech is interrupted to repair a detected error. However the error can also be corrected when a part of the error has already been pronounced. Speech will then be stopped (often in the middle of the word) and a correction will be produced. One influential monitoring theory has proposed that the monitor of speech production relies on the comprehension system (Hartsuiker & Kolk, 2001; Levelt, 1983, 1989; Levelt, Roelofs, & Meyer, 1999; but see Postma, 2000 for an alternative view). The prearticulatory speech plan would be checked for errors by the comprehension system. The internal self-monitor plays a key role in the interactive vs. discrete discussion which has divided the language production field. Therefore it is very important to investigate if the monitor indeed relies on the comprehension system.

Interactive models vs. discrete models

In the field of language production there is consensus that there are several stages in the production of language (Dell, 1986; Dell & O'Seaghdha, 1991; Levelt, 1989; Levelt et al., 1999). At the first stage it has to be chosen what one wants to say. Therefore semantic representations have to be activated at the conceptual level to make a pre-verbal message. This message combines the intention, world-knowledge and the context of the speaker at that moment. Then the pre-verbal message has to be converted into a lexical-syntactic representation. Each semantic representation activates a lexical-syntactic representation, often called lemma's (Kempen & Huijbers, 1983). These lemma's are representations of words that contain their syntactic information, like the grammatical gender of a noun. The syntactical structure and the hierarchical order of the lemma's is also specified at this level. The third stage is the word form level. Encoding at this level exists of two processes. One process selects the phonological

segments of the word and the other process selects the word's structure. Note however that not all theories make the lemma/word-form distinction, but argue that one level suffices (e.g. Carramaza, 1997; Starreveld & La Heij, 1995).

Even though most theories of language production agree that there are several levels in language production, there are very important differences between theories. In particular, there is a divide in the literature between theories that view these levels as discrete (e.g., Levelt, 1989; Levelt et al., 1999) and theories that assume at least local interaction between adjacent levels (e.g., Dell, 1986). The discrete theory suggests that a representation at a certain level has to be selected before retrieval at the next level can start. Furthermore this theory does not allow information to flow back from a lower level to a higher level. Thus information only flows from the conceptual level to the lexical-syntactic level to the word-form level (e.g. Levelt, 1989; Levelt et al., 1999). In contrast interactive theories allow activation to flow to higher levels in the production process (feedback). Furthermore these theories allow activation to flow forward as soon as this is possible (cascading). In other words activation can spread to the next level before one specific representation has been selected (e.g. Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gangnon, 1997). There is ample evidence for cascading (see Vigliocco & Hartsuiker, 2002, for review). However, the evidence for feedback almost exclusively comes from error patterns (Baars, Motley, & Mckay, 1975; Dell & Reich, 1981; Hartsuiker, Corley, & Martensen, 2005; Nooteboom, 2005; Rapp & Goldrick, 2000; Stemberger, 2004; Vitevitch, 2002). Importantly, discrete models are able to explain these error patterns by extending the model with an internal self-monitor. In the next part an interactive and a discrete explanation for an error pattern will be described.

Cause of the lexical bias effect

An error pattern that typically has been used to demonstrate that feedback is required is the lexical bias effect. This is the finding that phonological errors have a tendency to form real words instead of nonwords, at a rate that is higher than might be expected by chance (e.g., Baars et al., 1975; Dell & Reich, 1981; Hamm, Junglas, & Bredenkamp, 2004; Hartsuiker, Anton-Mendez, Roelstraete, & Costa, 2006; Nooteboom, 2005; Hartsuiker et al., 2005; Oppenheim & Dell, 2008). The lexical bias effect has been observed in both corpora data and in experimentally elicited errors. The SLIP-task has been used to elicit errors in an experimental setting (Baars et al., 1975). In this task participants have to read word pairs and once in a while they have to overtly name a word pair. The preceding word pairs provide a phonological context in which the chance for making a Spoonerism (exchange of the first phonemes of a word pair) is large. Baars et al. (1975) found that there were more Spoonerism when they constituted real words (e.g., *darn bore* > *barn door*) compared to when the Spoonerism formed nonwords (e.g., *dart board* > *bart doard*).

An interactive account which allows feedback between the phonological segments and the lexical level can easily explain the lexical bias effect. When the intended word is *cat*, the lemma [*cat*] will be activated. If all goes well, the phonological segments of *cat* will become activated by feedforward activation . Feedback from the phonological segments to the lexical level will activate neighbors of *cat* like *hat*. Then feedforward activation will again activate the corresponding segments including the segments that are not in the intended word (e.g., *h* from *hat*). These phonological segments will again send activation back to the lexical level. Of course the intended word will get the largest activation, this has been named a positive feedback loop (Dell, 1986). In contrast, when a phonological segment gets wrongly activated either by noise in the system or by priming there will also be feedback from these erroneously activated segments. Suppose, for example, that the *h* gets wrongly activated. This will lead to the activation of the lemma [*hat*] by the positive feedback loop and so possibly the word *hat* will be selected instead of *cat*. When instead the *w* gets wrongly activated, this phonological segment will also send activation back to the lexical level. But since there is no lemma for the nonword *wat*, this lemma cannot be activated and there can be no feedforward. Consequently there will be no positive feedback loop for nonwords. Hence the chance of a nonword to be wrongly produced is smaller than that of a word error.

In contrast, since a discrete model does not allow for feedback between the phonological segments and the lexical level, this model is not able to explain the lexical bias effect. However, when the model is amended with an internal self-monitor, it is able to explain the lexical bias effect. As mentioned before, the internal self-monitor is suggested to be situated in the comprehension system (Hartsuiker & Kolk, 2001; Levelt, 1983, 1989; Levelt et al., 1999) and inspects preverbal speech for errors. It has been suggested that this internal self-monitor uses a lexicality criterion (*is this word real?)*. Thus more nonwords will be intercepted in preverbal

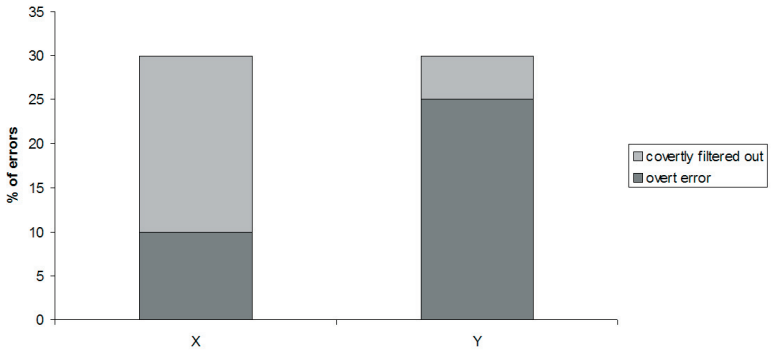

Figure 1. Fictional error pattern demonstrating a difference in overt errors between error X and error Y caused by a biased monitor. The light grey bar demonstrates the errors that are detected by the monitor and covertly corrected. The overt errors (really pronounced errors) are demonstrated by the dark grey bar.

speech; this will result in more word errors. Below we will give a fictional error pattern to further illustrate how the monitor is able to change an error pattern.

Assume that the normal language production system gives rise to two kinds of errors (e.g., error X and Y) with an equal frequency. However, the internal self-monitor is better at detecting errors X compared to errors Y. Hence more errors X will be detected and corrected covertly before these errors are pronounced. This will result in an overt error pattern in which there are more errors Y compared to errors X. Thus this difference is not caused by production internal processes but by the dissimilar ability of the internal self-monitor to detect both kinds of errors (see Figure 1). Note that a similar explanation holds for the lexical bias effect. If the monitor finds it easier to detect errors that are nonwords compared to errors that are words, more word errors will be actually pronounced.

In sum, because discrete models invoke a biased internal self-monitor to explain error patterns which typically have been used as evidence for feedback, it is extremely important to examine if this internal self-monitor exists and how it exactly works.

Disentangling production internal processes and the monitoring bias

It is very hard to disentangle whether an error pattern is caused by production internal processes or by a biased internal self-monitor. Both these accounts are in terms of covert mechanisms and only the output can be measured. Hartsuiker (2006) proposed a manner to evaluate indirectly if a specific error pattern can be reasonably accounted for in terms of biased monitoring. According to Hartsuiker, a specific error pattern should conform to three demands to be feasible to be brought about by a biased internal self-monitor. The first demand states that the monitor should be functional. This means that the monitor should adapt to the context that is relevant at that time and change the monitoring criteria to perform optimal within that context. This demand follows from the observation that different speaking situations make different demands on the speaker, and so a given utterance can be appropriate in one context (e.g., when the task is to name a mixed list of words and nonwords) but not in another context (e.g., when the task is to name a pure list of nonwords). Remember the fictional error pattern described before, when a speaker now is in a context in which error X is not definitely wrong but error Y is, the monitor should adapt and be better at detecting errors Y. This will result in an opposite bias (see Figure 2). The second demand holds that manipulations that influence the monitor should consequently influence the resulting error pattern. It has been suggested that the monitor is a resource demanding process (Levelt, 1989). Hence if there are fewer resources available for the monitor a monitoring bias should be reduced. Again take the fictional error pattern discussed above. If there is a secondary task at hand the monitor's resources are decreased and thus monitoring is less effective. Hence the monitor cannot cause a difference in the overt errors made, a

similar number of overt errors will be made for errors X and Y (see Figure 3). Note, however that it is very important that the manipulations do not influence language production itself; they should not cause more errors of one type. The third demand says that similar biases should be found in comprehension. Since it has been suggested that the comprehension system is used to inspect speech for errors, biases that are proposed to be caused by monitoring should also be present in comprehension. It should be noted that there is a difference between listening to overt speech (normal comprehension) and "listening" to one's own internal speech (monitoring). When monitoring one's own speech a person knows what was planned to be said and a comparison between the speech plan and what is "heard" can be made. However when listening to someone else the speech plan is not available. In addition during monitoring the first few steps of normal comprehension are skipped, simply because these are not necessary.

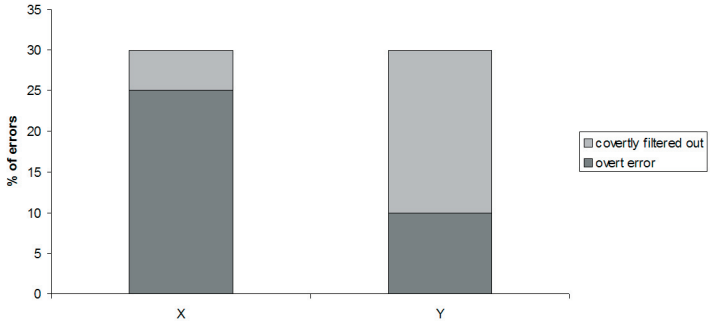

Figure 2. Illustration of an error pattern that shows an opposite bias due to the monitoring criteria that was relevant at the time. Here the monitor detects more errors Y, in contrast to Figure 1 where more errors X were detected. The light grey bar demonstrates the errors that are detected by the monitor and covertly corrected. The overt errors (really pronounced errors) are demonstrated by the dark grey bar.

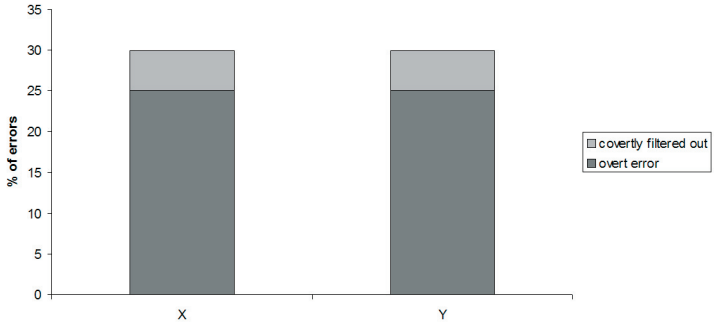

Figure 3. Illustration of an error pattern in which the monitor is not effective anymore thanks to too less resources for the monitor. In this error pattern there is no bias left. The light grey bar demonstrates the errors that are detected by the monitor and covertly corrected. The overt errors (really pronounced errors) are demonstrated by the dark grey bar.

Hartsuiker (2006) discussed whether five speech error patterns that are suggested to be caused by a monitoring bias, meet these three demands. The discussed speech error patterns are the: lexical bias, mixed error bias, exchange rate, morphophonological effects on agreement errors and conceptual effects on agreement errors. Table 1 shows to what extent each error pattern meets each demand. In the next sections the conclusions for each error pattern demonstrated in Table 1 will be discussed shortly.

Table 1. Evaluation of five suspected monitoring biases against the criteria of functionality (the monitor would set functional criteria), affectability (the bias is affected by manipulations that alter monitoring performance), and correspondence with perception (the bias would also occur in the perception of one's external speech and of other's speech). This Table is depicted from Hartsuiker (2006).

	Functionality	Affectability	Perception analogue
Lexical bias	+	+	0
Mixed error bias	+	0	0/+[a]
Exchange rate	+	0	0
Morphophonological effects on agreement errors	-	0	0
Conceptual effects on agreement errors	+	-	0

+ error pattern meets the demand, - error pattern does not meet the demand, 0 there is no conceivable evidence if the error pattern meets the demand. a. The "0" refers to the general case (do listeners detect phonologically unrelated semantic errors more often than mixed errors?). The "+" refers to the specific proposal that the internal channel will activate a cohort of phonologically similar competitors (Roelofs, 2004).

To reiterate, the lexical bias effect is the finding that phonological errors more often generate real words than nonwords than might be expected by chance (e.g., Baars et al., 1975; Dell & Reich, 1981; Hamm et al., 2004; Hartsuiker et al., 2006; Nooteboom, 2005; Hartsuiker et al., 2005; Oppenheim & Dell, 2008). As can be seen in Table 1 the lexical bias meets the first demand. Hartsuiker et al. (2005) demonstrated that the lexical bias effect disappears in a nonword context. They concluded that the monitor adapts to the specific context at hand; in a nonword context the lexical errors are suppressed. Thus in a nonword context the monitor sets its criteria differently so that it is able to detect lexical errors more often. Additionally it is of course very useful to treat nonwords as errors since in normal language these are errors. It has been found that the lexical bias effect is present before monitoring (Hartsuiker et al., 2005; Oppenheim & Dell, 2008). Additionally Humphreys (2002) found that there is a lexical bias effect in the nonword contexts when a time limit has been used. Combined these two findings confirm the second demand (Hartsuiker, 2006). When there is time pressure the monitor does not have enough time to monitor and thus the underlying error pattern becomes overt. Since there is a lexical bias effect in the covert error pattern, the finding that there is

also a lexical bias when there is time pressure shows that when the monitor is affected the underlying error pattern becomes overt. Nooteboom (2005) found that there is no lexical bias effect in overt corrections; this is not in agreement with the third demand. There however is no evidence for a lexical bias effect in the perception of someone else's speech.

The mixed error bias holds that semantically related errors are often also phonologically related to the intended word and this bias has been found in corpus data as well in experimental settings (Dell & Reich, 1981; Ferreira & Griffin, 2003; Harley, 1984; Martin, Gagnon, Schwartz, Dell, & Saffran, 1996). For example when *rat* was meant to be said, this will more often be erroneously substituted with *cat* than with *dog*. It has been suggested that the word one just produced is compared with the intended word by the monitor (Levelt et al., 1999; Roelofs, 2004). Roelofs (2004) suggested that when there is phonological overlap between the error and the intended word it is harder for the monitor to detect the error. This is caused by the activation of words that begin with the same phonemes. Naturally to compare the produced word with the intended word is very functional; the first demand is thus met. We are not aware of data based on which a conclusion can be drawn for demand 2. The third demand is partially satisfied. In comprehension studies a cohort effect has been shown; words starting with the same phonemes are also activated in comprehension (e.g. Zwitserlood, 1989). Additionally this effect was not overridden by context (Zwitserlood, 1989). Apparently, there is also activation of words with overlapping initial phonemes in comprehension, like Roelofs (2004) suggested to be the case in the monitor (the + in Table 1). However there is no evidence that we are aware of that shows that there is a mixed bias effect in comprehension, hence the 0 in table 1.

Errors that also occur are anticipations, perseverations and exchanges. These are phonological errors in which predominantly the first phonemes of two words move. In anticipations the first phoneme of the second word is used in the first word (*good beer* > *boot beer*). In perseverations the first phoneme of the first word moves to the second word (*good beer* > *good gear*) and in exchanges the first phonemes of the two words change places (*good beer* > *bood gear*). Anticipations occur the most, followed by perseverations and then by exchanges. For a monitoring explanation this is logic because in exchanges the monitor can detect an error at two places. It is thus possible that anticipations are corrected exchanges; the error is detected at the first word and then corrected covertly (Nooteboom, 2005). The second word is thus pronounced correctly. It is of course very functional to correct as many errors as possible. We are not aware that there is evidence which proves or disconfirms both the second and the third demand for the exchange rate.

Another type of errors that are made, are syntactic errors like subject-verb number agreement errors. In these kind of errors the subject and the verb do not agree in number (*the children *is playing*). Language production studies tried to elicit subject-verb number agreement errors. Typically participants had to read and complete sentence fragments (*e.g. the key to*

the cabinet/cabinets…). It has been found that there are more errors when the head noun (*key*) and the local noun (*cabinets*) mismatch in number (Bock & Miller, 1991). Furthermore, it has been found that phonological and semantic factors can influence the number of agreement errors that are made (Bock, Nicol, & Cutting, 1999; Bock et. al., 2006; Eberhard, 1999; Hartsuiker & Barkhuysen, 2006; Hartsuiker, Kolk, & Huinck, 1999; Humpreys & Bock, 2005; Vigliocco, Butterworth, & Semenza, 1995; Vigliocco, Butterworth, & Garret, 1996; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996). For example, morphophonological factors have been demonstrated to influence the number of subject-verb agreement errors made in a sentence completion study Hartsuiker, Schriefers, Bock, and Kikstra (2003). In Experiment 3, Dutch sentences were used that could start with a common-gender or a neuter-gender determiner. In Dutch the common-gender determiner (*de)* is ambiguous in number; in contrast the neuter-gender determiner is unambiguous in number. Sentences starting with a common-gender determiner elicited more agreement errors. A biased monitoring account would presume that it is easier for the monitor to detect errors in the neuter-gender condition. It is not functional for the monitor to check these morphophonological factors, because this leads to errors. It would be functional to just check all the syntactic errors without being influenced by these morphophonological factors. To our knowledge there is no robust evidence for or against the second and the third demand.

It has been established with sentence completion studies that conceptual factors can also influence the number of agreement errors that are made (Eberhard, 1999; Hartsuiker & Barkhuysen, 2006; Humphreys & Bock, 2005; Nicol & Greht, 2003; Vigliocco, et al., 1995; Vigliocco, et al., 1996). Sentences that are notionally plural but morphologically singular (*e.g., the label on the bottles*) elicit more subject-verb agreement errors than sentences that are both notionally and morphologically singular (*e.g., the baby on the blankets*). This difference has also been explained with a biased monitoring account; the monitor would also use conceptual information. It might be functional for the monitor to also check semantic information. For example, in languages which have gender-marked adjectives it has been found that the conceptual gender of the noun supports gender agreement (Vigliocco & Franck, 1999). The first demand is thus affirmed. There has been evidence that rebuts the second demand. Hartsuiker and Barkhuysen (2006) used the sentence completion task with distributive and non-distributive sentences together with a secondary working memory task. When performing both tasks concurrently the resources available for the monitor are smaller. There were more agreement errors when both tasks had to be carried out simultaneous. The distributive and non-distributive sentences had an equal enhancement in agreement errors. However if the distributivity effect was the result of a biased internal self-monitor then this effect should disappear or diminish when a secondary task has to be performed. The results did not show a decrease of the distributivity effect and thus demand two is not met. Both Nicol, Forster,

and Veres (1997) and Pearlmutter, Garnsey, and Bock (1999) investigated in English if distributivity of the subject influences comprehension. Both studies found that there was difference in comprehension between distributive and non-distributive sentences. However, both these studies were carried out in English a language in which the distributivity effect was not always found in production experiments either (Bock & Miller, 1991; Vigliocco et al., 1996). Additionally their stimuli were not tested for imageability. This factor has been found to influence the distributivity effect in production studies (Eberhard, 1999). There has thus been no convincing evidence in favor or against the third demand.

In addition to the speech error patterns just described there is another observation in speech errors that is important for the present dissertation. Namely, the observation that speech errors that have a phonological overlap with the intended word occur more often than speech errors which are unrelated to the intended word (Dell, 1986). This is very similar to the mixed error effect discussed above; however the errors in question are not semantically related. Nevertheless a similar monitoring explanation can be given. Since it has been suggested that the monitor compares the prepared word with the intended word on a phonological level (Roelofs, 2004), it is harder to detect errors that have a phonological overlap with the intended word.

Event-Related Potentials

In several studies presented in this dissertation Event-Related Potentials (ERPs) were used. ERPs are brain waves measured at the scalp that are averaged to a specific event, for example to the presentation of a word. ERPs give a signature of the cognitive activity of the brain. It has been suggested that different kinds of cognitive activities elicit different components in the ERP-wave. The large advantage of ERPs is that it gives an on-line measurement of the cognitive brain activities. Additionally ERPs can be measured without the need for the participants to carry out a task. Components that have typically been associated with language processing are the LAN, the N400 and the P600. In the next paragraphs each component will be discussed briefly.

The left anterior negativity (LAN) has been found in response to subject-verb agreement errors (De Vicenzi, Job, Di Matteo, Angrilli, & Penolazzi, 2003; Friederici, Hahne, & Mecklinger, 1996; Osterhout & Holcomb, 1992; Osterhout & Mobley, 1995; Roehm, Bornkessel, Haider, & Schlesewsky, 2005). As the name suggests the LAN most often has a left anterior distribution, however sometimes its distribution is more centrally. The LAN appears between 300 and 400 ms post stimulus (Friederici et al., 1996; Kluender & Kutas, 1993; Osterhout & Holcomb, 1992; Münte, Heinze, & Mangun, 1993; Rösler, Pütz, Friederici, & Hahne, 1993). It has been suggested that the LAN reflects the detection of morphosyntactic agreement errors (Rossi, Gugler, Hahne, & Friederici, 2005).

The N400 is a negative going component which peaks 400 ms post stimulus with a right posterior distribution (Kutas & Dale, 1997; Kutas & Van Petten, 1994). The first N400 was reported by Kutas and Hillyard (1980). They found a N400 in response to semantic incongruent words as in the sentence: *He shaved of his moustache and city*. Later it was found that the N400 was also elicited by words that are unexpected but congruous with the preceding context (Kutas & Hillyard, 1984) and when a word is unexpected based on world-knowledge (Hagoort, Hald, Bastiaansen, & Petersson, 2004). The N400 amplitude has been described as being reflective of the ease to which a word can be integrated into a preceding context (Federmeier & Kutas, 1999) and in its discourse (Van Berkum, Hagoort, & Brown, 1999). A larger N400 amplitude corresponds to more difficult semantic integration.

The last component is a large positive going wave (P600). Two research groups described the P600 around the same period for the first time. Osterhout and Holcomb (1992) found the P600 in garden-path sentences in response to syntactic unexpected words. Hagoort, Brown, and Groothusen (1993) reported a P600 in response to subject-verb agreement errors. The P600 has been described to processes related to syntactic sentence processing (syntactic processing: e.g., Hagoort et al., 1993; Osterhout, & Holcomb, 1995; syntactic repair or reanalysis: Friederici et al., 1996; Münte, Matzke, & Johannes, 1997; syntactic integration difficulty: Kaan, Harris, Gibson, & Holcomb, 2000). However it has also been described to reflect more salient violations (Coulson, King, Kutas, 1998). The last few years the P600 has also been found in response to semantic verb incongruencies (Hoeks, Stowe, & Doedens, 2004; Kim & Osterhout, 2005; Kolk, Chwilla, Van Herten, & Oor, 2003; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003; Van Herten, Kolk, & Chwilla, 2005). Therefore the P600 has also been associated with more general processes as comprehension monitoring processes (Kolk et al., 2003; Van Herten, Chwilla, & Kolk, 2006; Van Herten et al., 2005; Vissers, Chwilla, & Kolk, 2006) or continued combinatorial analysis (Kuperberg, 2007).

The predictions in the present dissertation are based on the number of errors that are detected by the internal self-monitor. A difference in amplitude of an ERP component can be elicited by a larger proportion of trials that carry the effect (Otten & Rugg, 2005). Therefore we expect that when more errors are detected more trials will carry an effect, and then we expect the amplitude to be larger. Thus when the least errors are made in production, the largest effects are expected in the present dissertation.

The present dissertation

In the current dissertation an attempt was given to test the internal self-monitor more extensively. This was done to get a better understanding of how the internal self-monitor works and which error patterns can be described to be the result of a biased monitor.

In the first part (Chapter 2 and 3) it has been examined if the monitor is sensitive for phonological information. Roelofs (2004) suggested that the monitor uses phonological information to check preverbal speech. By using this suggestion the mixed error effect and phonologically related errors can be explained by an internal self-monitor. In Chapter 3 a picture naming task was used in which there was interference from a preceding sentence. This paradigm has shown to successfully elicit semantic and homophone intrusions in picture naming (Ferreira & Griffin, 2003). If the monitors uses phonological information to check for errors there should also be phonological intrusions. This was tested in Chapter 3. The study described in Chapter 2 was a pre-test of the pictures used in Chapter 3.

In the second part of this dissertation it has been tested with several ERP experiments if we can find analogous biases that have been claimed to be caused by a monitoring bias in comprehension. It was thus tested if the third demand (Hartsuiker, 2006) was met by different error patterns.

Chapter 4 tested if morphophonological influences on subject-verb agreement errors had an analogous bias in comprehension. In order to test this ERPs were measured while participants read Dutch sentences that could contain a subject-verb agreement error. The determiner of the head noun could either be ambiguous in number or unambiguous in number. Furthermore the local noun could be singular of plural. Based on a biased monitoring account it was expected that more errors would be detected in the sentences starting with an unambiguous determiner.

Chapter 5 tested if the error pattern "conceptual influences on subject-verb agreement errors" meets the third demand. Distributive and non-distributive sentences were used that could contain a subject-verb agreement error. Participants' brain waves were recorded while they read these sentences. It was expected that more errors would be detected by the monitor in the non-distributive sentences.

Finally it was tested if the lexical bias effect has an analogue in comprehension (Chapter 6). Therefore, high-cloze sentences that could contain a correct word, a lexical error, or a nonlexical error were presented. Since it has been suggested that the monitor uses lexicality (*is this a word?*) as a criterion, more lexical errors are expected to be detected in the comprehension study.

In the General Discussion (Chapter 7) all the results will be discussed. It will be described which error pattern meets the third demand of Hartsuiker (2006). In addition, theoretical implications will be discussed.

chapter 2

Timed picture naming norms for 590 pictures in Dutch

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[1] This paper was co-authored by Sven Van Lommel, Elie Ratinckx and Robert J. Hartsuiker

Abstract

The present study presents timed norms for 590 pictures in Belgian Dutch. We determined name agreement and response latencies. Furthermore, we assessed which factors influenced the naming latencies of the pictures. It appeared that age-of-acquisition, the *H*-statistic (an index of name agreement), and the number of syllables of the dominant response were significant predictors of the naming latencies. These results are discussed in comparison with previous findings.

Introduction

Ever since the days of Cattell (1886), picture naming is a widely used technique in psycholinguistic research. It has been used to investigate a number of components of language production such as lexical access and phonological encoding (e.g., Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991; Santiago, MacKay, Palma, & Rho, 2000; Starreveld, 2000). Picture naming has also been used in fMRI studies (e.g., Hernandez, Martinez, & Kohnert, 2000; Rutten, Ramsey, van Rijen, & van Veelen, 2002; Spitzer et al., 1998), ERP studies (e.g., Hauk, Rockstroh, & Eulitz, 2001; Schiller, Bles, & Jansma, 2003; Schmitt, Münte, & Kutas, 2000; Schmitt, Schiltz, Zaake, Kutas, & Münte, 2001; Van Turennout, Hagoort, & Brown, 1997) and studies of bilingualism (e.g., Costa, Miozzo, & Caramazza, 1999). To be able to compare studies that used picture naming it is important to have norms of the pictorial stimuli that are used in these studies. This study reports new norms for 590 single-object pictures in Belgian Dutch.

An often cited norming study in English is Snodgrass and Vanderwart (1980). These authors standardized 260 pictures on four variables: name agreement, image agreement, familiarity, and visual complexity. Name agreement was defined as the degree to which participants use the same name for a given object. Image agreement was measured by asking subjects to make a visual image of a word. After a little while the picture of this word was presented and participants had to decide how closely the presented picture resembled their mental image. Familiarity was defined as the subjective judgment of how often one comes in contact or thinks about a certain object. Finally, visual complexity was defined as the subjective judgment of the amount of detail a picture has. The pictures were standardized with American English speaking students.

Subsequent studies suggested that there are cultural differences in picture naming. Van Schagen, Tansma, Bruggeman, Jackson, and Michon (1983) normed the Snodgrass and Vanderwart (1980) picture set in Dutch. Comparing their results with those of Snodgrass and Vanderwart, they found a large correlation between the studies in subjective visual complexity. However, they did not find a significant correlation between the two studies on name agreement and familiarity. The authors concluded that these discrepancies were caused by cultural differences. Kremin et al. (2003) collected norms for picture naming in Dutch, English, German, French, Italian, Russian, Spanish, and Swedish. They also found variability in name agreement between languages, and they suggested that name agreement is related to the language that is studied. It is thus important to carry out norming studies for pictorial stimuli in different languages.

Since the Snodgrass and Vanderwart study there have been several norming studies in different languages (Alario & Ferrand, 1999 for French; Martein, 1995 for Dutch; Nisi, Longoni, & Snodgrass, 2000 for Italian; Pind, Jónsdóttir, Gissurardóttir, & Jónsson, 2000 for Icelandic; Sanfeliu, & Fernandez, 1996 for Spanish; Wang, 1997 for Chinese). Other norming studies focused on the effects of the visual information made

available in the pictures (e.g., De Winter & Wagemans, 2004; Rossion & Pourtois, 2004). Most of these studies did not determine reaction times (RT). However, in many domains of investigation it can be very useful to have picture naming norms with naming latencies. For example, Bates et al. (2003) showed that cross-language correlation was largest for RT compared to other measures of naming behavior. This suggests that timed picture naming is sensitive to universal stages and/or processes that are not detected with off-line naming measures. Furthermore, naming latencies can be used to select stimuli (e.g., Levelt & Maassen, 1981) and make it possible to derive more accurate predictions for experiments.

An additional advantage of obtaining timed picture naming norms on a large set of pictures, is that it will allow for a simultaneous consideration of word variables that may influence naming latencies. In fact, there has been considerable debate about which factors determine picture naming latencies in recent years. For example, one of the factors that sometimes has been thought to influence naming latencies is name agreement (e.g., Barry, Morrison, & Ellis, 1997; Pind & Tryggvadóttir, 2002; Snodgrass & Yuditsky, 1996). Furthermore, the addition of color to the pictures has been found to shorten naming latencies of correct responses (Rossion & Pourtois, 2004). Additionally, three other variables have been debated in this context, namely, word frequency, age-of-acquisition, and word length. The next paragraphs will briefly discuss findings about these three variables.

It has been known for a long time that word frequency is an important factor in naming tasks (Jescheniak & Levelt, 1994; Oldfield & Wingfield, 1965). Words which have a high frequency are named faster compared to names with a low frequency. Recently, it has been shown that the age-of-acquisition (hereafter AOA) of a word is also a determinant of the RT. The AOA-effect is the finding that words that are learned at an early age in life are named faster than words that are learned later in life. Morrison, Ellis, and Quinlan (1992) re-analyzed the data of Oldfield and Wingfield, and found that AOA is the only independent determinant of RTs, and not frequency. The authors concluded that the frequency effect found by Oldfield and Wingfield is actually an AOA-effect. More recently, Bonin, Fayol, and Chalard (2001) found an AOA-effect in both written and spoken picture naming in French. In contrast, they did not find a frequency effect when they controlled for AOA. A replication with a larger set of items showed similar results (Bonin, Chalard, Méot, & Fayol, 2002). Barry, Hirsh, Johnston, and Williams (2001) also found an AOA-effect and no frequency effect in picture naming in English. The same results were found in Icelandic (Pind & Tryggvadóttir, 2002).

In contrast, several studies provided evidence that frequency independently determines naming latencies. Iyer, Saccuman, Bates and Wulfeck (2001) carried out a picture naming study in American English. Whereas AOA was the best predictor of naming latencies, frequency was an independent predictor of naming latencies (see also Snodgrass & Yuditsky, 1996 for similar results). Furthermore, similar results have been

obtained in other tasks and different languages. For instance, Brysbaert (1996) had primary school children do a word naming task in Dutch, and found a frequency effect in addition to an AOA effect. These results have been replicated with college students in Dutch (Brysbaert, Lange & Wijnendale, 2000) and in English (Morrison & Ellis, 2000). Additionally, Gerhand, and Barry (1999) found both the effects in speeded word naming in English. Thus, both a frequency and an AOA effect have been obtained with different linguistic tasks and in several languages. Barry, Morrison and Ellis (1997) found that the *interaction* between AOA and frequency was a significant determinant of naming latencies, indicating that words that are acquired later in life show a frequency effect and words that are acquired early in life do not show a frequency effect.

Another factor which has been suggested to influence naming latencies is the length of the word. According to Levelt, Roelofs, and Meyer (1999) people only begin to speak when having planned a complete phonological word. Furthermore, this plan is made in a sequential order, which results in the prediction that short words are named faster than long words. Meyer, Roelofs, and Levelt (2003) tested this prediction in a number of experiments with Dutch-speaking participants. They found a word length effect when the words were presented in separate blocks of long and short words. In contrast, when short and long words were presented in mixed blocks no length effect was obtained. Bates et al. (2003) found that length in *characters* was a significant predictor of naming latencies in English, Bulgarian, and Hungarian, but not in German, Spanish, and Italian. Furthermore, length in syllables appeared to be a good predictor of RT in Bulgarian, but it failed to reach significance in English, Hungarian, German, Spanish, and Italian. These results suggest that word length might influence naming latencies, depending on the language.

In the present study we obtained timed norms for a large set of pictures in Belgian Dutch (see Székely et al. 2003 for a validation study for norming large sets of pictures). Furthermore, we tested which factors influence picture naming latencies. In order to do this we standardized 590 black-and-white line drawings on name agreement in Belgian Dutch. In order to make the sample as representative as possible, we tested participants from two different universities with psychology departments: Ghent University in the west, and The University of Leuven in the east.

Method

Participants

Forty native Belgian Dutch speakers (mean age of 21.18 years; 31 females and 9 males) participated in exchange for 8 Euro. Twenty participants were tested at the University of Leuven and twenty at Ghent University. They all had normal or corrected-to-normal vision, and did not have any speaking disability.

Materials

The stimuli consisted of 590 black-and-white line drawings. A subset of these stimuli (517) were also used in the international picture naming project. This project is a cross-linguistic study of lexical access in which norms of naming and latencies have been obtained for 520 noun pictures in seven different languages: American English, Spanish, Italian, German, Bulgarian, Hungarian, and Mandarin Chinese (Bates et al., 2003). The other 73 stimuli were selected from various sources (see Table 1). All stimuli were digitally presented and measured 6 by 6 cm. At a viewing distance of 60 cm and a screen resolution of 1024 x 768 pixels, the visual angle of the picture subtended approximately 5.7° x 5.7° . The pictures can be subdivided into nine semantic categories, according to the subdivision of the international picture naming project (Bates et al., 2003): people (35 pictures), animals (80 pictures), vehicles (24 pictures), body parts (21 pictures), foods (41 pictures), things to wear (26 pictures), small artifacts (219 pictures), large artifacts (90 pictures) and objects of phenomena in nature (54 pictures). The whole stimulus set is available at http://expsy.ugent.be/research/Rdocuments/Rdocuments.htm.

Table 1. *Sources of the used pictures.*

Source	number
International picture naming project (Bates et al., 2003)	517
Snodgrass & Vanderwart, 1980	8
Max Planck Institute for Psycholinguistics	41
Ferreira & Cutting (1997)	24

Table note. For the exact sources of the pictures used in the international picture naming project, which includes many pictures from the Snodgrass & Vanderwart, see Bates et al. (2003).

Procedure

The participants were tested individually. They were seated in front of a computer screen, and instructions were provided on the screen. Participants were instructed to name the pictures as quickly and accurately as possible, and to name the object at once by using one word, without coughs or hesitations. Naming latencies were determined with a voice-key. To familiarize the participants with the voice-key, they were asked to read aloud words that disappeared when the voice-key was triggered. At this point the experimenter adjusted the voice-key if necessary. Before the experimental session, there was a practice session in which the participants were familiarized with the experimental procedure. During this practice session participants named geometrical objects such as circle and square. The pictures from the practice session were not used in the experimental session. The practice session could be repeated until the participant was completely accustomed to the procedure.

Picture presentation was controlled by the E-prime software system (Schneider, Eschman, & Zuccolotto, 2002a, 2002b). Stimulus presentation was as follows: First, a white fixation cross appeared in the center of the screen, for 600 ms. The fixation cross was followed by a picture, which was presented until the voice-key registered a response. If there was no response the picture disappeared after 3000 ms. After the presentation of the picture, a blank screen was shown, and the experimenter judged whether there was a voice-key error. After the experimenter judged the response there was a black screen for 600 ms. Subsequently the next trial started. The pictures were presented in a random order. In the experimental session there were 5 blocks of 118 pictures each, with a break between each block. Participants were allowed to go on at their own pace; if the participant required a break there could be a pause at any moment during the testing session. The whole experiment took about 50 minutes. The vocal responses were recorded with a mini disc or with a tape recorder. These recordings were analyzed afterwards and the responses were written down.

Scoring

Our scoring system was largely the same as in the International Picture Naming Project (Bates et al., 2003). Responses could be coded as valid, invalid, or as 'no response'. First, a response was coded as valid when the response was audible on the recordings and had a valid RT (88.08% valid responses). Second, when the participant produced a cough or hesitation, or when there was a voice-key failure, the response was coded as an invalid response (8.71% invalid responses). Finally, there were trials in which there was no response (3.22% no responses). In the analyses we only used the responses that were coded as valid.

For each picture, we determined the dominant name, the name that was used by the majority of the participants. When two names were used by the same number of participants we took the name that we expected for the picture (see Appendix A).

Results

Two measures of name agreement were calculated: The first measure was the percentage of participants that used the dominant name (100% were all the valid responses to a picture), hereafter called name agreement. This name agreement measure extended from 17.86% to 100%. There were 352 pictures that showed a name agreement of 75% or higher (see Table 2 for the descriptive statistics of this variable). The first name agreement measure underestimates real name agreement in the case where participants assigned only two different names, but equally frequently. In contrast, it overestimates name agreement when participants assigned many different names infrequently and one single name very frequently. Therefore, we calculated the H-statistic following Snodgrass and Vanderwart (1980), which compensates for these problems.

$$H = \sum_{i=1}^{k} p_i \log_2 (1 / p_i)$$

Where p_i is the percentage of participants that used the name and *i* stands for the number of the name. When there is only one name for the object, *H* will be zero. In contrast, when there are several alternatives *H* will be high, and the more alternatives there are the higher *H*. Thus, the *H*-statistic is dependent on the number of competing responses and the number of participants preferring the particular response compared to the other responses.

The results showed that 97 pictures yielded one name (see Appendix A). The highest number of names that were yielded by a picture was 16 names (for the picture *paint*). The mean number of names that were given to a picture was 4.13 (SD = 2.81). The *H*-statistic ranged from 0 to 3.19 (see Table 2 for the descriptive statistics of this variable).

Table 2. *Descriptive statistics for name agreement, H-statistic, morphological variants, synonyms, and lenient name agreement.*

	Name Agreement (%)	H-statistic (arbitrary units)	Morphological variants (%)	Synonyms (%)	Lenient Name Agreement (%)
Mean	75.92	1.00	7.11	3.93	86.96
SD	21.90	0.71	12.71	9.52	17.51
Min	17.86	0	0	0	23.08
Max	100	3.19	67.74	63.16	100
Median	81.08	0.93	0	0	94.60

Table note. SD = Standard Deviation

In addition to the two measures of name agreement we calculated which percentage of the alternative names was a morphological or morphophonological variant and which percentage was a synonym of the dominant name. An alternative name was coded as a morphological variant when the alternative name shared the word root (e.g., *hart* and *hartje*, meaning *heart* and *little heart*). The percentage of morphological variants was calculated by dividing the number of morphological alternatives by the number of valid responses to that picture. The percentage ranged from 0% to 67.74%.

Synonyms were words that had the same meaning as the dominant name (e.g., *nagel* and *spijker*, both meaning *nail* in English). Names already coded as a morphological variant were excluded from synonym classification. By dividing the number of synonyms by the number of valid responses the percentage of synonyms of a certain picture was calculated. This number ranged from 0% to 63.16%.

Lenient name agreement was calculated by adding the percentage of dominant responses, morphological variants and synonyms. A lenient

name agreement of 75% or higher was observed for 471 pictures. Table 2 lists the descriptive statistics of morphological words, synonyms and lenient name agreement.

Frequencies of the dominant names were found by using the program *wordgen* (Duyck, Desmet, Verbeke, & Brysbaert, in press). This program uses the Dutch component of the CELEX lexical database to find lemma frequencies of words (Baayen, Piepenbrock, & Van Rijn, 1993). Log frequencies and the frequencies in counts per million were gathered for the dominant names. The log frequencies were available for 572 dominant names. In Table 3 the statistics of the log frequencies are shown.

Table 3. *Descriptive statistics for log frequency, number of letters, number of phonemes, number of syllables and AOA.*

	Log Frequency	Number of Letters	Number of Phonemes	Number of Syllables	AOA
Mean	1.01	6.13	5.38	1.85	6.10
SD	0.73	2.53	2.20	0.91	1.46
Min	0	2	1	1	3.30
Max	3.67	17	14	6	11.20
Median	0.95	6	5	2	6

Table note. SD = Standard Deviation

The AOA of the dominant responses was retrieved from the norms collected for four- and five letter nouns by Ghyselinck, De Moor, and Brysbaert (2000). Additionally we used the norms collected by Ghyselinck, Custers, and Brysbaert (2003). The AOA was found for 435 out of the 590 names. The AOA ranged from 3.3 to 11.2 (Table 3).

Furthermore, the number of letters, phonemes, and syllables were counted for each dominant response. The number of letters ranged from 2 to 17, the number of phonemes from 1 to 14, and the number of syllables from 1 to 6. Table 3 lists the descriptive statistics of number of letters, phonemes, and syllables.

To determine which variables influence the picture naming latencies, a step-wise regression analysis was carried out with RT as dependent variable and log frequency, AOA, number of letters, number of phonemes, number of syllables, and the H-statistic as independent variables.
Only the responses with the dominant name were used in this regression analysis.

Table 4. *Correlation matrix for the five variables.*

	RT	Log Frequency	Number of Letters	Number of Phonemes	Number of Syllables	AOA	H-statistic
RT	1.00						
Log frequency	-0.31**	1.00					
Number of Letters	0.19**	-0.43**	1.00				
Number of Phonemes	0.21**	-0.45**	0.93**	1.00			
Number of Syllables	0.19**	-0.45**	0.81**	0.86**	1.00		
AOA	0.43**	-0.55**	0.27**	0.32**	0.27**	1.00	
H-statistic	0.67**	-0.15*	0.06	0.07	0.03	0.27**	1.00

*$p < 0.01$, **$p < 0.001$

Because AOA and frequencies of the dominant names were not available for all pictures, the regression analysis was based on 427 out of the 590 pictures. Table 4 shows the correlation between the different independent variables and RT as well as their intercorrelations. All independent variables correlated with RT. The independent variable that had the highest correlation with RT was the *H*-statistic, followed by AOA, log frequency, number of phonemes, number of syllables, and number of letters. The multiple regression analysis showed that the *H*-statistic, AOA, and number of syllables were significant predictors of the RT (Table 5). The regression analysis yielded $R = 0.73$, $F(3,423) = 156.50$, $p < 0.0001$. Table 4 shows that the different independent variables were correlated, but the tolerance was between 0.86 and 0.93; thus this correlation is not a problem for the validity of the multiple regression analysis.

Table 5. *Multiple regression analysis of picture naming times.*

	Beta	SE	t-value
H-statistic	0.60	11.29	17.33**
AOA	0.24	5.58	6.55**
Number Syllables	0.11	10.40	3.10*

Table note. SE = Standard Error
*$p < 0.01$, **$p < 0.001$

The current picture set had 517 pictures in common with the picture set used in the international picture naming project (Bates et al., 2003). In Table 6 the number of names, *H*-statistic, name agreement, morphological variants, synonyms, and RT are shown for the 517 pictures of the present study (the column labeled "Dutch") and for the seven languages studied in the international picture naming project (Bates et al., 2003). It seems that name agreement found in the present study is relatively low

and that the *H*-statistic is relatively high. The numbers of morphological variants and synonyms found in Belgian Dutch are high compared to the other languages. The other variables seem to be comparable. Properties of the dominant words found in Dutch for the 517 pictures and found in the seven languages studied by Bates et al. (2003), are presented in Table 7.

Table 6. *Comparison of results on several variables found for 517 pictures in the present study (Dutch column) with results found by Bates et al. (2003) in seven languages.*

	Dutch	English	German	Spanish	Italian	Bulgarian	Hungarian	Chinese
Number of names								
Mean	3.95	3.35	5.14	4.15	4.39	3.82	4.16	5.47
SD	2.64	2.28	3.42	2.91	2.85	2.56	2.96	3.63
H Statistic								
Mean	0.96	0.67	0.76	0.86	0.95	0.84	0.91	1.16
SD	0.69	0.61	0.68	0.72	0.73	0.65	0.73	0.79
Name Agreement								
Mean	77.0	85.0	81.1	80.0	77.0	80.2	78.0	71.9
SD	21.5	16.4	19.9	20.4	21.6	20.4	21.3	23.3
Morphological variants								
Mean	16.6	3.7	4.4	3.2	4.9	4.1	7.1	8.5
SD	14.9	8.7	10.0	8.4	10.4	9.8	12.9	12.4
Synonym								
Mean	15.4	2.4	3.2	4.2	5.2	2.5	4.3	1.6
SD	13.2	7.7	8.4	10.1	11.0	7.7	10.2	5.5
RT								
Mean	1.09	1.02	1.10	1.14	1.13	1.22	1.07	1.20
SD	216	211	273	262	264	261	268	312

Table 7. *Dominant word properties found for 517 pictures in the present study (Dutch column) compared with dominant word properties found by Bates et al. (2003) in seven languages.*

	Dutch	English	German	Spanish	Italian	Bulgarian	Hungarian	Chinese
Log Frequency								
Mean	1.00	2.50	2.01	2.90	1.16	4.25	1.38	3.36
SD	0.74	1.57	1.50	1.73	1.43	1.09	1.93	2.01
Length in Syllables								
Mean	1.85	1.74	2.13	2.76	2.92	2.40	2.28	2.09
SD	0.91	0.83	0.87	0.96	1.00	0.92	0.97	0.60
Length in Letters								
Mean	6.16	5.89	6.73	6.48	7.07	6.29	6.07	Not
SD	2.56	2.22	2.74	2.14	2.50	2.23	2.28	Relevant

The present study used 181 pictures from the Snodgrass and Vanderwart (1980) stimuli set. The mean *H*-statistic of these 181 pictures was 0.76 (SD = 0.78) in this study and 0.52 (SD =0.50) in the Snodgrass and

Vanderwart study. To test if these *H*-statistics differed from each other we carried out a paired samples *t*-test. It appeared that the two *H*-statistics differed significantly (t (180) = 4.29, $p < 0.01$).

Discussion

This study provides timed picture naming norms which we expect to be useful as a research instrument in future picture naming studies. Additionally, the regression analysis showed that in the current picture set, AOA was a better predictor of naming latencies than frequency. Furthermore, it was found that the number of syllables of the dominant response was a predictor of naming latencies. Together, these word variables explained a considerable portion of the variance ($R^2 = 0.53$).

As mentioned in the introduction, it has also been found in other studies that Age of Acquisition, and not frequency, is a determinant of naming latencies (Barry et al., 2001; Bonin et al., 2001; Bonin et al., 2002; Pind & Tryggvadóttir, 2002). A possible reason for the lack of a frequency effect (except for Bonin et al., 2002) is the small item set used in these studies. However, the present study used a large item set with 427 pictures, which still did not show a frequency effect. It is of course also conceivable that the frequency effect is of a smaller magnitude in Dutch and that this would be the reason why we did not find an effect. However, this is very unlikely because a frequency effect has been found in Dutch in a word naming task in both primary school children and adults (Brysbaert, 1996; Brysbaert et al., 2000). Importantly, it has also been found in Dutch using a picture naming task (Jescheniak & Levelt, 1994).

A more plausible explanation for the lack of a frequency effect is related to the fact that our target words had a high AOA. Barry et al. (1997) found that there is an interaction between word frequency and AOA. They obtained a significant frequency effect in words with a low AOA but no significant frequency effect in words with a high AOA. Barry et al.'s (1997) stimuli had a mean AOA of 2.46, but our stimuli had a much higher mean AOA (6.09), which was defined in the study of Barry et al. (1997) as late-acquired. Therefore, it seems likely that we did not find a frequency effect because most of our words were acquired relatively late in life.

In the present study there was no significant length effect when the length of the word was determined by the number of letters or phonemes. However, when the length effect was determined by the number of syllables this measure turned out to be a significant predictor of naming latencies. Bates et al. (2003) found that the pattern of word length measures which determined naming latencies was different for each language that was studied: In particular, Bulgarian showed an effect of length in syllables (as did the present study) but several other languages did not, suggesting that these effects are language specific.

Finally, we found a lower name agreement and a higher *H*-statistic compared to the ones found in English in the International Picture Naming Project (Bates et al., 2003) and Snodgrass and Vanderwart (1980). Mar-

tein (1985) obtained similar results and suggested that this was probably due to the richness of dialect variation in the Dutch language (especially in the Dutch-speaking part of Belgium), which results in many different names for one picture. Experimental evidence for this suggestion has been provided by Geeraerts, Grondelaers, and Speelman (1999). In their analysis of two semantic domains, they found that there are more alternative names for a given concept in 'Belgian' Dutch compared to 'Dutch' Dutch. The authors explain this finding by the fact that standardization of the Dutch language in Belgium just started in the 20th century, in contrast, standardization of Dutch in the Netherlands started centuries ago. This difference between 'Belgian' Dutch and 'Dutch' Dutch might limit the representativeness of the present norms for the Dutch language as a whole. Nevertheless, we are convinced that the set is useable for researchers in the Netherlands for many purposes. For example, the pictures with a high name agreement are very well useable, because these tend to have names that are standardized and therefore are identical to 'Dutch' Dutch. Furthermore, we found that the percentage of morphological variants and synonyms in Dutch picture naming is high. This suggests that there are several different names for the same object in Dutch and not so many in English, showing once again that name agreement is language dependent.

chapter 3

Are phonological influences on lexical (mis)selection the result of a monitoring bias?

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[1] This paper was co-authored by Elie Ratinckx, Victor Ferreira and Robert J. Hartsuiker

Abstract

A monitoring bias account is often used to explain speech error patterns that seem to be the result of an interactive language production system, like phonological influences on lexical selection errors. A biased monitor is suggested to detect and covertly correct certain errors more often than others. For instance, this account predicts that errors which are phonologically similar to intended words are harder to detect than ones that are phonologically dissimilar. To test this, we tried to elicit phonological errors under the same conditions that show other kinds of lexical selection errors. In five experiments, we presented participants with high cloze probability sentence fragments followed by a picture that was either semantically related, a homophone of a semantically related word, or phonologically related to the (implicit) last word of the sentence. All experiments elicited semantic completions or homophones of semantic completions, but none elicited phonological completions. This finding is hard to reconcile with a monitoring bias account and is better explained with an interactive production system. Additionally, this finding constrains the amount of bottom-up information flow in interactive models.

Introduction

Though people are extremely good at selecting the words that convey what they want to say, speech errors sometimes occur. As in many scientific domains (from particle physics to psychopathology), such breakdowns in a system can reveal critical properties of the normally functioning system. Competing theories of normally functioning word production differ in whether they assume the production system is interactive (e.g., Dell, 1986) or discrete (e.g., Levelt, Roelofs, & Meyer, 1999). Both classes of theories can explain certain error patterns (e.g., the lexical bias effect, see below), but to do so, discrete theories often need to assume an additional, production-external mechanism, namely a self-monitoring system that covertly "edits out" some errors more than others (see Hartsuiker, 2006, for a critical review of these accounts). The aim of this article is to arbitrate between these classes of theories with respect to one speech error finding, namely the phonological influence on lexical selection errors (Ferreira & Griffin, 2003).

Many theories of language production agree that when speakers want to say something, they first need to activate semantic representations at the conceptual level. Then they have to select lexical-syntactic representations, often named lemmas (Kempen & Huijbers, 1983), which contain syntactic information like a noun's grammatical gender (but note that some theories do not make the lemma/word form distinction, e.g., Caramazza, 1997). The lemma in turn activates the word form. Word form encoding contains two separate processes, one which retrieves the phonological segments and one which retrieves the structure of the word. Discrete models assume that at each production level, a representation must be selected before the selection of the next representation is started at the next level. Furthermore, discrete models forbid feedback from lower levels to higher levels (Levelt et al., 1999). In contrast, interactive models assume that information feeds forward or *cascades* even before an item is selected on a specific level, and there is also feedback from lower levels to earlier levels (Dell et al., 1997). The assumption of discrete models that each step has to be completed before the next step begins is challenged by a range of data (see Vigliocco & Hartsuiker, 2002, for review). However, there is relatively little evidence that argues against the assumption of feedforward-processing only, and most of this evidence comes from speech error patterns (Baars, Motley, & MacKay, 1975; Dell & Reich, 1981; Hartsuiker, Corley, & Martensen, 2005; Nooteboom, 2005; Rapp & Goldrick, 2000; Stemberger, 2004; Vitevitch, 2002). As mentioned above, discrete models can account for such speech-error patterns when invoking a self-monitoring system. To illustrate both kinds of explanations, we will next discuss the lexical bias effect.

The lexical bias effect is the finding that phonological errors are more often real words than nonwords than is expected by chance (e.g., Baars, et al., 1975; Dell & Reich, 1981; Hamm, Junglas, & Bredenkamp, 2004; Hartsuiker, et al., 2005a; Hartsuiker, Anton-Mendez, Roelstraete, & Costa, 2006; Nooteboom, 2005). Interactive models can explain this finding by

using feedback. Suppose a phonological segment becomes wrongly activated (e.g., because of priming or because of noise in the system). In conjunction with the other segments of the word, it will then send feedback to the lexical level. This means that segments belonging to existing words, and in particular for phonological neighbors of the target word, become highly active, so they are relatively likely to be produced. Conversely, because nonwords do not have lexical representations, feedback will never converge upon a nonword representation, so that segments belonging to nonwords are less likely to be produced (e.g., Dell, 1986).

In contrast, discrete models explain the lexical bias effect by assuming an internal self-monitor that inspects internal speech for errors and that attempts to filter these errors out before they are pronounced. One criterion that the self-monitor can use is lexicality. Because nonword errors fail this criterion, they have a higher chance of being detected and hence of being covertly replaced with the correct word. Word errors, on the other hand, pass the lexicality criterion, and can thus more easily slip through. As a result, unrepresentative numbers of word errors will be overtly produced, even though there were chance-level numbers of each error prior to monitoring (Baars et al., 1975; Levelt et al., 1999; Roelofs, 2004; Nooteboom, 2005).

Similar "monitoring bias" accounts have been presented for other speech error patterns that appear to reveal interactivity. For example, the mixed error bias (the tendency for speech errors to be related in both form and meaning to intended words), can be explained by feedback from the word form to the lemma level (e.g., Rapp & Goldrick, 2000). But the mixed error bias could also be explained by a monitoring bias account, under the assumption that it is more difficult to detect a semantic error when it is phonologically similar to the target word than when it is phonologically different from the target word (Levelt et al., 1999; Roelofs, 2004). The purpose of the present study is to test whether a monitoring bias account or an interactive account holds for another phonological effect on lexical selection, namely the effect that the partial activation of a particular word (e.g., *none*) triggers lexical selection errors when the target word (*priest*) is semantically related to a homophone of the primed word (*nun*; Ferreira & Griffin, 2003).

In particular, Ferreira and Griffin (2003) presented speakers with highly constraining sentence fragments, followed by a picture. Participants read the sentence fragments and then named each picture. The dependent variable was the frequency with which participants produced the sentence completion instead of the correct picture name. The sentence fragments were constructed so that on critical trials, the most obvious completion was semantically related to the picture, a homophone of the semantically related word, or an unrelated control word. For example, given a picture of a *priest*, a semantic competitor sentence was: *The woman went to the convent to become a…* and a homophone competitor sentence was: *I thought that there would still be some cookies left, but there were….* Speakers produced more sentence completions (i.e., *nun* or *none*) in sen-

tences that primed the semantically related word or the homophone of the semantically related word compared to unrelated sentences.

Under the assumption that the word forms of the homophone are shared (Biedermann, Blanken, & Nickels, 2002; Cutting & Ferreira, 1999; Jescheniak, Meyer, & Levelt, 2003; Note, however, that there is also evidence for separate word forms for both meanings of the homophone Caramazza, Costa, Miozzo & Bi, 2001), interactive models explain the results found in the homophone condition by claiming that the competitor sentence activates the concept and the lemma of the homophone *none*, and then the shared *nun/none* word form. This shared word form then feeds activation back to the lemma of the other meaning of the homophone *nun*. This other meaning of the homophone also receives some activation from the concept corresponding to the picture *priest*, due to the semantic relation between these two (Figure 1). Because feedback from the word form and the activation from the picture converge on the lemma of the sentence completion *nun*, it will be mistakenly selected more often than the lemma for an unrelated completion.

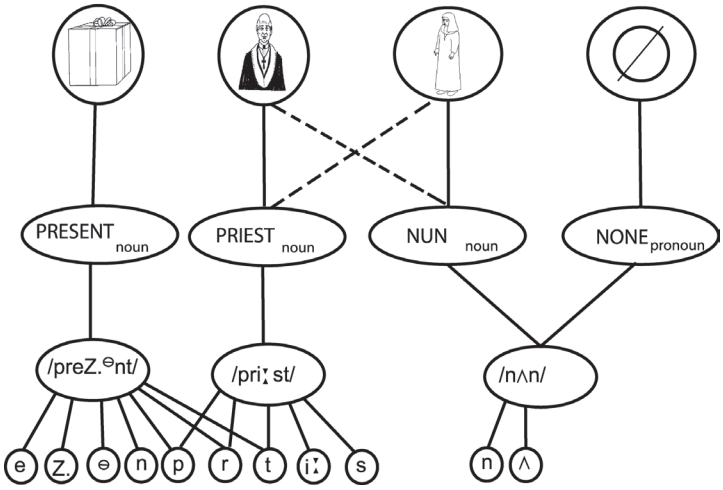

Figure 1. General model of language production based on Ferreira and Griffin (2003) and Cutting and Ferreira (1999). Representation of a homophone pair (***nun and none)***, and for one meaning of the homophone a semantic competitor (***priest***) is shown. Furthermore, the representation of two phonologically related words (***present and priest)*** is shown. Connections from concepts to semantically similar lemmas are represented by dashed lines.

Ferreira and Griffin's data can also be explained by a discrete model if one assumes that it is harder for the monitor to detect that the homophone was wrongly selected compared to unrelated words. Assume that in the homophone condition, the production process selects the phonologi-

cal representation of *none*. Before *none* (or *nun*) is articulated, the monitor will attempt to determine if it was erroneously selected. Critically, the monitor may have difficulty detecting the error, essentially because the second meaning of the homophone *nun* and the picture *priest* are semantically related. One possibility is that a comprehension-based monitor may have access only to the phonology (and not the semantics) of the originally selected form *nun/none*. If so, then the monitor may determine that *nun* had been selected, which because of its semantic similarity to the target *priest* (Hartsuiker, Pickering, & De Jong, 2005), may be permitted by the monitor. In fact, the monitor's determination that *nun* had been selected may be promoted because *nun* will have additional activation at a conceptual and lemma level, due to activation spreading from *priest*. Furhermore, when comprehension mechanisms process *none*, exhaustive access (Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979) may cause the *nun* form to become even more activated. All of these influences make it harder for the monitor to detect the error, under the assumption that the self-monitor checks whether the word recognized in comprehension matches an activated concept (Roelofs, 2004). When both words are unrelated, there is no match at the semantic level (as a result of the comprehension process or otherwise) and thus, more unrelated words are filtered out before they are erroneously pronounced.

This account, however, makes a further prediction. Consider a sentence context that primes a word that is phonologically related to the target, for example *For his birthday David got a huge … [picture: priest]*. According to a monitoring bias account, the monitor should find it more difficult to detect the error present compared to an unrelated word. This is because *priest* is in the comprehension cohort of *present* as a result of the shared initial two phonemes, so that as a comprehension-monitor processes present, the lexical and conceptual representations of *priest* will become activated (Zwitserlood, 1989). Thus, according to a comprehension-monitor account, cohort-primed activation should act just as exhaustive-access-primed activation does in the homophone case. This predicts that phonologically related completions should occur more frequently than unrelated completions.

There is of course a difference between the homophone condition and the phonological condition: In the homophone condition there is semantic activation of *nun* from the picture *priest*, but in the phonological condition there is no semantic activation of *present* from the picture *priest*; there is only the cohort-primed activation. However, our phonological case is still comparable to the explanation of the mixed error bias of Roelofs (2004). According to Roelofs (2004), the mixed error bias occurs because all else equal, the substitution *calf* for *cat* is more likely than *pig* for *cat*, because when the perceptual system processes *calf*, it will activate a cohort of similar sounding words including the target *cat*. This makes it more likely that the monitor will incorrectly accept *calf* as a correct production. Although in the mixed error bias there is a semantic relation between the error and the target, the same is true for phonologically unrelated semantic errors

and these are less frequent. The monitoring bias account can therefore only explain the mixed error bias on the basis of the phonological similarity in the mixed errors.

Additionally, Slevc and Ferreira (2006) provided empirical support for the hypothesis that the internal monitor inspects the phonological level to check errors during production. In a picture naming study, participants were sometimes presented with the picture's name or with phonologically related, semantically related, or unrelated words. These words were presented visually or auditory. If no word was presented or if the word was the same as the picture's name, participants had to continue to name the picture, but if the words were different, participants had to stop naming. Slevc and Ferreira found that stopping the production of the word was sensitive to phonological similarity, but not to semantic similarity. These results support the hypothesis that at least under some conditions, the monitor checks accuracy by assessing phonological similarity. If monitoring bias accounts are correct that the internal self-monitor is responsible for the higher number of sentence completions in the homophone condition, then one would also expect more sentence completions when the picture and the word primed by the sentence are phonologically related.

Interactive models might also expect that there are more sentence completions when there is a phonological relation, but this depends on the extent to which interaction is limited or unbounded (Goldrick, 2006). To explain phonological completions in the present paradigm, one needs to assume a relatively unbounded amount of cascading, so that the competitor sentence in our earlier example will activate the *present* concept, and activation will flow through the lemma level and then to the word form level. Meanwhile, the picture activates the concept *priest* and again it activates the corresponding lemma, word form and then its phonological segments. The first two phonological segments are the same for both words, thus through feedback the word form *present* gets some activation from the segments activated by *priest*, which adds to activation this word form may have from the cascading process. For the segments of *present* to win the competition for selection, a further cascading step is necessary, namely from word form to segments (Figure 1). Note, however, that this requires that the word form present maintains its activation (which cascaded to it from the concept and via the lemma) for a relatively long time, namely until the phonological segments for *priest* have been activated. Additionally, the activation has to cascade rather far (from concept to lemma to word form to segments). Based on neuropsychological data, simulation data and chronometric data, Goldrick (2006) concluded that interaction has to be limited. Taking into account that there are limitations on interactivity (Dell & O'Seaghdha, 1991; Goldrick, 2006), it is possible that in this paradigm phonological completions do not occur more often than unrelated completions.

To test for a phonological completion effect, we carried out five experiments. The first four experiments were conducted in Dutch. These experiments used phonological competitor sentences (*present-priest*)

and semantic competitor sentences (*nun-priest*). The last experiment was carried out in English with phonological competitor sentences and homophone-of-semantic-competitor sentences (*none-priest*; from now we will refer to this as simply "homophone competitor sentences"). A discrete model with internal self-monitoring predicts more sentence completions in the phonological competitor sentences compared to the unrelated competitor sentence. In both the semantic and homophone competitor conditions we expect to replicate the findings of Ferreira and Griffin (2003), namely, that both types of related competitor sentences will elicit more sentence completions than unrelated sentences do.

Experiment 1

Method

Participants
Eighteen native Belgian Dutch speakers (17 females and 1 male) participated in the experiment. All were first year psychology students at Ghent University and participated in exchange for course credit, had normal or corrected-to-normal vision, and did not have any speaking disability.

Materials
One-hundred-ninety pictures were selected from a database of normed pictures (Severens, Van Lommel, Ratinckx, & Hartsuiker, 2005). Each picture had a name agreement of at least 70%. For each picture we constructed two high cloze probability sentences. The last word of these sentences was either phonologically or semantically related to the picture. The mean length of the semantically related sentences was 8.9 words (range of 3 to 18 words) and of the phonologically related sentences 8.2 words (range of 3 to 16 words). Phonologically related words had the same first two phonemes as the pictures. This degree of overlap is at least as strong as the degree of overlap in which the mixed error effect has been found (Dell & Reich, 1981; Martin, Gagnon, Schwartz, Dell, & Saffran, 1996). Importantly, this shows that there is enough phonological overlap to activate the monitor. Care was taken that the phonologically related words were not semantically related and vice versa. Furthermore, the grammatical gender of the last word of the sentence and the picture were always the same (note that Marx, 1999 and Vigliocco, Vinson, Indefrey, Levelt, & Hellwig, 2004 found grammatical gender-influences on the frequency of semantic substitution errors). All the picture names and the phonologically related and semantically related words used in this experiment are shown in Appendix B.

In a pretest, 45 participants from the same population (who did not participate in any of the main experiments reported here) were asked to complete the sentence fragments. All the sentence fragments were finished with the word we expected in at least 75% of the trials. Mean sen-

tence completion in the semantic related sentence fragments was 89.5% and in the phonologically related sentence fragments 90.6%. There was no significant difference in sentence completion between phonological and semantic competitor sentences ($t(378) = -1.39$, $p = 0.166$).

To create an unrelated condition, all the related sentence fragments were paired with another picture. Care was taken that none of the words were either semantically or phonologically related to the pictures. Additionally, there were also 190 filler sentences. These sentences were highly constrained, followed by a picture which corresponded to the last word of the sentence. The pictures used in the filler sentences were never used in one of the experimental conditions.

Procedure

The participants were seated in front of a computer screen and signed an informed consent sheet. First there was a practice session in which participants were familiarized with the experimental procedure. Trials started with the 500 ms presentation of a fixation cross ("+") followed by the first word of the sentence fragment. Sentence fragments were presented word-by-word in the middle of the computer screen in red on a black background. Each word remained on the screen for 275 ms. The final word of the sentence was always replaced with a picture. The pictures were black-and-white line drawings. The participants were instructed to attentively read the sentences and not to complete it but to name the picture. The picture disappeared when the voice-key registered a response. The intertrial interval was 1500 ms. Stimulus presentation and response recording was controlled by E-prime (Psychology Software Tools, Inc., Pittsburgh, USA; www.pstnet.com/eprime). Oral responses were recorded with a mini-disc recorder.

Design and analyses

Two lists were constructed that consisted of 95 phonologically related and 95 semantically related trials each. Sentences were never repeated within a participant, thus the remaining 95 phonological and 95 semantic sentences were used in the unrelated condition. Each sentence fragment that occurred in the related condition in one list occurred in the unrelated condition in the other list and vice versa. Each list also contained 190 filler sentences, in which the picture corresponded to the expected sentence completion.

The dependent measure was the percentage of trials per condition in which the participants completed the sentence instead of naming the picture. We carried out two 2 x 2 repeated measures ANOVAs with type of relation (semantic or phonological) and relatedness (related or unrelated) with subjects (*F1*) and items (*F2*) as random variables. Differences were considered significant if *p* values were less than .05. Arcsine-transformed proportions yielded the same results as reported here.

Results

Figure 2 shows the percentages of sentence completions speakers produced in the semantically related, phonologically related, and corresponding unrelated conditions. Both the main effects and the interaction were significant (type of relation: $F1(1,17) = 23.54$, $MSE = .85$, $p < .0001$; $F2(1,189) = 12.26$, $MSE = 17.18$, $p < .01$; relatedness: $F1(1,17) = 26.87$, $MSE = 1.01$, $p < .0001$; $F2(1,189) = 15.85$, $MSE = 18.08$, $p < .0001$; type of relation x relatedness: $F1(1,17) = 31.15$, $MSE = .71$, $p < .0001$; $F2(1,189) = 13.76$, $MSE = 17.05$, $p < .0001$). There were significantly more sentence completions in the semantically related condition (2.4%) than in the semantically unrelated condition (0.1%), $F1(1,17) = 32.08$, $MSE = 1.54$, $p < .0001$ and $F2(1,189) = 15.37$, $MSE = 33.83$, $p < .0001$. There was no reliable difference between the phonologically related condition (0.2%) and the unrelated condition (0.1%), $F1 < 1$; $F2 = 1.0$.

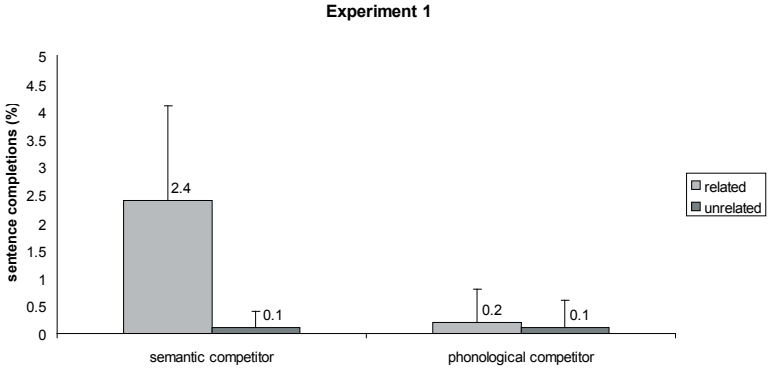

Figure 2. Percentages of sentence completions for the semantic and phonological competitor sentences in both the related and unrelated conditions. Error bars indicate standard errors of the mean.

Discussion

There were significantly more sentence completions in the semantically related condition than in the unrelated condition. This is a replication of the findings of Ferreira and Griffin (2003). There was no difference in percentage of sentence completions between the phonologically related and unrelated condition. This finding is at odds with the prediction that we derived from a monitoring bias account; if there is a biased monitor there should have been more sentence completions in the phonologically related condition due to the monitoring failing to filter out errors that are phonologically similar to the target. An interactive account would also predict that there are more sentence completions in the phonologically related condition, due to feedback from the phonological segments to the word-form, but as mentioned in the introduction, if interaction is

limited it might be that there is no phonological effect. However, before we conclude that there is genuinely no effect of phonological relatedness in this paradigm, it is important to note that the percentage of sentence completions found here (2.4% in the semantically related condition) were rather low (cf. Ferreira & Griffin, 2003, Experiment 1 to 3: 19.5%, 18.4%, 15.3%). Because the percentage of sentence completions was low in our benchmark condition, it is conceivable that any effect in the phonological condition was too weak to surface.

There are two potential reasons for this low percentage of sentence completions. First, in the current experiment participants saw each picture four times. Possibly, this repetition makes picture naming so easy that only few completion errors occur. Second, only one-third of the sentences were filler sentences, so that in two-third of the sentences the picture name was not a good completion of the sentence. This may have led the participants to anticipate that the picture would not complete the sentence, and therefore to pay relatively little attention to the word primed by the sentence context.

In the next experiment, we therefore removed one unrelated condition (note that Experiment 1 had separate unrelated conditions for the semantic and phonological conditions) and replaced it by 95 filler sentences. Hence, half of the sentences were followed by the correct pictures and half of the sentences by incorrect pictures. Additionally, the pictures were only repeated three times.

Experiment 2

Method

Participants
Twenty first year psychology students from Ghent University (16 females and 4 males) participated in exchange for course credit. They all had normal or corrected-to-normal vision, and did not have any speaking disability; all were native Belgian Dutch speakers.

Materials
The same materials were used as in Experiment 1, with the exception that one unrelated condition was now replaced by filler sentences. Therefore, in half of the trials the expected sentence completions were the names of the corresponding pictures.

Procedure
The same procedure was used as in Experiment 1.

Design and analyses
Two lists were constructed that consisted of 95 phonologically and 95

semantically related sentences. Half of the remaining phonologically and semantically related sentences were presented with an unrelated picture to create the control condition, which primed an unrelated word. This resulted in 95 control sentences. The sentences that were not used in one list as phonologically or semantically related sentences were used in the other list. Sentences were never repeated within a participant. Each list also contained 285 filler sentences, which ended in the corresponding pictures.

As in the previous experiment, the dependent measure was the percentage of trials per condition in which the participants completed the sentence rather than named the picture. Two repeated measures ANOVAs with Type of relation (semantic, phonological or unrelated) as a factor were carried out, one with participants (*F1*) and one with items (*F2*) as a random variable. Arcsine-transformed proportions yielded the same pattern of significance as reported here.

Results

Figure 3 shows the percentages of sentence completions speakers produced in the semantically related, phonologically related, and unrelated conditions. The main effect of type of relation was significant, $F1(2,38) = 23.81$, $MSE = 1.41$, $p < .0001$ and $F2(2,378) = 25.97$, $MSE = .001$, $p < .0001$. There were 2.3% of sentence completions in the semantically related condition, 0.2% in the phonologically related condition and 0.0% in the unrelated condition. The difference between the semantically related and the unrelated condition was significant $F1(1,19) = 26.58$, $MSE = 2.02$, $p < .0001$ and $F2(1,189) = 29.26$, $MSE = .002$, $p < .0001$. There was no significant difference between the phonologically related and the unrelated condition ($F1(1,19) = 3.35$, $MSE = .15$; $F2(1,189) = 3.03$, $MSE = .0002$).

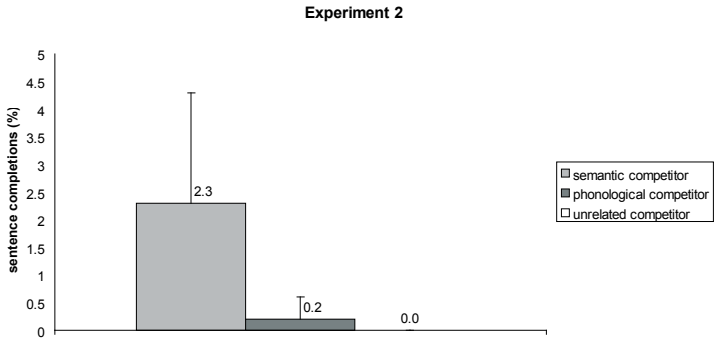

Figure 3. Percentages of sentence completions for the semantically related, phonologically related and unrelated competitor sentences. Error bars indicate standard errors of the mean.

Discussion

Again the percentages of sentence completion differed between the semantically related and unrelated conditions but there was no difference between the phonologically related and unrelated conditions. These results replicate (with very similar numbers) those of Experiment 1. Thus, the results do not seem to be affected by a difference in the number of repetitions of each picture (3 vs. 4) or by the proportion of trials in which the picture name was identical to the sentence completion (1/2 vs. 1/3). Note, however, that the percentage of sentence completions in the semantically related condition (2.3%) is still very low (cf. Ferreira & Griffin, 2003, Experiment 1 to 3: 19.5%, 18.4%, 15.3%). It is thus possible that we did not find a difference between the phonologically related condition and the unrelated condition because the production system did not make any errors. According to a monitoring account at least, if there are no phonologically similar errors to filter out, there should be no difference between the phonologically similar and the unrelated conditions. Note however, that the results are at odds with an unbounded interactive account.

In the next experiment, we used time-pressure to attempt to elicit more sentence completions. Several studies have found that by increasing time pressure, participants make more errors during speech production (Dell, 1986; Vitkovitch & Humphreys, 1991; Oomen & Postma, 2001). Oomen and Postma (2001) suggested that the internal self-monitor works normally under time pressure as they showed that speech errors were interrupted and corrected more quickly in a fast-speech compared to a normal-speech condition. Thus, a monitoring bias account still predicts more phonological completions compared to unrelated completions. Similarly an unbounded interactive account would also predict more phonological completions.

Experiment 3

Method

Participants

Eighteen native Belgian Dutch speakers (12 females and 6 males) participated in the experiment. All were first year psychology students at Ghent University; they received course credit for their participation. They all had normal or corrected-to-normal vision, and did not have any speaking disability.

Materials

The same material was used as in Experiment 2.

Procedure

The same procedure was used as in the previous experiments, but now

there was a deadline for naming the picture. Each picture was presented for 600 ms and participants were instructed to name the picture before it disappeared. Their response was registered for a further 900 ms, during which a blank screen was presented. When the voice-key detected a response or when the 900 ms period ended, there was a blank screen for 1500 ms.

Design and analyses

The same analyses were carried out as in Experiment 2. Arcsine-transformed proportions yielded the same pattern of significance as reported here.

Results

Figure 4 shows the percentages of sentence completions speakers produced in the semantically related, phonologically related, and unrelated conditions. Type of relation was significant, $F1(2,34) = 35.09$, $MSE = 11.54$, $p < .0001$ and $F2(2,378) = 36.77$, $MSE = 116.29$, $p < .0001$. There were 14.5% of sentence completions in the semantically related condition, 6.3% of sentence completions in the phonologically related condition, and 6.3% in the unrelated condition. The difference between the semantically related and the unrelated condition was significant, $F1(1,17) = 44.59$, $MSE = 13.53$, $p < .0001$ and $F2(1,189) = 41.23$, $MSE = 154.43$, $p < .0001$. There was no significant difference between the phonologically related and the unrelated condition, $F1 < 1$ and $F2 < 1$.

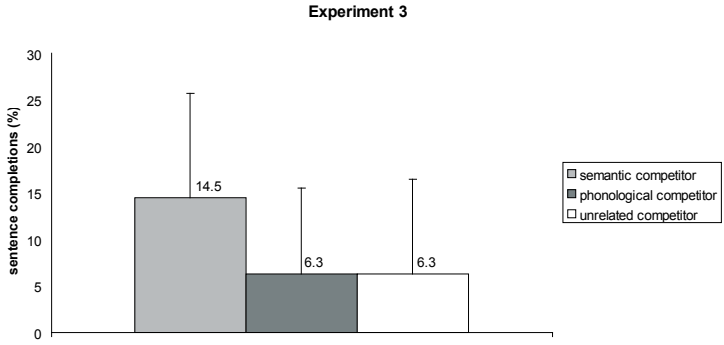

Figure 4.
Percentage of sentence completions for the semantically related, phonologically related, and unrelated competitor sentences. Error bars indicate standard errors of the mean.

Discussion

The change in procedure used in this experiment (adding time pressure) was successful in increasing the percentage of sentence completions. However, there was still no difference in sentence completion rate between the phonologically related condition and the unrelated condition. Even though a sizable number of errors were observed in the phonologically similar and unrelated conditions, the lack of a difference between these two conditions suggests the monitor does not filter out fewer errors in the phonologically similar condition. Also, as before, this finding is at odds with an unbounded interactive account. Similar to the previous experiments, there was a reliable difference between the semantically related and the unrelated condition.

Name agreement of our pictures was relatively low (70% and higher). Therefore it is possible that we did not find a phonological effect because a number of the pictures simply did not activate the right phonology. To explore this, we reconducted the analyses with the pictures which had a name agreement of 90% or higher (124 pictures). Type of relation was significant, $F1(2,34) = 17.04$, $MSE = 15.80$, $p < .0001$ and $F2(2,246) = 17.49$, $MSE = 106.04$, $p < .0001$ There were 13.1% of sentence completions in the semantically related condition, 6.1% in the phonologically related condition and 6.7% in the unrelated condition. The difference between the semantically related and the unrelated condition was significant, $F1(1,17) = 20.44$, $MSE = 17.81$, $p < .0001$ and $F2(1,123) = 18.09$, $MSE = 138.69$, $p < .0001$. There was no significant difference between the phonologically related and the unrelated condition, $F1 < 1$ and $F2 < 1$. These results show that even if pictures with a high name agreement were used there is still no difference between the phonologically related and the unrelated condition. This shows that the lack of a difference can not be the result of activating the wrong phonology.

In contrast to the predictions of the monitoring bias account and of an unbounded interactive account, three experiments thus far observed no difference between the numbers of phonologically related and unrelated completions in this paradigm. As a control experiment, we asked the participants to first complete the sentence and then name the picture. This way, we can ascertain that under experimental circumstances that are almost identical to the previous experiments, the final word elicited by each sentence fragment was indeed phonologically (or semantically) related to the picture names.

Experiment 4

Method

Participants

Twenty first year psychology students of Ghent University (12 females and 8 males) participated in exchange for course credit. All were native

speakers of Belgian Dutch, had normal or corrected-to-normal vision, and did not have any speaking disability.

Materials
The same material was used as in Experiment 3.

Procedure
The sentence presentation was the same as in the previous experiments, but now the sentences were followed by dash marks that stayed on for 1500 ms. Participants were instructed to complete the sentence. When the voice-key registered a response the dash-marks disappeared from the screen. There was a blank screen for 2000 ms followed by a fixation point ("*") for 500 ms and then the picture was shown for 600 ms, followed by another blank screen for 900 ms. Again participants were to name the picture before it disappeared; when the voice-key registered a response, the picture or the blank screen disappeared. Intertrial interval was 1500 ms.

Design and analyses
As dependent measures we used the percentage of correct sentence completions and the percentage of pictures which were named erroneously with the last word of the sentence (only for the correctly completed sentences). The same analyses were carried out as in Experiment 3. As in previous experiments, arcsine-transformed proportions yielded the same pattern of significance as reported here.

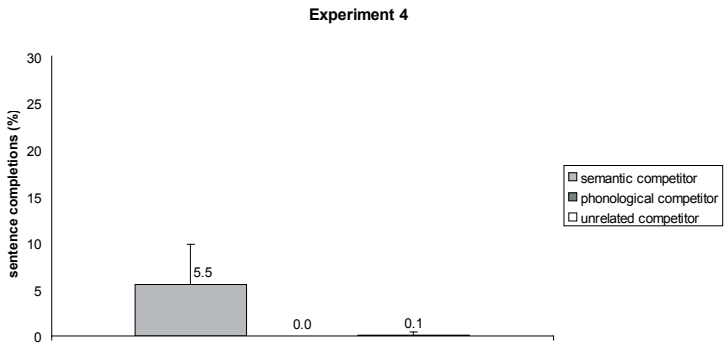

Figure 5. Percentages of sentence-completions for the semantically related, phonologically related, and unrelated competitor sentences. Error bars indicate standard errors of the mean.

Results

In the phonological, semantic and unrelated competitor sentence, there were respectively 87.3%, 87.1% and 87.1% correct completions; there was no significant effect of type of relation, $F1 < 1$ and $F2 < 1$.

Figure 5 shows the percentage of trials in which the pictures were named with the sentence completions in the semantically related, phonologically related, and unrelated conditions. There was a significant effect of type of relation $F1(2,38) = 31.78$, $MSE = 5.47$, $p < .0001$ and $F2(2,378) = 43.66$, $MSE = 37.83$, $p < .0001$. In the semantically related condition there were 5.2% of sentence completions, there were 0.0% of sentence completions in the phonologically related condition and 0.1% in the unrelated condition. The semantically related condition differed significantly from the unrelated condition $F1(1,19) = 32.28$, $MSE = 15.81$, $p < .0001$ and $F2(1,189) = 43.35$, $MSE = 111.90$, $p < .0001$. There was no significant difference between the phonologically related and the unrelated condition ($F1(1,19) = 2.11$, $MSE = .11$; $F2(1,189) = 2.00$, $MSE = 1.05$).

Discussion

The completion data showed that the sentence fragments were very successful in eliciting the expected completions and that the expected completion rate was very comparable in each condition (condition means varied from 87.0% to 87.3%). This demonstrates clearly that the lack of phonological completions in the naming of the pictures cannot be attributed to the sentence contexts priming other, unrelated words, from the ones we were expecting. Additionally, it shows that phonological sentences did not prime their completions more weakly than the semantic sentences did and this thus cannot cause the lack of phonological completions.

The rate of sentence completions, instead of naming the picture, was lower compared to Experiment 3, even though there was still a deadline. It is possible that the completion rate diminished because there was now a longer time interval between reading the sentence and naming the picture. As a result, the activation level of the sentence completion's lexical representations may have decayed, so that these representations can exert less of an influence on picture naming. Additionally, the errors (sentence completions, instead of picture naming) in this experiment are a different kind of error compared to the ones in the previous experiments: they are perseverations instead of substitutions. Participants have already finished the sentence with the same word as they erroneously used for the picture. It may be that perseverations occur less often then substitutions. In a Dutch corpus of spontaneous speech errors only 4.5% of the whole word errors were perseverations, in contrast to 59.1% anticipations and 36.4% transpositions (Nooteboom, 1969).

Importantly, the picture naming data nicely replicate the previous experiments. There were more sentence completions in naming the pictures following a semantically related competitor sentence than following an unrelated competitor sentence. Again, there was no difference between naming the picture following the phonological competitor sentence and the unrelated competitor sentence.

The previous experiments were carried out in Dutch, complicating a direct comparison with Ferreira and Griffin's (2003) study, which was

conducted in English. It has been suggested that there are cross-linguistic differences in patterns of speech errors (e.g., Del Viso, Igoa, & García-Albea, 1991; Hartsuiker, 2002; but see Hartsuiker et al., 2006). It is thus a theoretical possibility that phonological completions do not occur in Dutch but do occur in English. Additionally, there were slight procedural differences between Experiments 1-4 and Ferreira and Griffin's study. Furthermore, it is possible that we did not find phonological completions because having only two phonemes similar might simply not be enough. Experiment 5 therefore attempted to elicit phonological completions in English using exactly the same procedure as Ferreira and Griffin in their third experiment. Furthermore the phonological overlap between the picture and the last word was larger than two phonemes.

Because Dutch has a relatively transparent orthography and therefore few homophones, we used a semantic related benchmark condition in the Dutch experiments. In the English experiment we used a homophone condition, instead of a semantically related condition, to once more replicate the homophone effect.

Experiment 5

Method

Participants

Forty-eight undergraduates of the University of California, San Diego participated in exchange for course credit. All reported that they were native English speakers.

Materials

The same 24 black-and-white line drawings were used as in the Ferreira and Griffin study (2003). For each drawing, there was a homophone competitor sentence (with control sentences determined by re-assignment – see below). These were also the same as in the previous study. Additionally, we constructed 24 phonological competitor sentences. These sentences ended in a word that was phonologically similar to the picture. We selected phonologically similar words both by searching dictionaries for similar sounding words, and by presenting the names of the target pictures to 24 participants and asking them to come up with up to three words that sounded similar to the picture names. Note that this was done to have more phonological overlap than in the previous experiments. Then, sentences were constructed that ended in a large set of possible phonologically related words. These sentences were presented without the last word to a different group of 24 participants who were asked to complete the fragments. The final set of sentences was determined by jointly considering how strong the phonological similarity was to the target picture and how well the designed sentence elicited the phonologically similar form. The picture names, the phonologically related and the

homophone words used in this experiment can be seen in Appendix C.

To generate control sentences, sentences that elicited similar competitors (both homophone and phonologically similar ones) were re-assigned to different critical pictures that were not similar. This strategy controls for the possibility that some sentences will strongly elicit competitor intrusions irrespective of the similarity of the competitor to the target (because the same sentences are used both in similar and in control conditions). Finally, there were 32 filler sentences, which were highly constrained sentences followed by blank lines instead of a picture.

Procedure

The participants were seated in front of a computer screen and signed an informed consent sheet. First there was a practice session in which participants were familiarized with the experimental procedure. The experiment was administered with PsyScope 1.2.5 (Cohen, MacWhinney, Flatt, & Provost, 1993). Trials started with the 500 ms presentation of a fixation cross ("+") followed by the first word of the sentence fragment. Sentence fragments were presented word-by-word in the middle of the computer screen. Each word stayed on for 275 ms. The final word of the sentence was never shown, but on critical trials, a picture appeared instead. The participants were instructed to name the picture. The picture disappeared when the voice-key registered a response. The intertrial interval was 2000 ms. The filler sentences were followed by blank lines instead of pictures, and the participants' task was to complete the sentence as quickly as possible. This procedure was identical to that of Ferreira and Griffin (2003; Experiment 3).

Design and analyses

We constructed four counterbalanced lists, so that each picture occurred once with each sentence type (homophone related, homophone unrelated, phonologically related and phonologically unrelated) across the lists. Each list contained six trials of each sentence type and 32 filler sentences.

The dependent measure was the percentage of trials per condition in which the participants completed the sentence rather than named the picture. We performed two 2 x 2 repeated measures ANOVAs with Type of relation (homophone or phonological) and Relatedness (related or unrelated) as factors. One analysis treated participants as a random factor (*F1*) and one treated items as a random factor (*F2*). Differences were considered significant if *p* values were smaller than .05. Arcsine-transformed proportions yielded the same pattern of significance as reported here.

Results

Figure 6 shows the percentage of sentence completions. There was a main effect of type of relation ($F1(1,47) = 21.11$, MSE = 49.96, $p < .0001$; $F2(1,23) = 6.18$, $MSE = 73.19$, $p < .05$) and of relatedness ($F1(1,47) = 21.87$, $MSE = 41.34$, $p < .0001$; $F2(1,23) = 5.43$, $MSE = 97.09$, $p < .05$), and the

interaction was significant as well ($F1(1,47) = 12.76$, $MSE = 904.23$, $p < .01$; $F2(1,23) = 6.44$, $MSE = 70.17$, $p < .05$). There were significantly more sentence completions in the homophone related condition (10.1%) than in the homophone unrelated condition (1.4%), $F1(1,47) = 18.01$, $MSE = 100.41$, $p < .01$ and $F2(1,23) = 6,59$, $MSE = 137.32$, $p < .05$. There was no difference between the phonologically related and unrelated conditions (both 1.0% sentence completions), $F1 < 1$ and $F2 < 1$.

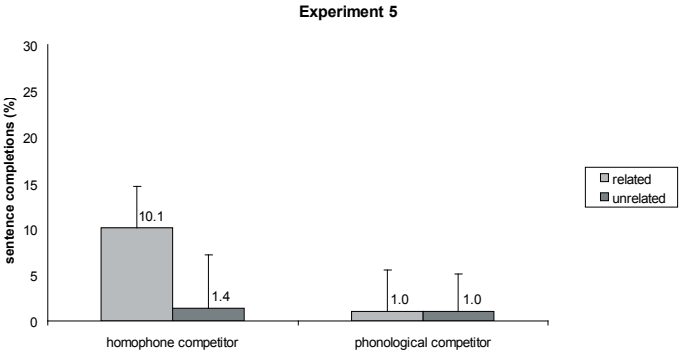

Figure 6. Percentages of sentence completions for the homophone and phonological competitor sentences in both the related and unrelated condition. Error bars indicate standard errors of the mean.

Discussion

The homophone conditions replicated the results of Ferreira and Griffin (2003). Significantly more sentences were erroneously completed in the related than the unrelated homophone condition. The homophone effect has now been found four times: Experiments 1, 2, and 3 of Ferreira and Griffin (2003) and Experiment 5 of the current study. In contrast, there again was no difference between the phonologically related and unrelated condition in the number of sentence completions, showing that the previous null effects were not the result of the Dutch language, of the procedure used in these experiments, or of a smaller phonological overlap.

General Discussion

In none of the five experiments reported here were there more phonological sentence completions than unrelated sentence completions. In contrast, clear effects were observed in the semantic competitor conditions (Experiments 1-4) and in the homophone of a semantic competitor condition (Experiment 5). Together these results show that the paradigm was able to elicit sentence completions in the semantic and homophone conditions, but not in the phonological condition.

The homophone effect alone can be explained by interactive models, by using feedback from the word form. Discrete models can only explain this effect by using a comprehension-based internal self-monitor, which inspects speech for errors. If the larger number of homophone completions than unrelated completions is caused by the internal self-monitor, one would expect that there are also more completions after phonological competitor sentences. A sentence completion in this case would activate the cohort in comprehension in which there is also the picture name (Roelofs, 2004), so that it would be harder for the monitor to detect that the sentence was completed instead of the picture named. Our experiments did not find more phonological sentence completions than unrelated completions, which is hard to reconcile with the monitoring bias account. Indeed, it would be very unsatisfactory if the internal monitor has to be invoked to explain the homophone completions but is then not used in the phonological condition, especially because the internal error-monitor has been shown to be sensitive to phonological information (Slevc & Ferreira, 2006). Furthermore, the effect of the cohort mechanism on monitoring specifically has been implicated in discrete accounts of mixed error effects; if such accounts hold, then phonologically similar intrusions should have appeared in the present task. Of course it can be argued that there are no intrusions in the phonological condition because these errors are simply not made by the production system and as a result there would be nothing to filter out by the monitor. However, Experiment 3 showed that with time-pressure there are intrusions in the phonological condition, and so by the monitoring account, a difference between the unrelated sentence completions and the phonological sentence condition should have been observed. The fact that we do not find this difference shows that the monitor does not filter fewer intrusions out in the phonological competitor condition even when there are such phonological intrusions.

An interactive language production theory might also predict that there should be more phonological completions than unrelated completions. In an interactive system the sentence will activate the concept, the lemma, the word form and the phonological segments of the last primed word. At the same time, the picture will activate its concept, lemma, word form, and phonological segments. The phonological segments of both the word and the picture will feed back to the word form of both the word and the picture. This will cause competition at the word form level and as a result we would expect errors. But it has been argued before that feedback is limited (Dell & O'Seaghdha, 1991; Goldrick, 2006) and thus it is possible that this feedback is not strong enough to cause errors.

Why then are there more sentence completions in the homophone competitor condition and not in the phonological competitor condition? Remember that in the homophone competitor condition, activation only has to flow to the word form to be able to cause competition. Similarly, to be able to cause mixed errors, information also has to flow only to the word form level. In the phonological competitor condition, activation has to go one step further to the phonological segments, and it is apparently

too weak to cause any detectable competition. Furthermore, the word form of homophone alternatives is a single, fully overlapping representation. In contrast, phonologically similar words overlap only in a fraction of the segmental contents of those words. This also suggests that interactive effects should be weaker for phonologically similar words, compared to homophones. In line with this, Goldrick (2006) concludes that interaction in speech production is limited, but what the upper and lower limits on feedback are is still unresolved. Current data support the conclusion that feedback is limited; if feedback from the phonological segments to the word form was strong there would have been phonological errors in this paradigm.

The issue of whether feedback or self-monitoring is responsible for certain speech error patterns has received much attention in recent years. In their review of the production literature, Vigliocco and Hartsuiker (2002) rejected the assumption that activation only flows to the next level when processing at the current level is complete. They did so on the basis of a fairly large number of studies that have found evidence for cascading of activation. In contrast, Vigliocco and Hartsuiker could not reject the assumption of a unidirectional flow of activation, precisely because of the account of discrete models of speech error patterns that seem to argue for interactivity in terms of a monitoring bias. Note however that Vigliocco and Hartsuiker did, albeit tentatively, argue for feedback, on the basis of a number of theoretical arguments (e.g., they assume that there is continuity between development and processing; in contrast, Levelt, 1989 admits a role of feedback in the developing system, but he assumes that this has disappeared in the mature system).

Additionally, Hartsuiker (2006) considered the tenability of specific monitoring bias accounts, based on theoretical and empirical criteria. For example, if it is true that a given speech error pattern is caused by self-monitoring, one would expect it to be affected by manipulations that reduce the quality of monitoring, such as adding a secondary task. On the basis of this exercise, he concluded that a monitoring bias account cannot be excluded in the case of the lexical bias and mixed error bias.

The current study, however, is one of the first to directly empirically test the predictions of a monitoring bias account. The only other studies to directly address this are Baars et al. (1975) and Hartsuiker et al. (2005a). The latter study concluded that monitoring biases can indeed interact with an underlying speech error pattern, but that the lexical bias effect results first and foremost from feedback (between phonological segments and word forms). It is thus possible that the completion errors in the homophone-of-semantic competitor conditions (Experiment 5 here; Ferreira & Griffin, 2003) are also the result of feedback, namely between word forms and lemmas. Note however, that this finding can also be explained by cascading alone. The sentence activates the concept *none*, which in turn activates the lemma *none* and the shared word form *none/nun*. Meanwhile the picture activates the concept *priest*, because of semantic similarity this concept also activates the lemma *nun*, due to cas-

cading the shared word form *none/nun* gets additional activation. In fact, a similar cascading mechanism could also explain the semantic errors made in Experiment 1-4. Importantly, this explanation only holds when lexical selection can take place at the word form level; if there is only lexical selection at the lemma level like Levelt et al. (1999) suggested, there has to be feedback to explain the homophone completions.

The current experiments did not elicit phonological sentence completions. However, this does not mean that it is completely impossible to elicit phonological errors in experimental settings. For instance, phonological errors have been found in the slip-task (e.g., Baars, Motley, & McKay, 1975; Motley, Camden, & Baars, 1982; Hartsuiker et al., 2005a; Möller, Jansma, Rodriguez-Fornells, & Münte, 2006). In the slip-task participants have to silently read pairs of words; once in a while the pair (target pair) is followed by a cue that the last pair has to be pronounced. The preceding pairs are biasing pairs in which the first phoneme of the first word is the same as the first phoneme of the second word of the target pair and vice versa. These phonological errors can be explained by feedback of phonological segments to the word form. One important difference between the slip-task and the task that was used in the current experiments is that they elicit different kind of errors. The slip-task elicits segmental level errors and the current task elicits lexical selection errors.

Another paradigm that has been used to elicit phonological errors is the tongue twister paradigm (Wilshire, 1998, 1999; Goldrick, & Blumstein, 2006). In this task participants have to recite tongue twisters, like: *palm neck name pack*. Phonological errors in the tongue twister paradigm can be explained in the same way as the errors in the slip-task. Again this task elicits segmental level errors instead of lexical selection errors. Thus phonological errors can be elicited on a segmental level, but the current task taps into lexical selection; it thus appears that it is not possible to elicit phonological errors at this level. Note that in line with this, Rapp, Benzing, and Caramazza (1997) tested an aphasic patient who showed semantic errors; but did not show phonological errors, and they suggested that this patient had damage at a lexical level.

Both the slip-task and the tongue twister paradigm show that phonological errors can be elicited in an experimental setting. But crucially, the experiments here showed that phonological errors cannot be elicited in a setting in which homophone of semantically-related errors can be elicited - whereas a biased monitoring theory predicts that both types of errors should occur more often than unrelated errors. We therefore conclude that the homophone completions can only be explained by interactive models, instead of by discrete models which need to assume a biased internal self-monitor. Finally, the fact that we did not find phonological completions constrains the parameters controlling bottom-up spread of activation in an interactive production system.

chapter 4

Morphophonological influences on the comprehension of subject-verb agreement: an ERP study

manuscript under revision[1]

[1] This paper was co-authored by Bernadette M. Jansma and Robert J. Hartsuiker

Abstract

Event-related potentials were used to study whether factors known to influence subject-verb number agreement in production exert analogous effects on sentence comprehension. Participants read Dutch sentences containing subject-verb number agreement errors. The determiner of the singular head noun could be ambiguous or unambiguous in number and the modifier ("local") noun could be plural or singular. When the local noun was singular, we observed a N400 in the incorrect verbs compared to the correct verbs. This effect was largest when the head noun phrase contained no number ambiguity. When the local noun was plural there was a larger P600 for incorrect verbs than for correct verbs. Again this effect was largest when the head noun phrase contained no number ambiguity. We propose that in the sentences with a singular local noun there is a shallow analysis of the sentence, in contrast to the deeper syntactic analysis in sentences with a plural local noun. Additionally, it will be argued that the effect of agreement violations on comprehension that was modulated by number ambiguity of the head noun supports an internal self-monitoring account.

Introduction

When we are talking, listening, or reading we constantly have to compute agreement between the subject and the verb. This is true in many languages (one exception is Chinese), and even very young children already know how to do this (Hoekstra & Hyams, 1998; Rondal, 1978). Many studies have examined subject-verb agreement in production, typically by eliciting agreement errors (e.g., Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Eberhard, 1997; Hartsuiker & Barkhuysen, 2006; Vigliocco, Butterworth, & Semenza, 1995). However, these kinds of errors have been investigated less intensively in comprehension studies. Investigating whether comprehension of sentences with correct and incorrect agreement is affected by similar factors that promote correct and incorrect agreement in production is important for two reasons. First, it allows for assessment of whether the processes underlying subject-verb agreement computation are similar or different in production and comprehension. In production it is obligated to compute agreement to be able to generate grammatically correct sentences. However in comprehension this is not necessary. It is possible that in comprehension there is a shallow analysis of the sentence and that no active computation of agreement takes places. Especially in languages like Dutch and English in which the word order in sentences is relatively fixed, comprehenders can know what the subject is by the place a word has in a sentence. Thus they do not have to compute if the subject and the verb agree in number to know what the subject is. However, it can also be argued that even in comprehension agreement is always calculated. A lot of linguistic theories argue that agreement is computed in comprehension (e.g., Vosse & Kempen, 2000). Secondly and most important for the present purpose, it allows for the evaluation of a more specific proposal, by which comprehension of intermediate representations in production can be used to guide production, so as to prevent production derailments (see Hartsuiker, 2006, for review). According to this idea the comprehension system is used to monitor production output. In language production models this internal self-monitor is very important in the on-going debate if production is interactive (e.g., Dell, 1986) or discrete (e.g., Levelt, Roelofs, & Meyer, 1999). The internal self-monitor has often been used by discrete models to explain data that seems to be interactive. Therefore, it is important to examine how and when this internal self-monitor works.

Production experiments have often elicited subject-verb number agreement errors, in which the subject and verb do not agree in number. In such experiments (e.g., Bock & Cutting, 1992; Bock & Miller, 1991) participants typically repeat and complete sentence fragments like *the [key/keys] to the [cabinet/cabinets]*.This naturally leads to the production of a verb, which in languages like English and Dutch carries an overt marker for number for at least some combinations of person and tense. It has often been found that there were more agreement errors when the head noun *(key)* was singular and the local noun *(cabinets)* was plural compared to when the local noun was singular (*cabinet*). These so-called "attraction

errors" (Zandvoort, 1961) have been found in several languages and with several experimental procedures (e.g., Dutch and German: Hartsuiker, Schriefers, Bock, Kikstra, 2003; English: Bock & Miller, 1991; French: Fayol, Largy, & Lemaire, 1994; Italian: Vigliocco et al., 1995; Slovak: Badecker, & Kuminiak, 2007; Slovene: Harrison, 2004; Spanish: Vigliocco, Butterworth, & Garrett, 1996). By investigating the attraction effect, it is possible to examine the factors influencing the construction of a sentence in the language production system.

Importantly for our purposes, the attraction effect can be influenced by morphophonological factors (Hartsuiker, Anton-Mendez, & Van Zee, 2001; Hartsuiker et al., 2003; Vigliocco et al., 1995). In one of Hartsuiker et al.'s (2003) experiments, participants completed Dutch sentence fragments that varied with respect to the morphophonological ambiguity of the head noun's determiners. Specifically, these sentence fragments started with either a common-gender or a neuter-gender head noun. In Dutch the common-gender determiner *de* is ambiguous in number, it can both be singular and plural (*singular: de straat [the street], plural: de straten [the streets])*. In contrast the neuter-gender determiner *het* is unambiguous in number, it can only be singular (*singular: het plein [the square], plural: de pleinen [the squares])*. In the conditions with singular head nouns and plural local nouns, participants made more agreement errors when the sentence fragments started with a common-gender (ambiguous) determiner than when they started with a neuter-gender (unambiguous) determiner.

One explanation for attraction effects in production and their modulation by morphophonological ambiguity assigns a role to an internal self-monitor (Hartsuiker et al., 2003; Hartsuiker, 2006). Many authors suggest that the internal self-monitor is situated in the comprehension system and filters specific errors out more often than other errors (e.g., Levelt, 1989; Levelt et al., 1999). This will be illustrated using a fictive speech error pattern. The production system makes an equal number of errors X and Y. However the internal self-monitor is better at detecting error X. When an error is detected this error can be corrected covertly, before the error becomes overt. Thus this will result in more overt errors Y, since less of these errors are detected and corrected covertly (see Figure 1). A similar explanation can be given to an existing error pattern: the lexical bias effect. This effect is the finding that speech errors are more often real words than nonwords than might be expected by chance (e.g., Baars, Motley, & MacKay, 1975; Hartsuiker, Corley, & Martensen, 2005; Nooteboom, 2005; Nooteboom & Quené, in press)[1]. It is harder for the internal self-monitor to detect errors that are real words than nonwords, and so more nonword errors are detected and corrected coverlty. Similarly, for sentences with a singular subject noun, it may be harder for the monitor to detect that there is an agreement error when the subject NP contains ambiguities for number. Thus when the sentence starts with a common-gender (ambiguous) determiner it is suggested that it is harder for the internal self-monitor to detect a subject-verb agreement error. This will result in more

[1] But note that both Hartsuiker et al. and Nooteboom and Quené argue that an additional cause of this effect is production-internal feedback.

agreement errors in these sentences in production studies.

It is very hard to prove that production effects are the result of a biased monitoring system, because such accounts postulate an interaction between two covert processes: speech planning and speech monitoring. However, Hartsuiker (2006) suggested that there is an indirect way of assessing a biased monitoring account by testing three criteria that such accounts should meet. In particular, the first demand is that the monitor should set functional criteria given the task at hand. Secondly manipulations that change the quality of monitoring should influence error patterns, if the quality of the monitor becomes worse biases that are suggested to be caused by the monitor should decrease. Thirdly and crucially for present purposes, the comprehension system should be sensitive to factors that influence the error pattern in production, under the assumption of Levelt (1983; 1989) that the internal self-monitor is situated in the comprehension system (see also Hartsuiker & Kolk, 2001; Özdemir, Roelofs, & Levelt, 2007). Based on this last criterion, if a biased monitoring account of the production data is correct we expect to find a complementary pattern of results to the production data in comprehension experiments.

The attraction effect has indeed been found in a few comprehension studies. Pearlmutter, Garnsey, and Bock (1999) used sentences like *The key to the [cabinet/cabinets] [was/were] rusty from many years of disuse*. In both a self-paced reading task and in an eye-tracking task they found that reading times were longer when either the local noun (*cabinets*) or the verb was plural (also see Nicol, Forster, & Veres, 1997). Kaan (2002) found a similar effect in an ERP-study. She found that there was a larger P600 (i.e., difference wave between correct and incorrect condition) in the singular head noun/singular local noun condition compared to the singular head noun/plural local noun condition. To our knowledge there are no studies

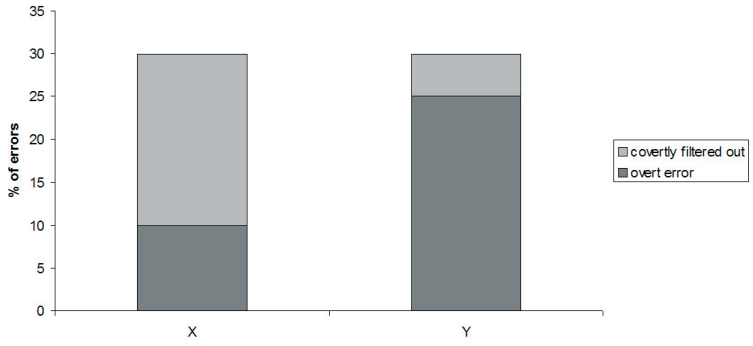

Figure 1. Fictional error pattern in which a biased error monitor is the cause of a difference in the number of overt errors between error X and error Y. The errors that are detected and covertly corrected by the monitor are demonstrated by the light grey bar. The actually pronounced errors (overt errors) are illustrated by the dark grey bar.

that tested the morphophonological influences on the comprehension of subject-verb agreement, therefore the present study aims to examine this.

To test if we can find comparable morphophonological influences in a comprehension study we used similar sentences to the ones Hartsuiker et al. (2003) used. Remember that the modulation of subject-verb agreement errors by morphophonological influences in this study can be explained by a biased self-monitor which is suggested to rely on the comprehension system. Thus a similar bias is expected in a comprehension study. The sentences started with either a neuter-gender determiner (*het*) or a common-gender determiner (*de*). In the critical sentences the head noun was always singular, the local noun could be singular or plural, and the verb could also be singular or plural. If we do find a pattern of results that is complementary to the one in production experiments, this supports the proposal that a biased internal self-monitor is the cause of the morphophonological influences on the attraction effect. Specifically, the biased monitoring account predicts the strongest effect in comprehension in the conditions that elicit the fewest agreement errors in production. More specifically the largest effects are expected when the sentence starts with a neuter-gender determiner. In this condition the largest amount of errors is detected and thus corrected covertly.

One ERP component of interest is the P600, which is a positive going wave starting around 500 ms after stimulus onset with a centro-parietal distribution. Various kinds of syntactic violations have been shown to influence the amplitude of the P600. Importantly, studies have observed a P600 in response to subject-verb agreement violations (for an overview see Vos, Gunter, Kolk, & Mulder, 2001). It is important to note, however, that several studies have observed a negativity with such errors, or a complex pattern in which the P600 is preceded by a negativity. Most often this negativity has a left anterior distribution (LAN: e.g., Chen, Shu, Liu, Zhao, & Li, 2007; Münte, Matzke, Johannes, 1997; Osterhout & Mobley, 1995) but also a more central distribution similar to the N400 has been reported (Coulson, King, & Kutas, 1998b; Gunter, & Friederici, 1999).

There is an ongoing debate about the functional interpretation of the P600-effect. It has been claimed to index syntactic processing (e.g., Hagoort, Brown, & Groothusen, 1993; Osterhout, & Holcomb, 1995), syntactic repair or reanalysis (Friederici, Hahne, & Meclinger, 1996; Münte, Matzke, & Johannes, 1997), syntactic integration difficulty (Kaan, Harris, Gibson, & Holcomb, 2000), more salient violations (Coulson, King, Kutas, 1998a), or monitoring for processing errors (Kolk, Chwilla, Van Herten, & Oor, 2003; Van Herten, Chwilla, & Kolk, 2006; Vissers, Chwilla, & Kolk, 2006). Recently the P600 has been suggested to reflect ongoing combinatory analysis (Kuperberg, 2007).

We expect to find a larger P600 when the verb does not agree with the subject; this is the basic P600 effect. Additionally we expect to find a larger effect when the sentence starts with the neuter-gender determiner (unambiguous), because in this case the error is more outstanding than when it starts with the common-gender determiner (ambiguous). When

an error is more outstanding more of these errors will be detected. Otten and Rugg (2005) describe that a difference in amplitude between two conditions can be carried by the proportion of trials. Thus when more errors are detected more trials with an effect will be averaged resulting in larger amplitudes. The more general interpretation of a difference in amplitude between two conditions is that there is a quantitative difference in the cognitive processes that are engaged (Otten & Rugg, 2005). Based on this interpretation we make the same predictions. When the sentence starts with a common-gender determiner (ambiguous), the determiner can be both singular and plural. Thus the conflict in this sentence is smaller when there is an erroneous (plural) verb, resulting in less engagement in the common-gender determiner sentences and consequently also in smaller effects.

Experimental procedure

Participants

Thirty-six Ghent University students, native speakers of Dutch, volunteered in exchange for money to participate in the experiment. Four participants were excluded from further analysis because of too many artifacts in the ERP signal. Participants' ages ranged between 19 and 25 (mean = 21.39), 21 of the participants were female. Handedness was assessed via a questionnaire (Van Strien, 1992), with possible scores ranging from -10 (extremely left-handed) to 10 (extremely right-handed). Participants were all right-handed as shown by their average score of 9.55 (SD=1.36). All participants reported to have normal or corrected-to-normal vision and no history of neurological and psychiatric disorders.

Materials

We constructed 160 sets of Dutch sentences with the structure exemplified in 1 and 2. Each set contained eight versions of each sentence, resulting from the crossing of three factors: gender of the head noun (neuter or common gender, latter is ambiguous), number of the local noun (singular or plural), and grammaticality (correct or incorrect). All the local nouns required the determiner "de". An example of these sentences is given in 1 and 2 (see Appendix D for a list with all the stimuli).

1 De straat bij de kerk/kerken is/*zijn mooi
  The street $_{\text{(common-gender)}}$ near the church/churches is/*are beautiful
2 Het plein bij de kerk/kerken is/*zijn mooi
  The square $_{\text{(neuter-gender)}}$ near the church/churches is/*are beautiful

Four lists were constructed; each list contained 160 sentences starting with a common-gender head noun (ambiguous) and 160 sentences starting with a neuter-gender head noun (unambiguous). For both the sentences starting with a common-gender and neuter-gender head noun, half had a singular local noun and half had a singular verb, resulting in 40 sentences of each type. This resulted in lists in which half of the sentences were incorrect. Within each list, one version of each sentence appeared

in the common-gender head noun (ambiguous) condition and one version appeared in the neuter-gender head noun (unambiguous) condition. Across the four lists, the ambiguous and unambiguous sentence occurred once in the four combinations of number match and grammaticality.

All lists contained 320 filler sentences, with the same syntactic structure as the experimental sentences. The filler items started with a plural subject so that across all experimental and filler trials a plural verb would be correct in 50% of trials. Half of the filler items contained a subject-verb agreement error. The resulting four 640-sentence lists were randomized separately for each participant.

In addition, participants occasionally answered yes-no questions on sentence content appearing at random between the target sentences via a button press (on average 1 question each 20 sentences, with a total of 32) to control participants attention during reading. All the questions were related to the adjective; a question for the example sentence 1 could be: "Is the street beautiful?".

Procedure

After electrode placement participants were seated in an electrically shielded room in front of a computer screen. Participants were told to attentively read the sentences and not to move or blink while the sentences were presented on the screen. First the participants performed a practice session; the experimental session only started when this practice session was performed correctly. Each trial started with a fixation cross in the center of the screen for 1500 ms and a blank screen for 500 ms, followed by a word-by-word presentation of the sentences. Each word was presented for 325 ms and followed by a blank screen for 200 ms, after the last word there was a blank screen for 500 ms. The questions were presented as a whole, and disappeared if the participant answered the question with a button press. One block took approximately 9 min and the entire experiment, including electrode placement and removal, took about 2.5 hours.

EEG recording and analysis

EEG was recorded with 31 scalp electrodes, placed according to the International 10-20 setting, all referenced to the mean of all scalp electrodes[2]. EOG was measured bipolarly; vertical eye movements and blinks were measured with two electrodes placed above and below the left eye, two electrodes placed on the left and the right outer canthus were used to measure horizontal eye movements. Impedances of all the electrodes were kept below 3 KΩ. The signal of all electrodes was re-referenced off-line to the average signal of the electrodes placed on the left and the right mas-

[2] The hardware of the amplifier is programmed in a way that we are obligated to take the averaged signal of all electrodes as a reference. Dien (1998) suggests that to be able to compare results of different studies similar reference sites should be used. Since most studies use the average signal of the right and the left mastoid as a reference, we off-line re-referenced to the average signal of these two electrodes.

toid. The EEG was digitized at 512 Hz. The continuous EEG was filtered off-line with a band pass filter of 0.01-30Hz.

EEG data were analyzed using EEProbe 3.1 (ANT, Inc., Enschede, The Netherlands) running on Red Hat Linux 7. ERPs were time-locked to the onset of the critical verb and epochs were generated with a time-window from -100 to 1000 ms around the onset of the verb. Epochs containing artifacts, such as blinks, were rejected from further analysis; the overall rejection rate of the analyzed participants was 11.55%, there was no difference in rejection rate between the conditions. Based on visual analysis of the data, the mean area amplitudes were subjected to two separate repeated measures ANOVAs with the Factors Gender of head noun (common/neuter), Grammaticality (correct/incorrect) and Electrodes (31), one ANOVA for the singular local noun condition and one for the plural local noun condition.

Additionally, to show that the effects found in the neuter-gender condition and the common-gender condition are the same component, we tested if the effects found in these conditions differed in topographical distribution. In order to do this the difference of the incorrect and the correct condition were calculated in the 350-400ms and the 600-650ms time window for both the neuter-gender and common-gender conditions. Following McCarthy and Wood (1986), the data was first normalized to make sure that the overall amplitude difference could not influence the topographical distribution. Two separate repeated measures ANOVAs were carried out with gender (common/neuter) and electrodes (31) as factors. If there was no significant interaction between gender and electrodes it was assumed that the topographic distribution was the same for the neuter-gender and the common-gender condition. When there was more than one degree of freedom in the numerator the Greenhouse-Geisser correction was applied, the corrected *p*-values were reported. The degrees of freedom are reported uncorrected.

Results

Comprehension Task

The mean error rate of the comprehension questions was 6.05%, indicating that the participants read and processed the sentences with sufficient attention.

Event-Related Potentials

Grand average Event-Related Potentials time-locked to the onset of the verb for the singular local noun (noun number match) conditions are shown in Figure 2 and for the plural local noun (noun number mismatch) conditions in Figure 3.

All conditions elicited an N1-P2 complex, as is typical for visual stimuli. Visual inspections suggested that in the noun number match condition (both head and local noun singular) there was a negativity around 400 ms in both gender conditions, with a more negative wave for the incorrect verbs compared to the correct verbs. Based on the central-parietal

distribution of this effect we believe that this effect is a N400. In the noun number mismatch condition (head noun is singular and local noun is plural) there seemed to be a P600 in both gender conditions, with a more positive wave for the incorrect verb than for the correct verb. Based on visual inspection of the data two time-windows were analyzed: 350-400 ms in the noun number match condition and 600-650 ms noun number mismatch condition. Additionally, based on visual inspection of the effect topography we compared the mean amplitudes of conditions in the 350-400 ms time-window separately for P7, P3, Pz, P4, P8, and the mean amplitudes of conditions in the 600-650 ms time-window separately for FT7, FC3, T7, C3, TP7 and CP3.

Noun Number Match Conditions

The omnibus ANOVA in the time-window 350 - 400 ms had the factors gender of head noun (common, neuter), grammaticality (correct, incorrect) and electrodes (31 electrodes). The analysis showed significant main effects of grammaticality ($F(1,31)=16.27$, $p < 0.01$) and of gender of head noun ($F(1,31)=3.17$, $p < 0.05$) and a significant interaction of grammaticality x electrodes ($F(30,930)=3.49$, $p < 0.01$). A more specific analysis of the parietal electrodes showed a significant main effect of grammaticality ($F(1,31)=13.93$, $p < 0.01$) and a marginally significant interaction between grammaticality x gender of head noun ($F(1,31)=3.78$, $p = 0.06$). As is visible in the ERP-waves and in Figure 4, the incorrect verbs elicited a more negative going wave than the correct verbs and this effect was largest when the sentence started with a neuter-gender noun (unambiguous). The ANOVA on topographical similarities showed no significant interaction of gender and electrodes ($F(30,930)=1.10$, $p = 0.36$), suggesting that the topographical distribution of the effect in the common-gender and the neuter-gender condition was the same.

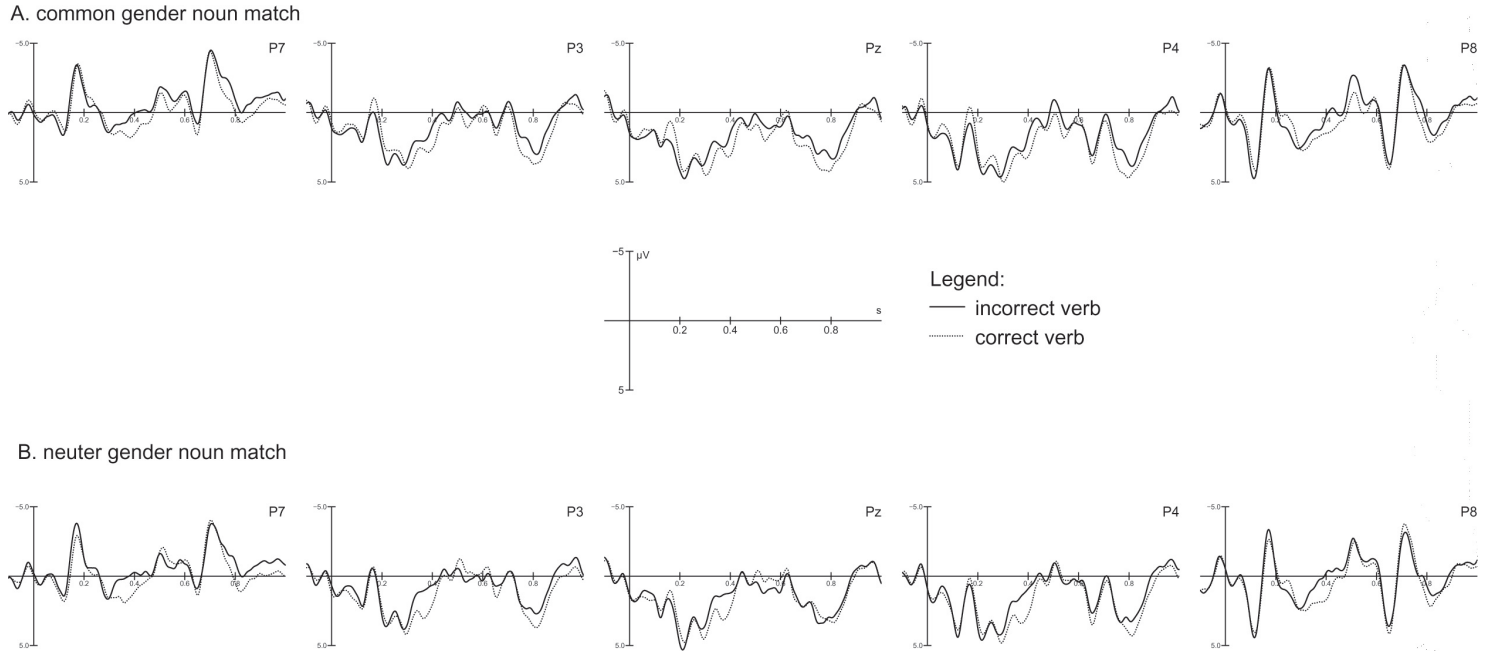

Figure 2. Grand averaged ERPs measured at the analyzed electrodes, time locked to the onset of the verb for the sentences with a singular local noun. A, sentences starting with a common-gender head noun. B, sentences starting with a neuter-gender head noun.

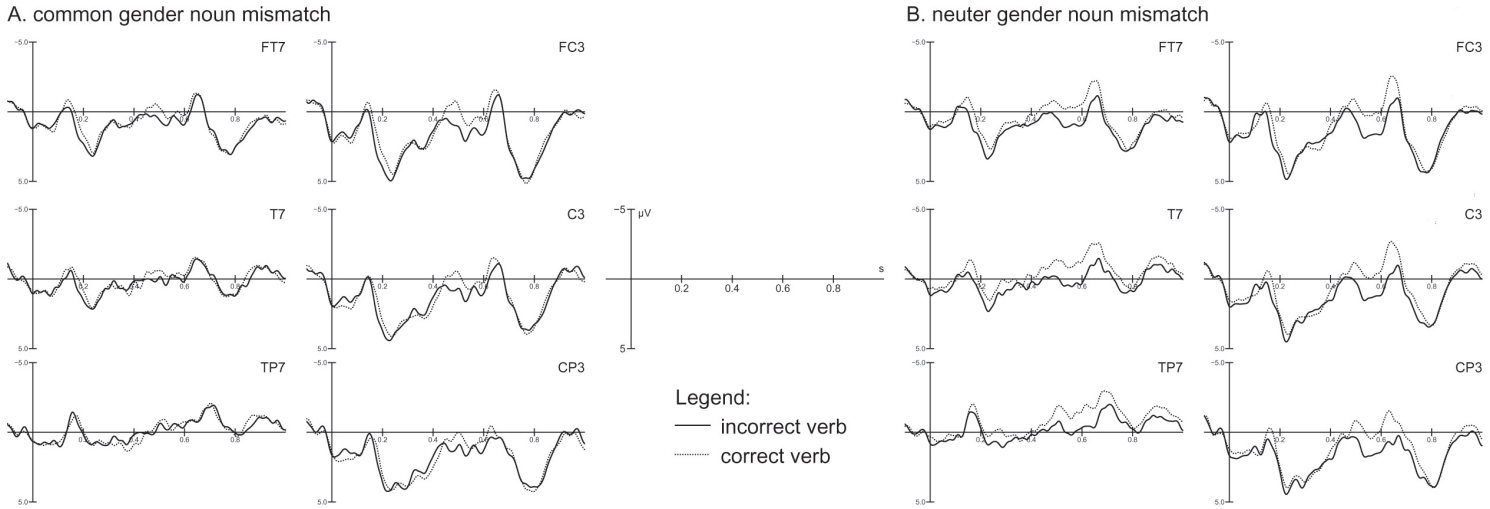

Figure 3. Grand average ERPs measured at the 6 analyzed electrodes, time locked to the onset of the verb for sentences with a plural local noun. A, sentences starting with a common-gender head noun B, sentences starting with a neuter-gender head noun.

Noun Number Mismatch Condition

The omnibus ANOVA in the time-window 600-650 ms, revealed a significant main effect of grammaticality ($F(1,31)=7.39$, $p < 0.05$). There was a significant interaction of grammaticality x electrodes ($F(30,930)=3.08$, $p < 0.05$). A more specific analysis at left central/frontal sites showed a significant main effect of grammaticality ($F(1,31)=11.03$, $p < 0.01$) and a significant interaction of grammaticality x gender of head noun ($F(1,31)=4.42$, $p < 0.05$) and of grammaticality x electrode ($F(5,155)=4.47$, $p < 0.01$). The grammaticality x gender of head noun interaction is visualized in Figure 5: the waves elicited by the incorrect verbs were more positive than those elicited by the correct verbs; this effect was larger when the gender was neuter (unambiguous) than when it was common (ambiguous). Additionally the effect seemed to be longer lasting in the neuter-gender condition, we believe this is caused by the fact that there are more errors detected in the neuter-gender condition. This caused an effect that is larger but also longer. The ANOVA on topographical similarities between the effect found in the common-gender and neuter-gender condition did not show a significant interaction of gender and electrodes ($F(30,930)=1.83$, $p = 0.12$). The non-significant interaction suggests that there was no topographical difference between the effect found in the common-gender and the neuter-gender condition.

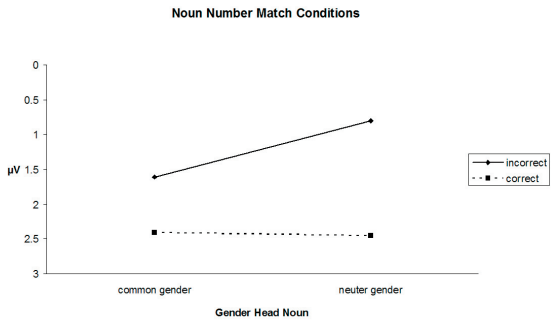

Figure 4. Mean amplitudes for the time window 350 till 400 ms are shown for both the correct and the incorrect verbs in the mismatch sentences for the neuter-gender and the common-gender head noun conditions.

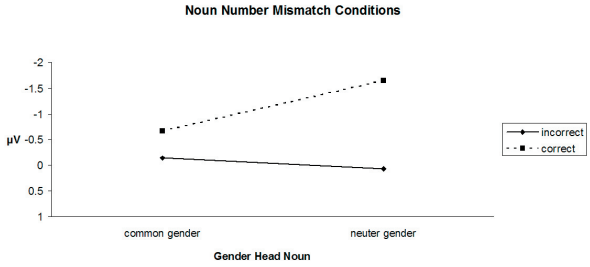

Figure 5. Mean amplitudes for the time window 600 till 650 ms are shown of both the correct and the incorrect verbs in the mismatch sentences for the neuter-gender and the common-gender head noun conditions.

Discussion

In the current study we aimed to find complementary results in a comprehension study to results from behavioral production studies (Hartsuiker, et. al., 2003), that speak to computing subject-verb agreement and hence may speak to biased internal monitoring. As in the behavioral production study, we presented sentences with singular head nouns and singular or plural local nouns and manipulated the gender of the head noun, so that the corresponding determiner was or was not ambiguous for number. We presented both correct (singular) and incorrect (plural) verbs and measured ERP, time-locked to verb onset. In the noun number mismatch condition we found a P600 for incorrect verbs compared to correct verbs. This P600 effect was larger in the neuter-gender (unambiguous) determiner condition compared to the common-gender (ambiguous) determiner condition. Additionally, this effect appeared to have a similar topographical distribution in both gender conditions, suggesting that it is caused by the same neural generator. In the noun number match condition we found a N400 for incorrect verbs compared to correct verbs, which was larger when the sentence started with a neuter-gender (unambiguous) determiner than when it started with a common-gender (ambiguous) determiner. Again the topographical distribution in both gender conditions was similar. We first discuss some implications for sentence comprehension, and then turn to the possibility that comprehension-based monitoring can affect production.

Sentence Comprehension

A striking finding in the present study is that there was a P600 in the noun number mismatch conditions and a N400 in the noun number match conditions. The P600 found in the noun number mismatch condition was as expected for the incorrect verb, since the P600 is elicited by syntactic violations (Hagoort et al., 1993; Osterhout & Holcomb, 1995).

The N400 found in the noun number match conditions was not expected, but it is important to note that previous studies also found negativities to syntactic violations. These include a left anterior negativity (LAN) (Chen et al., 2007; Münte et al., 1997; Osterhout & Mobley, 1995), but more importantly, also a more centrally distributed component (N400) as was the case in our data (Coulson et al., 1998b; Gunter and Friederici, 1999).

The N400 is thought to reflect the integration difficulty of a word into a preceding context (Federmeier & Kutas, 1999) and in its discourse (Van Berkum, Hagoort, & Brown, 1999). In the present experiment the N400 was unexpected, so our account of it is admittedly post-hoc. Wicha, Morena and Kutas (2004) showed that expectations of upcoming words in sentences are built immediately. Moreover even grammatical information like gender is used to build these expectations. In line with this we suggest that expectations are built immediately and that this expectation is more univocal in the noun number match conditions compared to the noun number mismatch condition. In the noun number match condition both the head noun and the local noun set up a context to build an expectation for a singular verb. However, when the plural (incorrect) verb is encountered this was not expected and there is a N400. Support for the idea that there can be a N400 when there is a subject-verb agreement error when the context strongly supports a specific expectation comes from a study of Coulson et al. (1998b). In this study there were subject-verb agreement errors. Additionally the probability that these subject-verb agreement errors occur was manipulated. There was a N400 for the incorrect verbs. More importantly probability seemed to influence the distribution of the effect; the effect was more centrally distributed for the improbable sentences. This shows that expectation can influence the distribution of the effect. In the improbable sentences a strong expectation can be built and apparently if this expectation is not met a N400 is elicited. As mentioned before in the noun number match condition in the present experiment also a strong expectation can be built. In contrast in the mismatch condition the local noun and the head noun support different expectations, the head noun supports a singular expectation and the local noun supports a plural expectation. Therefore we suggest that no strong expectation can be made in the noun number mismatch condition. Since no strong expectation can be built we believe that in the mismatch condition there is a need for a 'normal' syntactic analysis of the sentence when an incorrect verb is encountered, which is reflected by the P600. Next to building an expectation based on the number of the head noun and the local noun, the composition of the lists can be used to build expectations. We believe that since all our sentences have a similar structure and we only used the verb *to be* the building of expectations is increased. In the noun number match condition there is a shallow analysis of the sentence, there is no need to compute agreement since the strong expectation can be used. In contrast in the noun number mismatch condition there is need for a deeper analysis of the sentence. Agreement is computed in these conditions. However Kaan (2002) found a P600 instead of a N400 in the match condition. In

Kaan's experiment the participants had to make a grammaticality judgment of the sentence. Hence the participants were obligated to analyze the sentences more deeply. Additionally the experimental lists Kaan used were not that univocal compared to our lists thus it is harder to build a strong expectation.

Although more work is surely needed to understand agreement processing in sentence processing, our data make clear that if a strong expectation can be built there is a shallow analysis of the sentence and syntactic analysis is not necessary. Thus in comprehension there are circumstances in which there is no need to compute subject-verb agreement, for example when a strong expectation can be build. However, when no strong expectation can be build there is need for a deeper syntactic analysis of the sentences.

Biased monitoring

Another explanation of the finding that agreement violations on comprehension are modulated by number ambiguity of the head noun in the number mismatch condition comes from a biased monitoring account. Most interestingly, the effects were larger for neuter-gender (unambiguous) compared to the common-gender (ambiguous) conditions. This effect size difference can be interpreted as a difference in detectability of the violation. It seems to be easier to detect all errors in the neuter-gender (unambiguous) condition (large effect), whereas on probabilistic grounds the system detects only a proportion of violations in the ambiguous gender conditions, leading to smaller violation effects in the ERP. We believe this holds at least for the P600 observed.

In Hartsuiker et al.'s (2003) production experiment, speakers produced more agreement errors in the number-ambiguous head noun condition than in the number-unambiguous condition (in the noun number mismatch conditions). Under the assumption that a difference in P600 is caused by the number of errors that are detected, the current results lend support to an explanation of these production data in terms of comprehension-based monitoring. Because violations are relatively difficult to detect in the number-ambiguous (common-gender) conditions, these violations lead to a reduction of the P600 in comprehension and to an increase in overt errors in production.

Additionally, the data show that a manipulation of determiner number-ambiguity also affects agreement processes when there is a number match between head noun and local noun. Note that no comparable effect of ambiguity in the match conditions is observed in sentence production studies (Hartsuiker et al., 2003). The noun number matching items do not elicit agreement errors in production studies. Therefore since there are no errors elicited there is nothing to covertly correct and thus the comprehension-based monitoring cannot affect the production results. However in the current comprehension study there is a difference in the match sentences. This finding does not counter the biased monitoring account; it even supports that the comprehension system is sensible

for morphophonological manipulations of the determiner's gender. This effect however is not visible in production studies since in production studies no subject-verb agreement errors are produced.

Other comprehension studies, in addition to the current study, lend support to the biased monitoring account. Monitoring has been suggested to be a resource demanding process (Levelt, 1989; Oomen & Postma, 2002; Postma, 2000). There are some production studies which support this idea; it has been found that monitoring is affected by a dual task (Hartsuiker & Barkhuysen, 2006; Oomen & Postma, 2002). In comprehension tasks, it has also been found that performing a second task affects the number of agreement errors that are detected (Blackwell & Bates, 1995; Hayiou-Thomas, Bishop, & Plinkett, 2004). Both these production and comprehension studies find complementary results, which can be attributed to a biased monitoring account.

The current study clearly demonstrates that a biased monitoring account of subject-verb agreement errors (and its modulation by morphophonlogical ambiguity) meets the "comprehension criterion" proposed by Hartsuiker (2006). We acknowledge of course, that observing similar biases in perception and production do not necessarily prove that perceptual monitoring influences production. It is possible, for example, that production and comprehension work independently, but are based on the same principles. If agreement of the subject and the verb is computed in the same way in the production and the comprehension system, errors that are made more often in production due to the way agreement is computed would also be more difficult to detect in comprehension because the same principles are used to compute agreement. It is also possible that the comprehension system displays biases, because it has become attuned to the frequency with which particular errors occur in naturalistic speech. On such an account, the effects are larger in the neuter-gender condition, because these errors occur less frequently in naturalistic language and are thus more salient than the subject-verb agreement errors in the common-gender condition. Although we cannot reject these explanations, our results are certainly consistent with a (notoriously difficult to test) comprehension-monitoring account of number agreement errors in production, and show evidence for an important precondition of such an account: an analogous bias in production and perception.

Conclusions

Altogether, the current results suggest that there are two different processes in computating subject-verb agreement in the present experiment, in sentences with a plural or a singular local noun. When there was a singular local noun it is suggested that a strong expectation is built and that there is only a shallow analysis of the sentence. In contrast there is a deeper syntactic analysis when there was a plural local noun. Most importantly, it appeared that effects of subject-verb agreement in comprehension are modulated by number ambiguity of the head noun. This is in line with results found in production experiments, which may be explained by

a biased internal self-monitor. If results found in production are caused by the internal self-monitor, similar results are expected in a comprehension experiment. The present results are thus compatible with the idea that an internal self-monitor, situated in the comprehension system, caused the morphophonological influences on subject-verb agreement in production experiments.

chapter 5

Does notional number matter? Event-related potentials of agreement checking in sentence comprehension[1]

[1] This paper was co-authored by Robert J. Hartsuiker

Abstract

The present study tested if subject-verb agreement computation in comprehension is sensitive for distributivity of the subject. Therefore we presented participants with Dutch sentences containing subject-verb agreement errors and measured the on-line effects on comprehension using EEG. The subject could be distributive *(distributive: the label on the bottles)* or non-distributive *(non-distributive: the baby on the blankets)*. In the distributive sentences there was a Left Anterior Negativity (LAN) and a P600 for the incorrect verbs compared to the correct verbs. In the non-distributive sentences there was no LAN or P600. However, the latter sentences showed a LAN on the word after the incorrect verb, suggesting that the processing of the incorrect verb is delayed. The results will be discussed using a biased monitoring account.

Introduction

In most languages at least one kind of agreement (e.g., gender and/or number agreement) has to be computed. It is obvious that one has to compute agreement when producing language, since our speech is mostly grammatically correct. In contrast in language comprehension it is not obvious that agreement has to be computed to be able to understand what is heard or read. There is however evidence that we can detect agreement errors when we are reading, suggesting that at least in some circumstances agreement is computed in comprehension. For example, in self-paced reading tasks (Pearlmutter, Garnsey, & Bock, 1999), eye-tracking (Pearlmutter et al., 1999) and ERP studies (Hagoort, Brown, & Groothusen, 1993; Osterhout & Mobley, 1995) it has been shown that we are able to detect subject-verb disagreement. Thus it is probable that we are computing agreement in both production and comprehension, but are there also similarities between the way that agreement is computed in production and comprehension? Some authors have used similar processes to compute agreement in production and comprehension. For example, Badecker and Kuminiak (2007) used comprehension processes to explain subject-verb agreement computation in production.

When producing sentences one has to make sure that the subject and the verb agree in number. In English and Dutch (the language used in this study) only the number has to agree, but in for example Spanish and Italian also the gender of the determiner and the noun have to agree. For sentences to agree in number there has to be a singular verb when the subject is singular. In language production studies it has been shown that intervening nouns can influence the computation of subject-verb number agreement (e.g., Bock & Cutting, 1992; Bock & Miller, 1991). In these studies participants typically read or hear sentence fragments, which they have to repeat and complete. Normally these sentence fragments contain a singular or plural head noun and a singular or plural local noun, for example: *the key/keys to the cabinet/cabinets*…When the sentence started with a plural head noun (keys) there was an equal number of agreement errors for the plural and the singular local nouns (cabinet/cabinets). In contrast, more agreement errors were made when there was a plural local noun in sentences starting with a singular head noun. These errors have been named *attraction errors* (Zandvoort, 1961). This attraction effect has been found in several languages (e.g., Dutch and German: Hartsuiker, Schriefers, Bock, Kikstra, 2003; English: Bock & Miller, 1991; French: Fayol, Largy, & Lemaire, 1994; Italian: Vigliocco, Butterworth, & Garret, 1995; Slovak: Badecker, & Kuminiak, 2007; Slovene: Harrison, 2004; Spanish: Vigliocco, Butterworth, & Garrett, 1996a).

In several studies it has been shown that the attraction effect can be influenced by conceptual factors (e.g., Eberhard, 1999; Hartsuiker & Barkhuysen, 2006; Humphreys & Bock, 2005; Nicol & Greht, 2003; Vigliocco, et al., 1995; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996b). In these studies it was investigated whether distributivity of the subject had an influence on computing subject-verb agreement. Sentence frag-

ments like: *The label on the bottles* are distributive, the head noun (*label*) is morphologically singular, but it is notionally plural. Namely, the most obvious interpretation of this sentence fragment is that there is one label on each bottle. In contrast, sentences like *the baby on the blankets* are non-distributive, here the most obvious interpretation is that there is one baby on more blankets. Thus the head noun (*baby*) is morphologically and notionally singular. In these studies participants were presented with distributive and non-distributive sentences fragments which they heard or read and then had to complete. There were more agreement errors when the sentence fragment was distributive (conceptually plural) in contrast to when it was non-distributive (conceptually singular). Note that in English the influence of distributivity on subject-verb agreement is not that clear cut, there are several studies which do not find this effect in English (Bock & Miller, 1991; Vigliocco et al., 1996a). However, there is also evidence that distributivity influences subject-verb agreement computation in English (Eberhard, 1999; Humphreys & Bock, 2005)

The influence of distributivity on the attraction effect found in production has been explained by production internal processes. The maximal input hypothesis assumes that in computing agreement conceptual information is directly used (Vigliocco & Hartsuiker, 2002). If a sentence is distributive the conceptual number is plural, this information is also used for computing subject-verb agreement. Therefore there are more agreement errors in distributive sentences. Another explanation comes from the marking and morphing account which claims that the conceptual number of the subject phrase is marked and that this number is reflected on the verb (Bock, Eberhard, Cutting, Meyer, Schriefers, 2001; Eberhard, Cutting, & Bock, 2005). Alternatively, the results can be explained by an internal self-monitor which find it harder to detect and filter out some errors more than others (Hartsuiker, et al., 2003; Hartsuiker, 2006). This will be illustrated by using a fictional error pattern, in which the production system generates an equal number of errors X and of errors Y. If it is easier for the internal self-monitor to detect error X in comparison with error Y, more errors X will be detected by the internal self-monitor before these errors are pronounced. When an error is detected by the internal self-monitor, the production process is interrupted and the error will be corrected covertly. Since more errors X are detected, more of these errors can be filtered out covertly. This will result in fewer errors X in overt speech (see Figure 1). A biased monitoring explanation has been used for another existing error pattern, the lexical bias effect (e.g., Baars, Motley, & MacKay, 1975; Hartsuiker, Corley, & Martensen, 2005; Nooteboom, 2005; Nooteboom & Quené, in press)[1]. This effect is the finding that speech errors are more often words than nonwords than might be expected by chance. It has been suggested that it is harder for the internal self-monitor to detect errors that are real words than nonwords, and so more nonword errors are filtered out before they are pronounced. Likewise, it might be harder for the internal self-monitor to detect that there is a subject-

[1] Note that the lexical bias effect some times has been explained to be the result of both monitoring and certain production-internal mechanisms (i.e., feedback, Hartsuiker et al., 2005; Nooteboom & Quené, in press).

verb number agreement error when the sentence is conceptually plural, compared to when it is conceptually and morphologically singular.

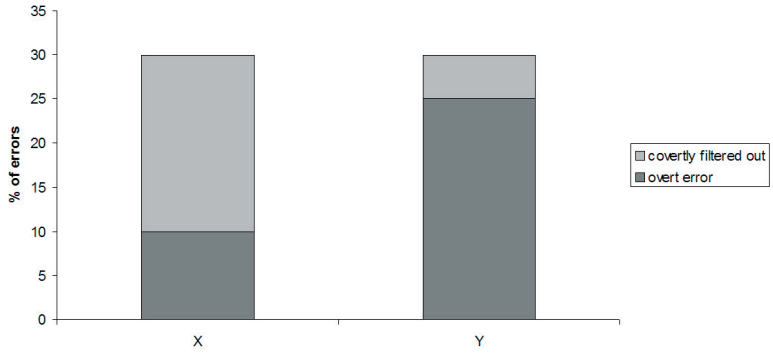

Figure 1. Illustration of how a biased error monitor can alter the overt error pattern. The dark grey bar are the errors that are produced overtly and the light grey bar are the errors that are covertly filtered out by a internal self-monitor that detects more errors X than errors Y.

In language production models the biased monitor plays a central role in the discussion if language production is interactive (e.g. Dell, 1986) or discrete (e.g. Levelt, Roelofs, & Meyer, 1999). Discrete models often use a biased monitor to explain error patterns that seem to be interactive, like for example the lexical bias effect (see Vigliocco & Hartsuiker, 2001, for review). Since both the production internal explanations and the biased monitoring account are covert processes it is very hard to prove that an error pattern is the result of a biased monitor. Hartsuiker (2006) proposed that it can be tested indirectly whether a biased internal self-monitor gives rise to a particular error pattern. To test this, three demands have to be confirmed. The first demand is that the monitor has to be functional, for example the monitor has to be able to adapt its monitoring criteria depending on the context at hand. Second, the speech error pattern has to be influenced by manipulations influencing the monitor. The monitor has been suggested to be a resource demanding process (Levelt, 1989). Thus if there is for example, a second task leaving the monitor with fewer resources, the error pattern in speech should change. Third, and most important for the present purpose, since it has been suggested that the internal self-monitor is situated in the comprehension system (Levelt, 1983, 1989; Hartsuiker & Kolk, 2001; Özdemir, Roelofs, & Levelt, 2007) the bias found in speech error patterns should also be found in comprehension studies. In order to investigate if this is the case for the distributivity effect, we performed an Event-Related Potential (ERP) study in which participants had to read distributive and non-distributive sentences that could contain a subject-verb agreement error. ERPs were used since

these allow for an on-line measurement of the cortical processes involved in sentence processing.

Nicol, Forster, and Veres (1997) tested in an English reading study if distributivity of the head noun influenced sentence comprehension. In this study only sentences in which the subject and the verb agreed, thus grammatically correct sentences were used. They found no difference in reading difficulty between distributive and non-distributive sentences. Using a self-paced reading task and an eye-tracking study Pearlmutter et al. (1999), also examined if distributivity of the subject influenced subject-verb agreement in comprehension. In this study also grammatical incorrect sentences were used. In Experiments 1 and 2 participants were presented with sentences containing either a distributive subject or a non-distributive subject, the local noun and the verb could be singular or plural. In both experiments distributivity of the subject did not influence the way agreement is computed in comprehension. However, as mentioned before, the distributivity effect is not always found in English production studies. Eberhard (1999) found that imageability of the sentence influences the appearance of a distributivity effect in production. When the sentences were highly imaginable a distributivity effect has been found in English (Eberhard, 1999). Note that both the comprehension studies (Pearlmutter et. al., 1999; Nicol et al., 1997) discussed here were carried out in English. Moreover, the sentences were not tested for imageability. The current study will be carried out in Dutch, a language in which a distributivity effect has been found in production (Hartsuiker & Barkhuysen, 2006; Hartsuiker, Kolk, & Huinck, 1999; Vigliocco, et al., 1996b). Furthermore, the sentences were tested for imageability, sentences in both the distributive and the non-distributive condition were relatively highly imaginable.

The detection of syntactic agreement violation has been associated with two ERP components: the LAN and the P600. Both these ERP components will be discussed in the following two paragraphs.

The first study that investigated the brain's response to syntactic violations was reported by Kutas and Hillyard (1983). Subject-verb number agreement violations were used. There was a negativity with a left anterior distribution in response to the incorrect verbs. This component was later dubbed the left anterior negativity (LAN, Friederici, 1995). Since then several studies have also found the LAN in response to subject-verb agreement violations (De Vicenzi, Job, Di Matteo, Angrilli, & Penolazzi, 2003; Friederici, Hahne, & Mecklinger, 1996; Osterhout & Holcomb, 1992; Osterhout & Mobley, 1995; Roehm, Bornkessel, Haider, & Schlesewsky, 2005). The LAN has been interpreted reflecting the detection of morpho-syntactic agreement errors (Rossi, Gugler, Hahne, & Friederici, 2005).

The P600 is a positive going wave starting around 500 ms after stimulus onset which has a centro-parietal distribution. Hagoort et al. (1993) found this component in response to subject-verb agreement violations. After this first study more studies found a P600 in response to subject-verb agreement violations (for an overview see Vos, Gunter,

Kolk, & Mulder, 2001). The functional interpretation of P600 is still under discussion. The P600 has been claimed to index syntactic processing (e.g., Hagoort, et al., 1993; Osterhout, & Holcomb, 1995), syntactic repair or reanalysis (Friederici, et al., 1996; Münte, Matzke, & Johannes, 1997), syntactic integration difficulty (Kaan, Harris, Gibson, & Holcomb, 2000), more salient violations (Coulson, King, Kutas, 1998), monitoring for processing errors (Kolk, Chwilla, Van Herten, & Oor, 2003; Van Herten, Chwilla, & Kolk, 2006; Van Herten, Kolk, & Chwilla, 2005; Vissers, Chwilla, & Kolk, 2006), or to continued combinatorial analysis (Kuperberg, 2007).

In the present experiment we set out to test if distributivity of the subject influences sentence comprehension. If the distributivity effect in production is caused by a biased monitor, which relies on the comprehension system, it is expected that comparable results will be found in comprehension. To test this, distributive and non-distributive sentences were used that could contain a subject-verb number agreement error. The biased monitoring account predicts that it is easier to detect errors in the non-distributive sentences, since the subject of these sentences are morphologically and notionally singular. If there is a similar effect in comprehension then more subject-verb agreement errors are detected in the non-distributive condition, leading to larger effects. The most robust effect in subject-verb number agreement studies is the P600. We thus expect a larger P600 effect in the non-distributive sentences compared to the distributive sentences.

We will elaborate on this prediction to make it clearer. If more errors are detected, more trials carrying the effect will be averaged, resulting in larger effects. Otten and Rugg (2005) state that a difference in amplitude can be elicited by a difference in proportion of trials carrying the effect. In addition, similar predictions follow from a more general interpretation of a difference in ERP amplitude. A difference in amplitude is often thought to reflect a quantitative difference in the cognitive processes engaged in the two conditions (Otten & Rugg, 2005). We predict that this engagement is larger for the non-distributive sentences than for the distributive sentences, because there is less information in the latter sentences that conflicts with an erroneous (plural) verb. Specifically, in the non-distributive sentences, the notional and morphological number of the subject noun both point to singular, whereas in the distributive sentences, the notional number points to plural and only the morphological number points to singular. Thus when the plural verb is encountered more engagement is needed, we think this prediction applies to all the functional interpretations of the P600.

Given the results of earlier studies presenting subject-verb number agreement violations it is possible that we also find a LAN in the present study. Again we expect this effect to be larger in the non-distributive sentences because it is expected that more errors are detected in this condition.

Method

Participants
Thirty-six students (32 females and 4 males) of Ghent University participated in the experiment, in exchange for money. Six participants were excluded from further analysis because of too many artifacts or too many incorrect answers. All the participants were native Dutch speakers, with an age ranging from 19 till 28 (mean 21.87) years, and were neurologically and psychiatrically healthy. They all had normal or corrected to normal vision, and had no reading or speaking disorders. Furthermore, as was indicated by a questionnaire (Van Strien, 1992) they were all right-handed, their averaged score was 9.47. The score of this questionnaire ranges from -10 (extremely left-handed) to 10 (extremely right-handed).

Materials
Hundred-and-eighteen sentence pairs were constructed, with a structure as illustrated in sentences 1 and 2. Each pair contained a distributive sentence and a non-distributive sentence. The head noun was always singular, and its gender was always the same in the distributive and the non-distributive sentence of a pair; the local noun was always plural. The verb was always an auxiliary and the inflection could either be correct (singular) or incorrect (plural).

1. De dop van de flessen zal/*zullen ingeleverd worden.
   The cap of the bottles will$_{(sg)}$/*will$_{(pl)}$ be submitted
2. De kist met de flessen zal/*zullen ingeleverd worden.
   The box with the bottles will$_{(sg)/}$will$_{(pl)}$ be submitted

Each correct sentence was judged by 15 further participants on distributivity on a scale of 1 to 7, with 1 being not distributive at all. As distributive sentences, sentences were chosen which scored higher than 5; as non-distributive sentences only sentences that scored lower than 3 were used. Furthermore, each sentence was judged on plausibility by 15 further participants on a scale of 1 to 7 with 1 being highly plausible. Imageability of the sentences was also judged on a scale of 1 to 7 (1 was low imaginable) by another 15 participants. Sentences pairs of which one of the two sentences had a plausibility of higher than 4 or an imageability of lower than 4 were excluded from the experiment. This left us with 80 sentence pairs (see Appendix E for all the sentences); the distributive sentences had a mean distributivity of 5.88 (SD = 0.43), mean plausibility of 2.31 (SD = 0.56) and a mean imaginability of 5.44 (SD = 0.56). The non-distributive sentences had a mean distributivity of 1.43 (SD = 0.43), a mean plausibility of 2.43 (SD = 0.86) and a mean imageability of 5.23 (SD = 0.76). The distributive and non-distributive sentences differed significantly on distributivity ($t(158) = 65.42$, $p < 0.001$), showing that our manipulation was successful. Both sentence types were highly plausible, and there was no difference between the two sentence types on this variable ($t(158) =$

-1.07, $p = 0.29$). There was a marginally significant effect for imageability between the distributive and the non-distributive sentences ($t(158) = 1.92$, $p = 0.06$). However, both the distributive and the non-distributive sentences with an imageability of respectively 5.44 and 5.23, are relatively highly imaginable.

Two lists were constructed of 160 sentences. If the distributive sentence of a pair was presented in the correct form, the non-distributive sentence of the pair was presented in the incorrect form. Each list thus contained 40 correct distributive sentences, 40 incorrect distributive sentences, 40 correct non-distributive sentences and 40 incorrect distributive sentences.

Hundred-and-sixty filler items were constructed with the same sentence structure as the experimental sentences. The head nouns of the filler sentences were always plural, so that the plural verb was correct in half of all the sentences.

Additionally, there were 32 sentences with the same structure as the experimental sentences which were followed by a question. For example, a sentence like: *Het sap met de vruchten is lekker (The juice with the fruits is delicious*), could be followed by a question like: *Is het sap lekker?* (*Is the juice delicious?*). All the questions were yes- no- question and were answered with a press on a corresponding button. Finally, there were 160 further filler items (80 high-cloze sentences that ended in the correct word and 80 high-cloze sentence of which ended in a phonologically related word or nonword.) For the present purpose these sentences are only assumed to distract the participants from the purpose of the experiment.

Procedure

After signing an informed consent form, electrodes were placed to measure the participants' EEG. Participants took place in a shielded room. Instructions were given both in speech and writing. The participants were instructed not to blink during sentence presentation and to try not to make any large movements. Furthermore, the participants were instructed to read the sentences attentively and answer the questions with a press on either the right or the left button. Before the real experiment started there was a practice session, in which the participants were familiarized with the experimental procedure. The experimenter also checked if the participants were not blinking too much.

Each trial started with a fixation cross for 1500 ms in the center of the screen, followed by a 500 ms blank screen. Then the sentence was presented word-by-word, with each word visible for 325 ms and followed by a 200 ms blank screen. There was a 500 ms blank screen after the last word. The question was presented all at once, and disappeared when the participant answered the question with a button press. The entire experiment, including electrode placement and removal, took about 2.5 hours.

EEG recording and analysis

Brainwaves were measured with 31 electrodes mounted in an elastic electrode cap according to the international 10-20 setting. The electrodes were referenced to the mean of all the electrodes[2]. Impedances of the electrodes were kept below 3 KΩ. The electro-oculo gram (EOG) was measured with a bipolar montage. The vertical EOG was measured with two electrodes placed above and below the left eye; the horizontal EOG was measured with two electrodes placed on the left and right cantus. The signal was re-referenced offline to the average signal of the electrodes placed on the left and right mastoid. The EEG was digitized at 512 Hz. The continuous EEG was filtered off-line with a band pass filter of 0.01-30Hz.

EEG data were analyzed using EEProbe 3.1 (ANT, Inc., Enschede, The Netherlands) running on Red Hat Linux 7. ERPs were time-locked to the onset of the verb and epochs were made with a time-window from -100 to 1000 ms around the onset of the verb. Epochs containing artifacts, such as blinks, were rejected from further analysis; the overall rejection rate of the analyzed participants was 8.90 %. Mean area amplitudes were calculated for two time-windows: 350-450 ms and 500-600 ms. Based on visual analysis of the data, the mean area amplitudes were treated separately for the distributive and the non-distributive sentences. Data acquired at the midline, medial-lateral and lateral-lateral sites were treated separately to be able to quantitatively analyze hemispheric differences. Data from the midline sites for both the distributive and non-distributive sentences were subjected to a repeated measures ANOVAs with the Factors Grammaticality (correct/incorrect) and Electrodes (5). Data from the medial-lateral and lateral-lateral sites were subjected to a three-way ANOVA with the Factors Grammaticality (correct/incorrect), Hemisphere (left/right) and Electrodes (5). The Greenhouse Geiser correction was applied when there was more than one degree of freedom in the numerator. The corrected p values will be reported.

Additionally, ERPs were calculated for the local noun with an epoch of -100 to 1300 ms, to see if there is already a difference between the distributive and the non-distributive sentences. There were no large differences visible between the distributive and the non-distributive sentences. Therefore no further analyses were carried out on this ERP epoch.

Finally, ERPs were averaged for a 1400 ms epoch with a 100 ms prestimulus baseline in order to analyze processing at the word after the verb. Epochs containing artifacts were rejected from further analysis; the overall rejection rate of the analyzed participants was 11.40 %. Mean area amplitudes were calculated for the 900-1000 ms time-window. This time-window corresponds to the time-window 375-475 ms after the onset of the word following the verb. The same analyses were performed as were carried out on the 350-450 ms and 500-600 ms time-windows. In addition, based on visual inspection of the data a repeated measures ANOVA was carried out with the Factors (correct/incorrect) and Electrodes (F7, F3, Fz, FT7, FC3 and FCz).

[2] The hardware of the amplifier takes the averaged signal of all electrodes as a reference. Most studies use the average of the left and right mastoid as a reference and to be able to make a good comparison of the results similar reference sites should be used (Dien, 1998). Hence we re-referenced offline to the average of the left and right mastoid.

Results

Behavioral data

Participants had an averaged error rate of 3.06% on the comprehension questions, showing that they were reading the sentences attentively.

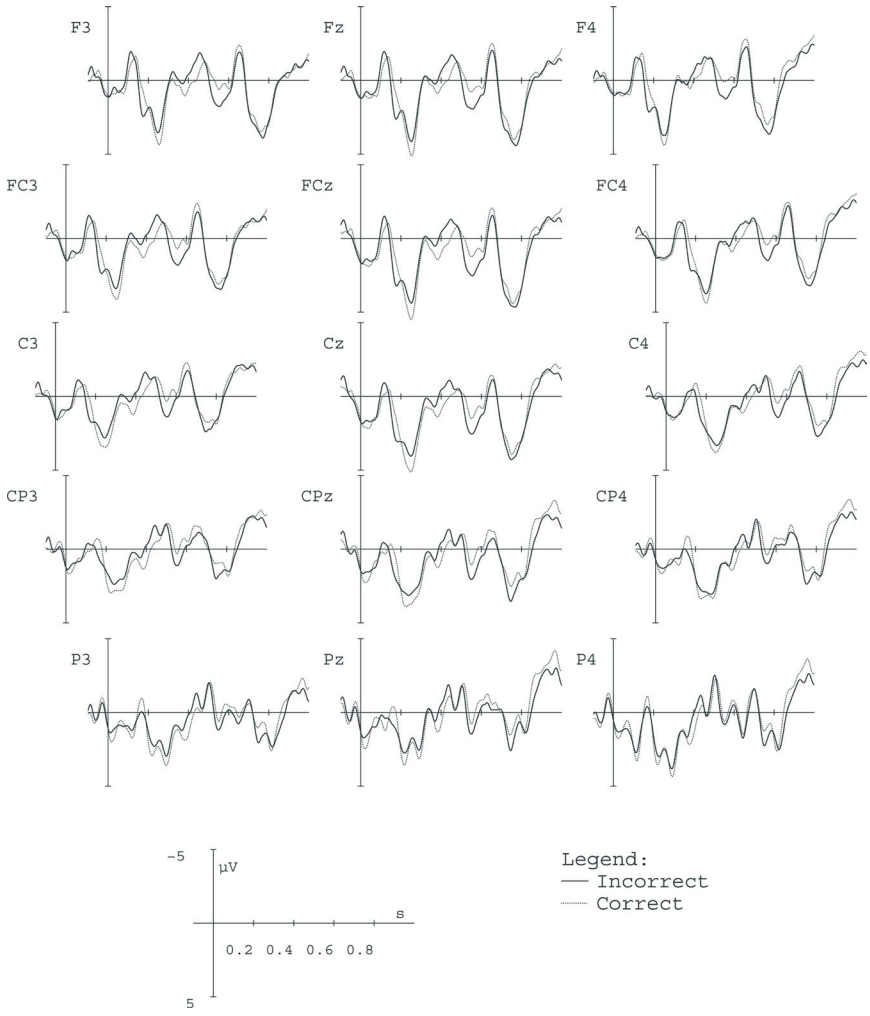

Figure 2. Grand average ERPs for the distributive sentences measured at the midline and medial-lateral sites. Averages are time-locked to the onset of the correct or incorrect verb.

Event Related Potentials

Grand-average ERPs to the critical verbs for the distributive sentences can be seen in Figure 2 and for the non-distributive sentences in Figure 3. All conditions elicited an N1-P2 complex, as is typical for visual stimuli. In the distributive sentences these early components were followed by a negativity, the LAN, that was larger after the incorrect verb. This negativity was followed by a positivity, the P600, that again was larger after the incorrect verb. In the non-distributive sentences no large differences between the correct and the incorrect verb can be seen in the time-window of the LAN and in the time-window of the P600.

350-450 ms time-window

The analysis carried out in the distributive sentences in the 350-450 ms time-window revealed a significant main effect of grammaticality at the midline and medial-lateral sites and a marginal effect at the lateral-lateral sites (midline: $F(1,29) = 5.60$, $p < 0.05$; medial-lateral: $F(1,29) = 5.47$, $p < 0.05$; lateral-lateral: $F(1,29) = 3.58$, $p = 0.07$). A significant interaction between grammaticality and hemisphere at the medial-lateral sites ($F(1,29) = 4.40$, $p < 0.05$) suggests that the effect is larger at the left hemisphere. An analysis carried out separately for the electrodes at the left and the right site showed that there is a main effect of grammaticality at the left site ($F(1,29) = 8.10$, $p < 0.01$), whereas the effect of grammaticality was only marginally significant at the right site ($F(1,29) = 3.08$, $p = 0.09$).

There were no significant grammaticality effects in the non-distributive sentences for the analyses on the midline and the medial-lateral sites (midline: $F < 1$; medial-lateral: $F(1,29) = 2.04$, $p = 1.66$). However, grammaticality reached significance in the lateral-lateral sites ($F(1,29) = 5.50$, $p < 0.05$).

500-600 ms time-window

There was a main effect of grammaticality in the distributive sentences at midline and medial-lateral sites and a marginal significant effect at lateral-lateral sites (midline: $F(1,29) = 8.13$, $p < 0.01$; medial-lateral: $F(1,29) = 6.91$, $p < 0.05$; lateral-lateral: $F(1,29) = 3.58$, $p = 0.08$). The effect was larger at the left hemisphere as was demonstrated by the interaction between grammaticality and hemisphere (lateral-lateral: $F(1,29) = 4.84$, $p < 0.05$). Analyses carried out separately for the left and the right hemisphere showed a significant effect of grammaticality at the left sites ($F(1,29) = 8.27$, $p < 0.01$). At the right sites there was no significant effect of grammaticality ($F < 1$).

The analyses carried out for the non-distributive sentences did not show any significant effects ($F's < 1$).

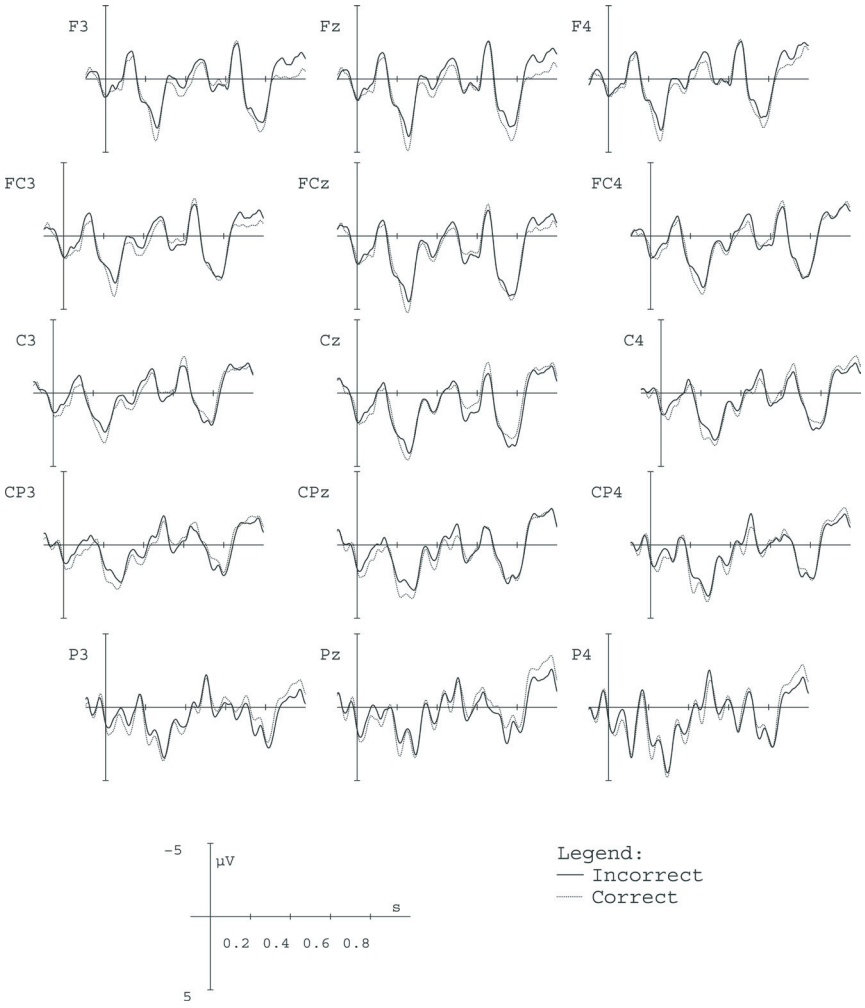

Figure 3. Grand average ERPs for the non-distributive sentences measured at the midline and medial-lateral sites. Averages are time-locked to the onset of the correct or incorrect verb.

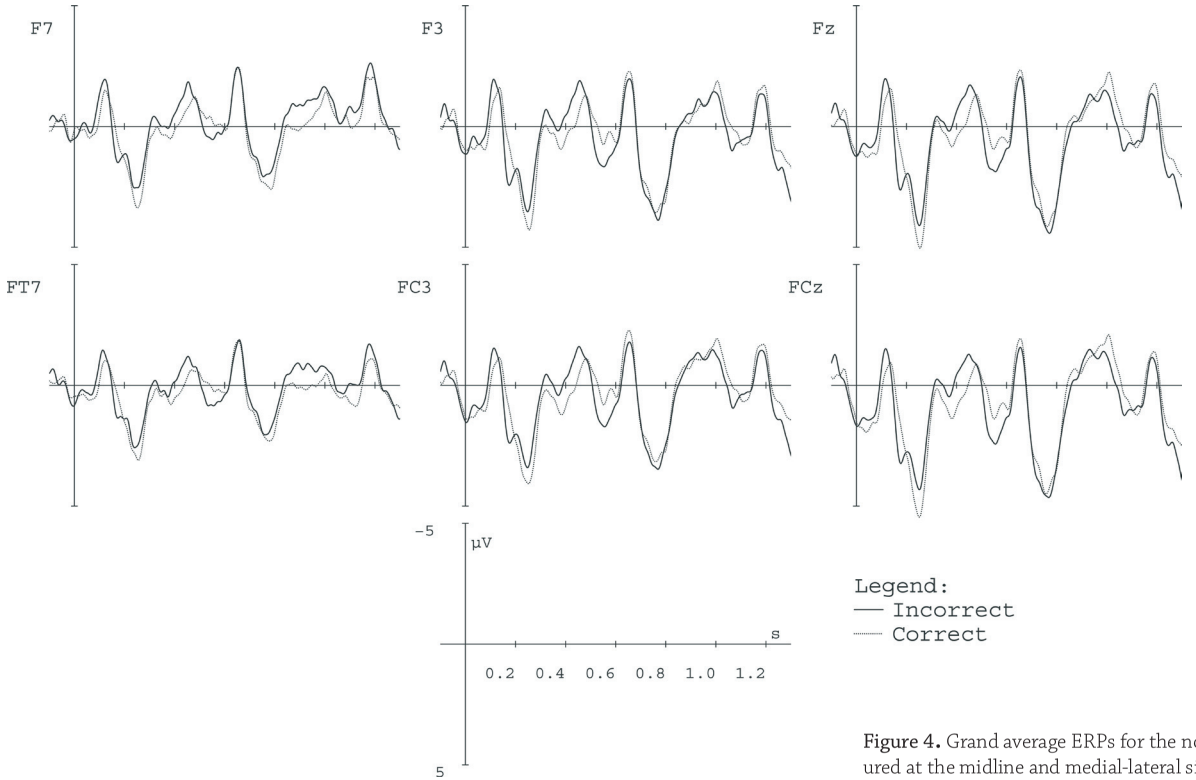

Figure 4. Grand average ERPs for the non-distributive sentences measured at the midline and medial-lateral sites. Averages are time-locked to the onset of the correct or incorrect verb.

900-1000 ms time-window

Figure 4 shows the grand averaged ERPs in response to the correct and the incorrect verb for the distributive sentences at six electrode sites for a time-window to 1300 ms after verb onset. Figure 5 displays these grand averaged ERPs for the non-distributive sentences. In addition to the ERP-pattern described before, Figure 5 shows that there is a negativity in response to the incorrect verbs compared to the correct verb in the 900-1000 ms time-window. We believe that this is a LAN elicited by the word after the incorrect verb. In the distributive sentences (see Fig 4) there is also a negativity in the 900-1000 ms time-window, which is only apparent at two electrodes sites.

In the distributive sentences none of the main effects reached significance. In the lateral-lateral analysis there was a significant interaction between grammaticality and hemisphere ($F(1,29) = 5.23$, $p < 0.05$) and between grammaticality and electrodes ($F(4,116) = 4.40$, $p < 0.05$), indicating that there is an effect at the anterior electrodes at the left hemisphere. In the ANOVA with the six electrodes there was no significant effect of grammaticality, the interaction between grammaticality and electrodes was marginally significant ($F(5,145) = 2.71$, $p = 0.06$). Post-hoc analyses carried out on two electrodes (F7 and FT7) showed that there was a significant effect of grammaticality ($F(1,29) = 5.52$, $p < 0.05$).

No statistical main effects of grammaticality were observed for

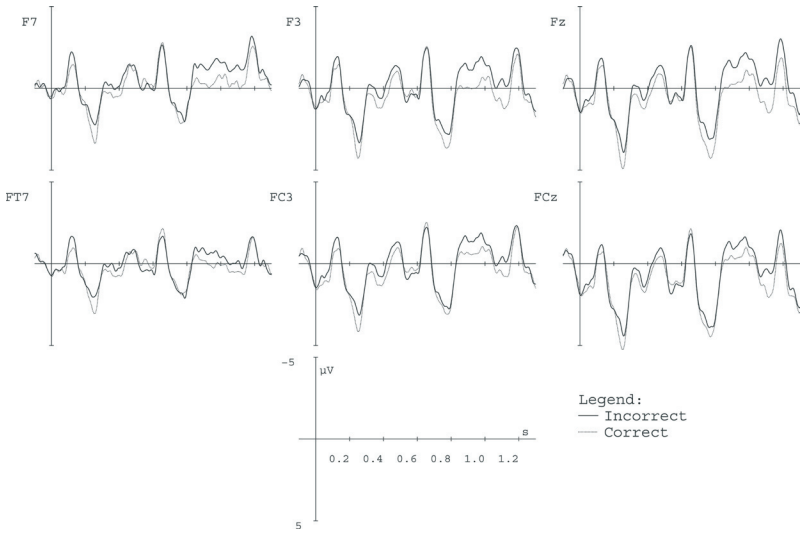

Figure 3. Grand average ERPs with -100 till 1300 ms time-window, for the non-distributive sentences measured at six electrodes (F7, F3, Fz, FT7, FC3 and FCz). Averages are time-locked to the onset of the correct or incorrect verb.

the non-distributive sentences. However, anteriorly there appears to be an effect as indicated by the interaction between grammaticality and electrodes (midline: $F(4,116) = 7.35$, $p < 0.001$; medial-lateral: $F(4,116) = 12.37$, $p < 0.001$; lateral-lateral: $F(4,116) = 10.29$, $p < 0.001$). In the ANOVA carried out with the six electrodes there was a significant main effect grammaticality ($F(1,29) = 5.48$, $p < 0.05$).

Discussion

The aim of the present study was to investigate whether distributivity of the subject influences the computation of subject-verb agreement in comprehension. Many production studies showed that distribitivity of the subject influences subject-verb agreement computation; there are more agreement errors in distributive sentences (Eberhard, 1999; Hartsuiker & Barkhuysen, 2006; Humphreys & Bock, 2005; Nicol & Greht, 2003; Vigliocco et al., 1995 ; Vigliocco, et. al., 1996b). A biased monitor, which has been suggested to rely on the comprehension system (Levelt, 1983, 1989; Hartsuiker & Kolk, 2001; Özdemir, et al., 2007), has been put forward as an explanation. Hence a similar bias was expected in comprehension. To examine this participants were presented with distributive and non-distributive sentences that could either be correct or contain a subject-verb number agreement error, while their EEG was recorded. In the distributive sentences we observed a LAN and a P600 in response to the incorrect verbs. In contrast, in the non-distributive sentences neither the LAN nor the P600 was elicited. However, in a later time-window there appeared to be a negativity at the left anterior sites that was larger in the incorrect sentences. We believe this negativity to be a LAN in response to the word after the incorrect verb. In the distributive sentences there was also a small LAN (only at two electrode sites) in response to the word following the incorrect verb.

Based on a biased monitoring account we expected the effects in the non-distributive sentences to be larger compared to the distributive sentences. According to a biased monitoring account subject-verb agreement errors are easier to detect in non-distributive sentences. As mentioned in the introduction there are two more studies that have examined distributivity in English comprehension (Nicol, et. al., 1997; Pearlmutter, et. al., 1999). Both these studies concluded that distributivity of the subject does not influence sentences comprehension. However, with an on-line measure the current study showed an effect of distributivity in Dutch, although not in the direction as expected. Thus distributivity seems to be able to influence sentence comprehension.

Can the difference in effects between the distributive and the non-distributive sentences be explained by the small difference in imageability between the two kinds of sentences? Remember that the distributive sentences scored slightly higher on imageability than the non-distributive sentences. Eberhard (1999) suggested that the lack of a distributivity effect in English production studies can be explained by the imgeability of the distributive sentences. The higher the imgeability of a distributive

sentence the more subject-verb agreement errors are made in production. In other words, the fewer errors are detected by the monitor. Thus, if the difference between the two kinds of sentences found in the present experiment was carried by the difference in imageability of the sentences, fewer errors should be detected in the distributive sentences. This would result in a smaller effect in the distributive sentences; we found the opposite. Additionally, the imageability of our sentences was relatively high; we believe that it was high enough in both conditions to be able to elicit effects.

The most plausible explanation of the lack of effects in the non-distributive sentences is based on the LAN found in response to the word following the incorrect verb compared to the correct verb. This LAN suggests that the processing of the incorrect word is delayed until the following word. Or that the verb is recognized as being incorrect, not at the presentation of the verb but at the presentation of the following word. It is important to note that in Dutch, sentence fragments like "de kist met de flessen zullen " (the box with the bottles shall_pl.) are temporarily ambiguous - that is, they can be completed with a post-verbal subject (which would render the subject phrase a direct object), as in (3) and (4).

3. De kist met de flessen zullen wij wegbrengen
   [The box with the bottles]$_{object}$ shall we take away
4. De dop op de flessen zullen wij wegbrengen
   [The cap on the bottles]$_{object}$ shall we take away

This ambiguity is resolved when the word following the modal verb *zullen* turns out not to be a subject, and elicits a LAN. Garden-path sentence also render a sentence temporary ambiguous (e.g., *the broker persuaded to…*). The verb *persuaded* can be a simple active verb, this is the preferred syntactic analysis (e.g., *the broker persuaded his client to sell)*. However it can also be completed with a more complex syntactic structure, like *to* in the example. It has been found that there is a P600 on *to* since this is the less preferred syntactic analysis of the sentence (Osterhout & Holcomb, 1992). These results show that an expectation for a certain syntactic structure is build immediately. With our stimuli the continuation with a post-verbal subject is an infrequent structure. However the parser has to choose between the infrequent structure and a syntactic violation, we believe that when it is plausible that there is a post-verbal subject the parser chooses this infrequent structure. Of course, there is an ambiguity on the verb for both the distributive and non-distributive conditions, but we speculate that in the distributive case, the implausibility of a post-verbal subject helps resolve the ambiguity earlier. In our opinion, this is because the subject in the non-distributive sentences tends to be physically larger than the subject in the distributive sentences (e.g. a box is larger than a cap), and therefore more likely to be analyzed as the object of a plural subject (it is plausible that it takes more than one person to carry a box, but implausible that it takes more than one person to carry a

cap). Of course this is just a suggestion and experiments should be carried out to verify this suggestion.

Hartsuiker (2006) suggested that a speech error pattern should meet three demands to be able to be explained by an internal self-monitor. In the present study we tested the third demand for the distributivity effect, namely that there should be comparable results in comprehension as have been found in production. To reiterate based on a biased monitoring account it was expected that there are larger effects in the non-distributive sentences, however the opposite was found. Thus the effects found in this study were not comparable with effects found in production. Therefore we did not confirm the third demand. Has there been empirical evidence for the first two demands for the distributivity effect? The first demand states that the self-monitor has to be functional. Hartsuiker (2006) concluded that when checking agreement it might be functional for the monitor to use semantic information. The second demand holds that the quality of the monitor should be affected when certain manipulations influence the monitor. Levelt (1989) assumes that the monitor is constrained by working memory. Thus, when working memory is used the quality of the monitor should decrease. Hartsuiker and Barkhuysen (2006) tested whether the distributivity effect was affected by occupying working memory with another task. They found that the number of agreement errors was larger when working memory was occupied by a second task. However, the increase of agreement errors was equally large in the distributive and the non-distributive condition. If the self-monitor was responsible for the distributivity effect in production, this effect should disappear when there was a resource limitation for the internal self-monitor. Thus for the distributivity effect only the first demand has been confirmed. With the current new data also the third demand has to be rebutted. However, note that if it is true that the analysis is postponed till the word after the verb in the non-distributive sentences, we cannot disconfirm the third demand. Hence we tentatively conclude that it is improbable that the distributivity effect found in production is caused by an internal self-monitor. The distributivity effect should thus be explained by production-internal processes alone.

chapter 6

Is there a lexical bias effect in comprehension monitoring?

Manuscript submitted for publication[1]

[1] This paper was co-authored by Robert J. Hartsuiker

Abstract

Event-related potentials were used to investigate if there is a lexical bias effect in comprehension monitoring. The lexical bias effect in language production has been attributed to a self-monitoring system, which uses the comprehension system to monitor internal speech, and which employs lexical status as a monitoring criterion. It has been suggested that we monitor language comprehension too, and that the P600 reflects comprehension monitoring processes. If both production and comprehension monitoring rely on the comprehension system it is plausible that both processes are very similar. Hence the lexical bias effect is expected in comprehension monitoring. High-cloze sentences that could contain a correct word, a lexical error, or a nonlexical error were presented. There was a larger N400 in the lexical error and the nonlexical error condition compared to the correct word condition. Importantly, the P600 was the largest in the nonlexical error condition, intermediate in the lexical error condition and the smallest in the correct condition. Apparently, the comprehension monitor is sensitive to lexicality, suggesting that both production and comprehension monitoring rely on one system.

Introduction

We constantly monitor our motor actions, to verify if we are doing what we planned to do and to check if we did not make a mistake; we do this for example while we are walking, cycling, and driving. While we are talking we monitor our own speech for errors (*did I say this correctly?*). But when we are listening or reading we can also monitor if we made a mistake in perception (*did I read this correctly?*). Put differently, in language processing we are not only monitoring our output, but also our perception of the input. It is possible that we have separate monitoring systems for each modality; but it would be of course highly efficient when a single system carries out both of these monitoring processes.

Kolk et al. (2003) described a monitoring process in sentence comprehension. They suggested that during sentence processing simple heuristics are used in addition to syntactic algorithms, and together these two processes determine the sentence interpretation. If the two processes lead to conflicting interpretations a monitoring process is started to check if there has been a processing error. Similarly, when the comprehension system encounters a misspelled word (for example a homophone of a highly expected word) there would be conflict between a phonologically-based reading process (which suggests the word was read correctly) and an orthographically-based reading process (which suggests the word may have been misread). Again, a monitoring process would begin to check for a processing error (Vissers, Chwilla, & Kolk, 2006).

Monitoring of language production also involves the comparison of representations (e.g., of an intended word with an actually produced word). When there is a discrepancy, one has to reattend to the speech plan and correct the error (Hartsuiker & Kolk, 2001; Levelt, 1983, 1989; Postma, 2000). In the production literature it has been suggested that the monitor relies on the comprehension system (Hartsuiker & Kolk, 2001; Levelt, 1983, 1989; Özdemir, Roelofs, & Levelt, 2007). This proposal has the advantage of parsimony, because one would use a single system for perceiving one's own speech and the speech of others (but see Postma, 2000, for an alternative view).

In short, monitoring processes have been described to take place in production and comprehension and the monitor in production has been suggested to rely on the comprehension system. We hypothesized that if the monitoring processes in production rely on the comprehension system, these processes in production and comprehension might be similar, and thus susceptible to the same influences. Therefore, this article asks if comprehension monitoring demonstrates a monitoring bias that has been claimed to cause a typical speech error pattern in production, namely the lexical bias effect.

The lexical bias effect is the finding that phonological errors are more often real words than non-words than might be expected by chance (Baars, Motley, & Mackay, 1975; Dell & Reich, 1981; Hamm, Junglas, & Bredenkamp, 2004; Hartsuiker, Anton-Mendez, Roelstraete, & Costa, 2006; Hartsuiker, Corley, & Martensen, 2005; Nooteboom, 2005). It is as-

sumed that the verbal self-monitor inspects internal speech for errors and corrects some of these errors covertly (i.e., before they are pronounced). It has been proposed that it is easier for the monitor to detect nonword errors compared to word errors, because the monitor would use a lexicality criterion (*is this a word?*). Therefore, more nonword errors than word errors are detected and covertly corrected. Consequently, more word errors than nonword errors are overtly produced, even though there were comparable numbers prior to monitoring (Baars et al., 1975; Levelt et al., 1999; Nooteboom, 2005; Roelofs, 2004)[1].

Evidence for the suggestion that a monitoring bias causes the lexical bias effect has been demonstrated using the SLIP-task (Baars et al., 1975). In this task participants have to silently read word pairs, on some trials target pairs have to overtly be named. The word pairs preceding the target pair can influence the naming of the target pair by their phonological make up. In studies using the SLIP-task the lexical bias effect appeared to be context-sensitive (Baars et al., 1975; Hartsuiker et al., 2005). These studies demonstrated that the lexical bias effect only occurred in a mixed context of words and nonwords. When the context existed exclusively of nonwords the lexical bias effect disappeared, demonstrating that the monitor can change its error detection criteria depending on the context that is relevant at the time.

In order to test whether comprehension monitoring is sensitive to lexicality, we visually presented participants with high-cloze sentences that could end in the correct word (CW), a lexical error (LE; phonologically related word) or a nonlexical error (NLE; phonologically related nonword), while their brainwaves were measured. The component of interest was the P600, which has been argued to be sensitive to comprehension monitoring (Kolk et al. 2003; Van Herten, Chwilla, & Kolk, 2006; Van Herten, Kolk, & Chwilla, 2005; Vissers et al., 2006). These authors argued that the P600 arises when two or more processing mechanisms come up with conflicting interpretations. In visual word recognition, this conflict can mean that the text contained a spelling mistake, but it can also mean that the reader misread the word. To check if the sentence was read correctly a monitoring process is started and this causes a P600. Vissers et al. (2006) presented participants with high- and low-cloze probability sentences that could end in a pseudohomophone or the CW (e.g., In that library the pupils borrow *books* (CW)/*bouks* (pseudohomophone) to take home, a Dutch equivalent was used in this experiment). In the high-cloze probability sentences, but in the low-cloze probability sentences the pseudohomophones elicited no P600. On their account, the comprehension monitoring process (and thus the P600) is triggered in the high-cloze condition because there is a conflict between accepting the word on grounds of phonology and semantics activated through phonology, and rejecting the word on grounds of orthography. In the low-cloze condition there is less conflict, because the interpretation derived from phonology is not supported by the sentence context.

[1] Note that on some accounts, monitoring and certain production-internal mechanisms (i.e., feedback) jointly create the lexical bias effect (Hartsuiker et al., 2005; Nooteboom & Quené, in press).

Münte, Heinze, Matzke, Wieringma, and Johannes (1998) presented participants with nonwords that were phonologically and orthographically similar to a highly expected word of the sentence. Similar to the findings of Vissers et al. (2006), these nonwords elicited a P600 compared to the expected word. Again these results can be explained by a monitoring process that checks the veridicality of the nonword in the sentence.

In addition to the P600, two other ERP components have been found in response to nonwords and CW: The N270 and the N400. Newman and Connolly (2004) presented participants with high-cloze sentences that could either end in the CW a pseudohomophone, an incongruent word or a nonword, which was orthographically, semantically and phonologically unrelated to the expected word. They found a N270 in the pseudohomophone, the incongruent word and the nonword condition, suggesting that the N270 is sensitive to orthographic incongruencies. Additionally, there was a N400 in the incongruent word and the nonword condition. These authors inferred that the absence of the N400 in the pseudohomophone condition shows that the integration of the word meaning in the sentence is influenced by phonology.

In Vissers' et al. (2006) experiment there was also a N270 for the pseudohomophone in the low-cloze sentences. But in contrast to Newman and Conolly (2004), there was no difference in the high-cloze sentences. The lack of a difference in the N270 in the high-cloze sentences, might be because at first the pseudohomophone error was not detected and was read as the CW. However later on, the pseudohomophone error was detected as demonstrated with the P600 effect. In the low-cloze sentence there is not a strong expectation for a single word so it is easier to detect the incongruency in the orthography, resulting in a difference in the N270. Furthermore, a standard N400 effect appeared in Vissers' et al. (2006) experiment for both words and pseudohomophones when comparing high-cloze and low-cloze sentences. The amplitude of the N400 was larger in the low-cloze than in the high-cloze sentences. The N400 for the pseudohomophones is again interpreted as the result of phonological influences on semantic integration.

In both Newman and Connolly's (2004) and Vissers' et al., (2006) experiments the nonwords were homophones of the expected word, which are thus semantically correct when read phonologically. In the current study, we tested errors that are similar to (word and nonword) phonological speech errors, namely substitutions of the initial consonants or consonant cluster. In the correct word condition, high-cloze sentences contained a correct word (CW). In the non-lexical error (NLE) condition, these sentences instead contained a nonword that was phonologically related to the correct word (as in Münte et al., 1997). In the lexical-error (LE) condition, these sentences contained a phonologically related real word. First, based on the hypothesis that the P600 reflects a comprehension monitoring process we predicted a P600 in both the NLE and the LE condition in comparison to the expected word. Second, if the comprehension monitor is sensitive to lexicality we predict the P600 to be

larger in the NLE condition than in the LE condition. Third, we predicted a difference in the N400 in the LE and the NLE condition compared to the expected word condition, because in both these conditions the item cannot be semantically integrated with the beginning of the sentence; this is the standard N400 effect. Fourth, based on the absence of a N270 in the high-cloze sentences in Vissers et al. (2006) we did not expect a difference in the N270 between the three conditions currently tested.

Method

Participants

Thirty-six students (32 females and 4 males) of Ghent University (mean age = 21.87 years; age range = 19 to 28), participated in exchange for money. Six participants were excluded from further analysis because of too many artifacts or too many incorrect answers. All the participants were native Dutch speakers, and were neurologically and psychiatrically healthy. They all had normal or corrected-to-normal vision, and had no reading or speaking disorders. Furthermore, as was indicated by a questionnaire (Van Strien, 1992) they were all right-handed (mean score = 9.47). The score of this questionnaire ranges from -10 (extremely left-handed) to 10 (extremely right-handed).

Materials

Hundred-and-twenty high-cloze probability sentences, with a cloze probability of at least 80% (mean = 93.25%) were selected from a previous study (Severens, Ratinckx, Ferreira, & Hartsuiker, in press). In order to avoid sentence wrap-up effects, all sentences were lengthened with some words after the cloze word. The mean length of the sentences was 11.97 words (range 7 to 18 words), the mean number of words before the critical word was 7.96 (range from 3 to 14), after the critical word there was a mean number of 3.01 words (range from 1 to 6). For each CW a LE (phonologically related word) and a NLE (phonologically related non-word) were selected, which only differed in the first phoneme (77 items) or cluster of phonemes (44 items cluster of 2 phonemes; 1 item cluster of 3 phonemes) from the CW. All CWs and LEs were nouns, with the same gender. An example of each condition is presented in Table 1 (See Appendix F for a list with all the stimuli). The mean log-frequency of the CWs was 1.40 and the mean log-frequency of the LEs was 1.25, these log-frequencies did not differ, $t(238) = 1.50$, $p = .34$.

Table 1. Example sentences in the correct, the LE and the NLE conditions.

Conditions	Sentences
CW (word-by-word translation)	Tijdens mijn slaap had ik een rare ***droom*** over een reis During my sleep had I a weird ***dream*** about a journey (During my sleep I had a weird ***dream*** about a journey)
LE (word-by-word translation)	Tijdens mijn slaap had ik een rare ***boom*** over een reis During my sleep had I a weird ***tree*** about a journey (During my sleep I had a weird ***tree*** about a journey)
NLE (word-by-word translation)	Tijdens mijn slaap had ik een rare ***noom*** over een reis During my sleep had I a weird ***neam*** about a journey (During my sleep I had a weird ***neam*** about a journey)

Three lists were constructed; each sentence appeared once in each list. Across the three lists each sentence appeared once with the CW, once with the LE, and once with the NLE. Furthermore, each list contained 40 filler items. These were high-cloze sentences that were presented with the CW, which was never the last word of the sentence.

The lists contained 48 extra sentences about which a comprehension question was asked, to ensure the participants were paying attention. The participants had to answer this yes-no-comprehension question by pressing a corresponding button. For example, for the sentence: *Vroeger werd er water gehaald bij de put* (In the old days people got water from the well), there was a question like: *Werd er water gehaald uit de kraan?* (Did they get water from the tap?). There were also 80 sentences containing a subject-verb agreement error and 80 sentences with the same structure without a subject-verb agreement error. For the current purpose these sentences were only expected to distract the participants.

Procedure

Participants were seated in an experimental room. They were instructed not to blink during sentence presentation. Furthermore, they were instructed to read the sentences attentively and answer the questions with a press on either the right or the left button. The participants were familiarized with the experimental procedure, by performing a practice session.

Sentences were presented word-by-word, with each word visible for 325 ms and followed by a blank screen for 200 ms. There was a 500 ms blank screen after the last word. Sentences were preceded by a fixation cross for 1500 ms followed by a 500 ms blank screen. The question was presented all at once, and disappeared when the participant answered the question with a button press. The entire experiment, including electrode placement and removal, took about 2.5 hours.

EEG recording and analysis

Brainwaves were measured with 31 electrodes mounted in an elastic electrode cap according to the international 10-20 setting. The electrodes were

referenced to the mean of all the electrodes[2]. Impedances of the electrodes were kept below 3 KΩ. The electro-oculo gram (EOG) was recorded bipolarly. The vertical EOG was measured with two electrodes placed above and below the left eye; the horizontal EOG was measured with two electrodes placed on the left and right cantus. The signal was re-referenced offline to the average signal of the electrodes placed on the left and right mastoid. The EEG was digitized at 512 Hz. The continuous EEG was filtered off-line with a band pass filter of 0.01-30 Hz.

EEG data were analyzed using EEProbe 3.1 (ANT, Inc., Enschede, The Netherlands) running on Red Hat Linux 7. ERPs were time-locked to the onset of the critical item (CW, LE, or NLE) with a time-window from -100 to 1000 ms. Epochs containing artifacts, such as blinks, were rejected from further analysis; the overall rejection rate of the analyzed participants was 8.58%. Based on visual inspection of the data, the mean area amplitudes were calculated for two time-windows: 350-450 ms (N400) and 600-800 ms (P600). To allow for quantitative analysis of hemispheric differences data acquired at the midline (Fz, FCz, Cz, CPz, Pz), medial-lateral (left: F3, FC3, C3, CP3, P3; right: F4, FC4, C4, CP4, P4) and lateral-lateral (left: F7, FT7, T7, TP7, P7; right: F8, FT8, T8, TP8, P8) sites were treated separately. Data from the midline were subjected to a repeated measures ANOVA with the Factors Relatedness (correct/LE/NLE) and Electrodes (5). Data from the medial-lateral and lateral-lateral sites were subjected to a three-way ANOVA with the Factors Relatedness (correct/LE/NLE), Hemisphere (left/right) and Electrodes (5). Significant main effects were followed by simple effects analysis. To check if the N270 was present analyses were performed on the amplitude of the most negative peak between 200 and 350 ms like Newman and Connolly (2004) did. The Greenhouse Geiser correction was applied when there was more than one degree of freedom in the numerator. The corrected p values will be reported.

Results

Behavioral data

Participants had an averaged error rate of 3.06% on the comprehension questions, showing that they were reading the sentences attentively.

Event Related Potentials

Grand-average ERPs to the critical words can be seen in Figure 1.

All conditions elicited an N1-P2 complex, as is typical for visual stimuli. Visual inspection of the data suggested a negativity in the LE and NLE conditions around 400 ms, which did not differ between the LE and the NLE condition. Later on there was a P600 for the LE and the NLE compared to the CWs. The P600 seemed to be the largest for the NLE and the smallest for the CWs, with the LE in between these two.

[2] The averaged signal of all electrodes was used as a reference because this is set in the hardware of the amplifier. It has been suggested that similar reference sites should be used to be able to compare results (Dien, 1998) and most studies use the average of the left and right mastoid as a reference. We therefore re-referenced off-line to the average of the left and right mastoid.

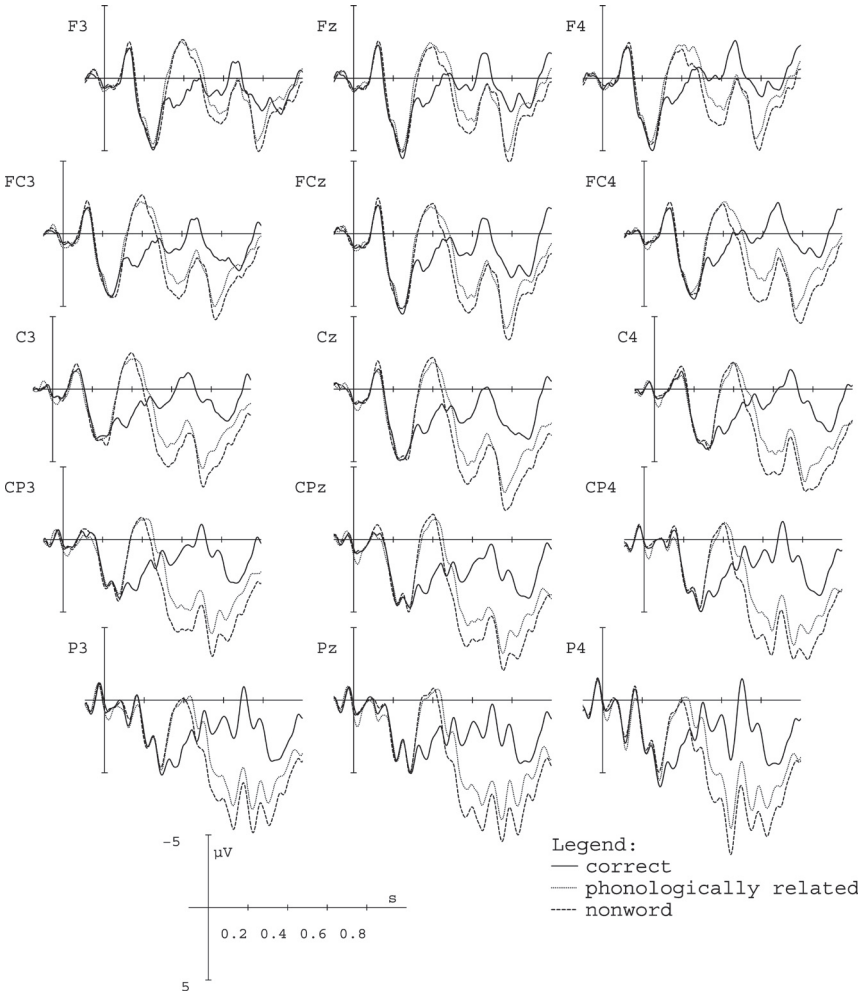

Figure 1. Grand average ERPs for the CW, the LE and the NLE for the midline and medial-lateral sites. Averages are time-locked to the onset of the critical word.

P600 time-window (600-800 ms)

There was a main effect of relatedness in the 600-800 ms time-window (midline: $F(2,58) = 30.71$, $p < 0.001$; medial-lateral: $F(2,58) = 40.41$, $p < 0.001$; lateral-lateral: $F(2,58) = 50.24$, $p < 0.001$). The effect appeared to be larger at posterior sites as shown by the interaction between relatedness and electrodes (midline: $F(8,232) = 12.01$, $p < 0.001$; medial-lateral: $F(8,232) = 27.76$, $p < 0.001$; lateral-lateral: $F(8,232) = 19.66$, $p < 0.001$). Additionally, the effect was slightly larger at right electrode sites demonstrated by the interaction of relatedness and hemisphere in the medial-lateral analyses (medial-lateral: $F(2,58) = 3.82$, $p < 0.05$). Simple effect analysis showed that both the LE and the NLE condition had a more positive going wave compared to the correct condition (correct vs. LE: midline:

$F(1,29) = 26.17$, $p < 0.001$; medial-lateral: $F(1,29) = 30.06$, $p < 0.001$; lateral-lateral: $F(1,29) = 39.21$, $p < 0.001$; correct vs. NLE: midline: $F(1,29) = 54.14$, $p < 0.001$; medial-lateral: $F(1,29) = 71.95$, $p < 0.001$; lateral-lateral: $F(1,29) = 74.60$, $p < 0.001$). Importantly, there was also a difference between the LE condition and the NLE condition (midline: $F(1,29) = 4.73$, $p < 0.05$; medial-lateral: $F(1,29) = 8.99$, $p < 0.01$; lateral-lateral: $F(1,29) = 14.97$, $p < 0.01$).

N400 time-window (350-450 ms)

In the 350-450 ms time-window a main effect of relatedness was observed (midline: $F(2,58) = 26.12$, $p < 0.001$; medial-lateral: $F(2,58) = 30.66$, $p < 0.001$; lateral-lateral: $F(2,58) = 47.03$, $p < 0.001$). Simple effect analyses showed that both the LE and the NLE condition were more negative going than the correct condition (correct vs. LE: midline: $F(1,29) = 38.24$, $p < 0.001$; medial-lateral: $F(1,29) = 46.99$, $p < 0.001$; lateral-lateral: $F(1,29) = 73.22$, $p < 0.001$; correct vs. NLE: midline: $F(1,29) = 40.27$, $p < 0.001$; medial-lateral: $F(1,29) = 42.88$, $p < 0.001$; lateral-lateral: $F(1,29) = 56.02$, $p < 0.001$). There was no difference between the LE and the NLE condition (midline, medial-lateral, and lateral, Fs < 1).

N270

There were no significant main effects or interactions for the amplitude of the N270 in the midline ($F < 2$), medial-lateral ($F < 1$) and lateral-lateral sites ($F < 1$).

Discussion

The current study aimed to test if monitoring in comprehension is similar to monitoring in production. Therefore we tested if the comprehension monitor also reflects a lexical bias effect. In production this effect has often been attributed to a biased monitor which relies on the comprehension system (Baars et al., 1975; Hartsuiker et al., 2005; Levelt et al., 1999; Nooteboom, 2005; Roelofs, 2004). If monitoring processes in production and comprehension monitoring are indeed similar, one thus expects a lexical bias effect in comprehension monitoring. High-cloze sentences with the CW, a LE, or a NLE were used to test this. As expected, a P600 appeared in the LE and the NLE condition compared to the correct condition, with an intermediate P600 for the LE condition. Additionally, both the LE and the NLE condition elicited a N400, compared to the correct condition, which did not differ in amplitude. There was no difference in the N270 between the three conditions.

The finding that the P600 evoked by the NLE was larger than the P600 elicited by the LE confirmed our prediction that the comprehension monitor is sensitive to lexicality. To reiterate, the P600 has been suggested to reflect comprehension monitoring, which is started when the veridicality of the word has to be checked (Kolk et al., 2003; Van Herten

et al., 2006; Van Herten et al., 2005; Vissers et al., 2006). This process is started when there is a tendency to accept the word on one ground (e.g., semantics activated by phonology and by sentence context) and to reject it on another ground (e.g., orthography). This predicts a P600 under conditions when sentence context and phonology suggest a word is correct, but orthography suggests the word is incorrect, or incorrectly read, and this prediction is borne out in our data and those of Münte et al. (1998) and Vissers et al. (2006). Importantly, if comprehension monitoring pays attention to lexical status, there should be a modulation of the P600 as a function of lexicality, and this is what our data show.

As predicted, there was no difference in the amplitude of the N400 between the NLE and the LE. This is consistent with the suggestion that the N400 is sensitive to phonological information (Newman & Connolly, 2004; Vissers et al., 2006), because in our experiment the NLE and LE conditions had comparable phonological similarity to the CW. Holcomb and colleagues (Holcomb & Grainger, 2006; Holcomb, Grainger, & O'Rourke, 2002) inferred from their masked priming experiments that it is possible that the nonwords activate their real word neighbors, and that these neighbors then serve as a context for integration. Because the neighborhoods of the LE and the NLE in our experiment were very similar, integration would be equally hard.

As expected there was no difference in the N270 between the three conditions, similar to Vissers' et al. (2006) results with high-cloze sentences. It has been argued that the N270 is sensitive to orthographic features. Since high-cloze sentences were used and the orthography in the three conditions is very similar, it is possible that the LE and the NLE at first were read as the CW. Because there was a N270 in the low-cloze sentences in Vissers' et al. (2006) experiment, we tentative suggest that the sentences used in the experiment of Newman and Connoly (2004) had a lower cloze probability than those in the current and in Vissers' et al. (2006) experiment. Because there is no strong expectancy the misspelling is detected directly as shown by the N270. Moreover, this also explains the lack of a P600 in the experiment of Newman and Connoly (2004); the misspelling is detected, thus there is no need for comprehension monitoring.

Most importantly, the current experiment shows that there is a lexical bias effect in comprehension monitoring as has been indicated by a larger P600 amplitude in the NLE compared to the LE. In contrast, the N400 and the N270 did not reflect lexicality. The finding that the P600 shows a lexical bias effect in comprehension monitoring supports the hypothesis of similar processes in comprehension and production monitoring. This suggests that there might be a modality-independent system that monitors language. This system checks speech for errors by checking, if the things said are really the things that were planned to be said. In production, this system asks 'Did I say this correctly?'. In comprehension, the system asks 'Did I read (or hear) that correctly?'. Of course, the hypothesis of a modality-independent monitoring system has the advantage of parsimony.

chapter 7

General conclusions

General Conclusions

The aim of the experiments reported here was to investigate how the internal self-monitor works and for which speech error patterns it might be responsible. As mentioned in the introduction it is important to explore the internal self-monitor since it plays a key role in an important discussion in language production, namely whether language production models are interactive (e.g. Dell, 1986) or discrete (Levelt, Roelofs, & Meyer, 1999). In the first part of this dissertation it was investigated if the internal self-monitor is sensitive to phonological overlap between the intended word and the error. In the second part it was examined with Event-Related Potentials (ERPs) whether similar biases that have been found in production were also present in comprehension. Results of both parts will be described and discussed in two separate sections. The chapter will be closed with some future research directions and conclusions.

Phonological vulnerability of the internal self-monitor

Roelofs (2004) suggested that the internal self-monitor compares the intended word with the prepared preverbal word. The preverbal word activates a cohort of words in the comprehension system; these words share the initial phonemes with the preverbal word. Therefore it is harder for the internal self-monitor to detect an error when there is phonological overlap between the prepared word and the intended word. In language production the phonological vulnerability of the self-monitor will result in a higher number of errors that are phonologically related to the intended word. The mixed error bias can be explained by an internal self-monitor which is susceptible for phonological overlap (Levelt et al., 1999; Roelofs, 2004). As mentioned in the introduction also errors that only have a phonological relation without a semantic relation (as in the mixed error bias) occur more often than completely unrelated errors (Dell, 1986). The first part of this dissertation was set up to test if the internal self-monitor is actually susceptible to phonological overlap. In order to examine this, a sentence priming paradigm that has been proven to successfully elicit errors was used (Ferreira & Griffin, 2003). In this paradigm highly constraining sentence fragments followed by a picture were presented to the participants. The last word of the sentence was never shown; this last word could be phonologically related, semantically related, or a homophone of a semantically related word to the picture. Participants' task was to name the pictures. Because it was necessary to have Dutch name agreement data for these pictures, we first conducted a norming study (Chapter 2). A total of 590 pictures were tested. Participants had to name the pictures; name agreement and RT were measured.

Five experiments (Chapter 3) demonstrated that there were no phonological intrusions in both Dutch (Experiment 1-4) and English (Experiment 5). In contrast, there were semantic intrusions (Experiment 1-4) and homophone intrusions (Experiment 5). On a monitoring account, if the participants erroneously prepare to complete the sentence instead of naming the picture a comprehension cohort of this error is activated.

When there is phonological overlap between the last word and the picture, the concept represented in the picture will also become activated through the comprehension cohort of the last word. Therefore more phonological intrusions were expected compared to unrelated intrusions. This hypothesis was not confirmed. The present data thus do not support the view that the internal self-monitor is vulnerable to phonological overlap between the error and the intended word.

Converging evidence has been found by Huettig and Hartsuiker (submitted). These authors demonstrated in an eye-tracking study that participants looked at phonologically related distracter words about 200 ms after the onset of overtly naming a target picture. The time-course of these eye-movement patterns driven by one's own speech was highly comparable to the situation of listening to some one else's speech (Huettig & McQueen, 2007). If speech would be monitored internally, looks to phonologically related words are expected to start earlier when producing speech, because then it is possible to check speech internally.

In contrast, Slevc and Ferreira (2006) found that the internal self-monitor is vulnerable to phonological overlap. In their experiments participants had to name pictures while they were presented (auditory or visually) with interfering words. These words could be phonologically or semantically related to the picture. If these interfering words were the same as the word illustrated in the picture, the production of this word had to be stopped. It was found that interrupting the production of words was harder when the picture and the interfering word were phonologically related. Additionally there was no influence of semantically relatedness. They concluded that the internal self-monitor is sensitive to phonological information. However, in Slevc and Ferreira's study the intended word had to be compared with an externally presented word. This might be different from the prearticulatory word that is used in self-monitoring of speech. Furthermore, it is possible that in the task of Slevc and Ferreira the monitor's criterion is set differently because naming had to be stopped more often than in normal speech. Hence it is possible that the monitor is set to detect a difference as soon as possible, and this of course makes phonological information very relevant. This contrasts with the task used in Chapter 3 in which monitoring might be more natural and as demonstrated there was no influence of phonological similarity. Altogether, the data suggest that the monitor in a natural setting is not sensitive to phonological information. Therefore we concluded that the homophone intrusions found in Experiment 5 and by Ferreira and Griffin (2003) have to be caused by feedback and not by an internal self-monitor. It would be very unsatisfying if the homophone effect would be caused by a monitor but that this monitor is not sensitive for phonological overlap between the intended word and the error. In addition we question if a biased internal self-monitor can be responsible for the mixed bias effect since this effect has also been explained by the vulnerability of the internal self-monitor to phonological overlap.

Perception analogue

In the second part of this dissertation it was examined with ERPs if for three speech error patterns a similar bias can be found in comprehension. Hartsuiker (2006) proposed that three demands should be met by an error pattern to be able to be explained by an internal self-monitor. To reiterate, the first demand holds that the internal self-monitor has to be functional. Second, manipulations influencing the monitor should also influence the observed error pattern. Third, a similar bias should also be present in comprehension studies as the error pattern that is thought to be caused by an internal self-monitor. In the present dissertation the third demand was tested for morphophonological influences on subject-verb agreement (Chapter 4), for conceptual influences on subject-verb agreement (Chapter 5), and for the lexical bias effect (Chapter 6). In the introduction we presented a table that shows the extent with which five error patterns meet the three demands proposed by Hartsuiker (2006). Table 1 shows an adapted table which updates the extent with which the third demand is met for the three explored error patterns. Below we will discuss the findings of the three studies.

Table 1. Adjusted evaluation of five suspected monitoring biases against the criteria of functionality (the monitor would set functional criteria), affectability (the bias is affected by manipulations that alter monitoring performance), and correspondence with perception (the bias would also occur in perception of one's external speech and others' speech). The table is adapted from Hartsuiker (2006). The parts with the grey background show the new additions.

	Functionality	Affectability	Perception analogue
Lexical bias	+	+	+
Mixed error bias	+	0	0/+[a]
Exchange rate	+	0	0
Morphophonological effects on agreement errors	-	0	+
Conceptual effects on agreement errors	+	-	-

+ error pattern meets the demand, - error pattern does not meet the demand, 0 there is no conceivable evidence if the error pattern meets the demand. a. The "0" refers to the general case (do listeners detect phonologically unrelated semantic errors more often than mixed errors?). The "+" refers to the specific proposal that the internal channel will activate a cohort of phonologically similar competitors (Roelofs, 2004).

In Chapter 4 the morphophonological influence on subject-verb agreement errors was scrutinized. Production studies have shown that the gender of the determiner of the head noun influences the number of subject-verb agreement errors that are made. This effect was only present when the local noun is plural (Hartsuiker, Schriefers, Bock, & Kikstra, 2003). In order to investigate if there is a perception analogue, sentences that started with a neuter-gender (unambiguous determiner) or a common-gender (ambiguous determiner) noun were presented. Furthermore

these sentences could contain a singular or plural local noun and the verb could agree with the subject or not. In the present comprehension study there was a N400 in the noun number match condition which was larger when the sentence started with a neuter-gender determiner compared to when it started with a common-gender determiner. In the noun number mismatch condition there was a P600 for the incorrect verbs. Again this effect was modulated by number ambiguity of the NP, with larger amplitudes for the neuter-gender determiner. We suggested that in the noun number match condition there is a shallow analysis of the sentence, hence the N400. This is caused by the strong expectation that can be built in these sentences. In contrast, in the noun number mismatch condition there is a need for a syntactic analysis of the sentence. These results support the expectations that were based on a biased monitoring account. In production studies there is only an influence of number ambiguity on the production of subject-verb agreement errors in the noun number mismatch conditions. Therefore the comprehension effects will only be discussed for this condition. According to a monitoring account it is easier for the internal self-monitor to detect errors in the sentences that start with a neuter-gender determiner. Consequently it would also be easier to detect these errors when comprehending language. If more errors are detected, larger effects are expected. This is exactly what we found. Thus these results show that there is a similar bias in comprehension as there is in production. This finding meets the third demand for the error pattern morphophonological influences on subject-verb agreement. As can be seen in Table 1 and as has been discussed in the introduction the morphophonological influences on subject-verb agreement do not meet the functionality criteria. Furthermore there is no evidence that we are aware of that can confirm or disconfirm the second demand for this error pattern. To be able to conclude whether the morphophonological influences on subject-verb agreement can be explained by an internal self-monitor it is necessary to investigate the second demand. Thus it is important to carry out an experiment which tests whether the morphophonological influence disappears when the monitor is occupied with another task.

The influence of conceptual factors on subject-verb agreement errors was investigated in Chapter 5. Distributive and non-distributive sentences with or without subject-verb agreement errors were presented to participants. In production studies it has been found that distributive sentences elicit more subject-verb agreement errors in sentence completion studies than non-distributive sentences. According to a biased monitoring account that uses conceptual information it would be easier for the monitor to detect errors in non-distributive sentences compared to distributive sentences. If Hartsuiker's third demand holds for this error pattern these errors should also be easier to detect in comprehension. Consequently the effects in the non-distributive sentences were predicted to be larger; this was not confirmed by the data. The distributive sentences showed normal ERP-components to syntactic violations, namely the LAN and the P600. In contrast in the non-distributive sentences there were no effects

in these time-windows. However there was an effect in the LAN time-window for the word after the incorrect verb. This effect was also observable in the distributive sentences although this effect was smaller and only present at two electrode sites. We suggested that the effect on the word after the incorrect verb was caused by the possibility of completing the non-distributive sentences with a post-verbal subject (e.g., *De kist met de flessen zullen wij brengen, translation: [the box with the bottles]*$_{object}$ *shall we*$_{subject}$ *take away]*). We suggested that the chance of having a post-verbal subject is larger in the non-distributive sentences than in the distributive sentences. Hence the larger effect in the non-distributive sentences. To recapulate, this comprehension study does not show a similar bias as the bias found in production studies. Therefore, the third demand for the conceptual influences on subject-verb agreement has not been confirmed. As mentioned in the introduction the conceptual influences on subject-verb agreement do meet the functionality criterion however the affectability criterion is not met (see Table 1). Since two out of three demands are not met we believe that it is unlikely that this error pattern found in production is caused by a biased internal self-monitor. Therefore, we conclude that it is unlikely that the monitor uses conceptual information to detect errors. However, bear in mind that if it is true that the processing in the non-distributive sentences is postponed to the word after the incorrect verb the third demand cannot be excluded definitely for this error pattern. More research is needed to explore this possibility. However, based on the available data it is very unlikely that this error pattern can be explained with an internal self-monitor.

The third demand was tested in Chapter 6 for the lexical bias effect. This was tested with high cloze sentences in which there was the correct word, a lexical error or a non-lexical error. Since the monitoring account explains the lexical bias effect by suggesting that the monitor uses lexicality (*Is this a real word?*) as a criterion, it was expected that non-lexical errors were easier to detect. Therefore larger effects were expected in the non-lexical errors compared to the lexical errors. Following this prediction there was a larger P600 elicited by the non-lexical errors compared to the correct word. The lexical errors elicited a P600 that was between the non-lexical error and the correct word. Based on this finding it was concluded that the lexical bias effect is present in comprehension monitoring. As mentioned in the introduction the lexical bias effect has been shown to also meet the first and the second demand (see Table 1). Thus all the three demands are met for the lexical bias effect. Therefore, we conclude that it is very likely that the lexical bias effect is caused by a biased internal self-monitor, which uses lexicality as a criterion.

To summarize a perception analogue has been found for the morphophonological influence on subject-verb agreement and for the lexical bias, there was no evidence for a conceptual influence on subject-verb agreement. When looking at Table 1 it can be suggested that it is very plausible that the lexical bias is caused by an internal self-monitor. It is possible that the morphophonological influence on subject-verb

agreement is the result of an internal self-monitor; however the second demand should still be investigated. Finally it is very unlikely that the conceptual influences on subject-verb agreement are caused by an internal self-monitor.

Difference in ERP-results

Both the morphophonological study (Chapter 4) and the distributivity study (Chapter 5) used subject-verb agreement errors. Why then was there a difference in the ERP-components found in both these studies? In the morphophonological study (Chapter 4) we found a P600 in the mismatch conditions and a N400 in the match conditions. In contrast we observed a LAN and a P600 in the distributivity study (Chapter 5). In the non-distributive sentences we found a LAN to the word after the incorrect verb and in the distributive sentences there was a LAN and a P600 to the incorrect verb. We suggest these discrepancies result from differences between the two studies with respect to the stimuli and list composition. The stimuli in the morphophonological study were all very similar, in contrast to the great variety in the distributivity study. In the morphophonological study all the sentences had the same structure. Additionally the verb was always "*to be*". In the distributivity study a variety of auxiliary verbs were used. Furthermore there were also sentences which did not have the same sentence structure as the experimental stimuli. Additionally these sentences contained different incongruencies than subject-verb errors. We believe the difference in the variety of stimuli were responsible for the differences in ERP-components between the two studies. As described in Chapter 4 we believe that the N400 in the match condition is elicited by the possibility of building a strong expectation. We suggested that this possibility is large because of the similarities in sentence structures. The absence of the LAN in the mismatch condition of the morphophonological study (note that in the distributivity study all the sentence contain a mismatch) on the word after the incorrect verb is also caused by the similarity of the sentence structures. Hence it was obvious for participants that these sentences would not be completed with a post-verbal subject. Remember that we think that the plausibility of a post-verbal subject caused the LAN on the word after the incorrect verb (see Chapter 5). It is not clear why there is no LAN in the morphophonological study on the incorrect verb, while there is a LAN on the incorrect verb in the distributive sentences. However also in other studies the LAN has not been consistently found and it is still not clear what causes this inconsistency (for an overview see Vos, Gunter, Kolk, & Mulder, 2001).

Monitoring vs. Comprehension monitoring

One important point in the present dissertation that should be noted is the difference between internal self-monitoring and comprehension monitoring. Internal self-monitoring is the process that checks internal speech for errors; this process has been suggested to rely on the comprehension system (Hartsuiker & Kolk, 2001; Levelt, 1983, 1989; Levelt, et al., 1999;

but see Postma, 2000 for an alternative view). Comprehension monitoring is a process in comprehension that verifies if the words that are perceived are correctly perceived. In other words to self-monitor is similar to asking the question: *Is this what I planned to say?.* Comprehension monitoring can be compared to the question: *Did I read/hear this correctly?*. Kolk and colleagues argue that when there is a conflict between for example semantics and syntax about whether the word that is perceived is correct comprehension monitoring is started (Kolk & Chwilla, 2007; Kolk, Chwilla, Van Herten, & Oor, 2003; Van Herten, Chwilla, & Kolk, 2006; Van Herten, Kolk, & Chwilla, 2005; Vissers, Chwilla, & Kolk, 2006). In the present dissertation Chapter 6 described a study that investigated comprehension monitoring. We believe that if the internal self-monitor proposed in production relies on the comprehension system, comprehension, comprehension monitoring and internal self-monitoring should reflect similar biases. It would be very parsimonious to have monitoring systems for comprehension and production separately. Thus we think that if the internal self-monitor of production relies on the comprehension system, comprehension monitoring should also rely on the comprehension system.

The subject-verb agreement errors examined in Chapter 4 and 5 can also reflect comprehension monitoring, although not described as such in these Chapters. It is possible that when an incorrect verb is perceived this causes a conflict which starts comprehension monitoring. We believe this would not cause any differences for the results discussed in the present dissertation. As mentioned before it would be extremely parsimonious if both comprehension monitoring and the internal self-monitor of production are situated in the same system. Thus if the results discussed in the present dissertation are the reflection of comprehension monitoring we suggest that this still would reflect similar biases as found in production.

Kolk and colleagues (Kolk & Chwilla, 2007; Kolk et al., 2003; Van Herten et al., 2006; Van Herten, et al., 2005; Vissers et al., 2006) suggest that this comprehension monitoring is a more general executive control. They argue that the P600 reflects executive control of language, which they suggest is comprehension monitoring. This executive control is suggested to resolve the conflict that is present at that time in the comprehension system. Support for this suggestion comes from a study by Novick, Trueswell, Thompson-Schill (2005) they found that when reading garden-path sentence, which typically elicit a P600, the same region becomes active as the region that becomes active while performing the incongruent trials in a stroop task. In the incongruent trials there is also a conflict that should be resolved. These authors suggest that the function of the region that is active in both the incongruent trials of the stoop task and during garden-path sentences is executive control. This is in line with the suggestion that the P600 reflects executive control.

How would monitoring occur in production if comprehension monitoring is a more general process like executive control? If comprehension monitoring is part of a more general executive control system then it is likely that the internal self-monitor in production would also

use executive control to resolve the conflict between the intended word and the prepared word that is detected in the comprehension system. It is possible that when there is a conflict in the comprehension system this will activate executive control, which Kolk and colleagues called comprehension monitoring. Thus this executive control to resolve the conflict is start whenever there is a conflict in the comprehension system. This conflict can be caused by normal comprehension but also by monitoring of production.

It is also possible that there is no monitoring of speech production that relies on the comprehension system. As mentioned in the introduction the internal self-monitor is an "escape route" for discrete models to be able to explain error patterns that seem to be interactive. The interactive models do not need an internal self-monitor to be able to explain speech error patterns, it is thus possible that there is no internal self-monitor. There is only one study which provides direct evidence for an internal self-monitor relying on the comprehension system (Motley, Camden, & Baars, 1982). In this study the SLIP-task was used to elicit taboo-words or neutral words. It was found that the number of taboo errors that were made were lower than the neutral errors. Additionally in the taboo condition there was a Galvanic Skin Resistance (GSR) which was interpreted as showing that the taboo words are produced but corrected covertly. The GSR is not a very reliable measure of cognitive processes; therefore this evidence can not be taken as very strong. Since every other speech error pattern can be explained with feedback and the results found in this dissertation provide only indirect evidence for an internal self-monitor that relies on the comprehension system it is possible that there is no such monitor in language production. It is thus important to further investigate whether the existence of such internal-self monitor is reliable.

Conclusions and directions for future research

To conclude the present dissertation gave us some restrictions on how the internal self-monitor works. Based on the present findings we believe that the monitor is not sensitive for phonological information alone. It uses a lexicality criterion and morphophonological information is also used, however it does not check for conceptual information in subject-verb agreement errors. The present results show that it is important to investigate how the internal self-monitor works and that this monitor cannot be used as an escape route for the discrete models all the time. However it is also possible as discussed in the previous part that there is no internal self-monitor in language production. The first part of this dissertation shows that the monitor does not use phonological information. This is a very important assumption of the internal self-monitor account; the mixed error bias is explained by this assumption (Roelofs, 2004). The morphophonological study and the lexical bias study only show that it is possible that there is an internal self-monitor that relies on the comprehension system. They do not show that there has to be an internal self-monitor. It is however hard to investigate if there is an internal self-moni-

tor or if monitoring is carried by feedback since both these explanations are completely internal. However Hartsuiker (2006) suggested if three demands are met the existence of an internal self-monitor can be indirectly proven. Therefore it is important to further investigate these demands. Additionally the present dissertation raises a number of questions that future research needs to address; these questions will be discussed in the next sections.

Further investigating the demands

First of all, if one assumes there is an internal self-monitor that relies on the comprehension system, it is important to test the demands proposed by Hartsuiker (2006) for each error patterns. When looking at Table 1, which shows to what extent various speech error patterns meet the three demands, it is obvious that there are still are a number of empty cells. Thus, it is still not clear whether there is a perception analogue for the mixed error bias and for the exchange rate. In the case of the mixed error bias this could be tested in an ERP-study that is similar to the lexical bias study in the present dissertation. It might be possible to test the exchange rate with an eye-tracking study. If two phonemes of two words are exchanged this is suggested to be easier to detect compared to anticipations and perseverations. Therefore it might be expected that in sentences with an exchange there is a longer fixation time on the sentence part containing the exchange compared to sentence parts containing only an anticipation or a perseveration. Furthermore, the second demand has to be investigated for the mixed error bias, the exchange rate, and the morphophonological effect on subject-verb agreement. This can be done by carrying out production experiments in which these errors are elicited and combining these tasks with a secondary task. If the error patterns are the result of an internal self-monitor the biases should change when there are less resources available for the monitor. In the present dissertation we only discussed the error patterns that are in Table 1, however it should be noted that there are more speech error patterns for which it is possible that they are influenced by the internal self-monitor. Of course it is also important to investigate to what extent other speech error patterns meet the three demands.

Resolving questions raised by the present research

To examine if the verbs in the match conditions of the morphophonological study are indeed more expected, it is possible to carry out this study with an eye-tracking study. By measuring eye-movements it is possible to see how much time the participants spent on the verbs. It might be expected that there is less time spent on the verb in the match condition compared to the mismatch condition. This prediction is based on our suggestion that the building of an expectation is stronger in the match condition. In addition it is possible to check if participants look back at the determiner. In this way we can compare if there is a difference between the neuter-gender and the common-gender determiner. It might be expected

that participants more often look back at the common-gender determiner, since this determiner is ambiguous in number.

We suggested that there are no effects found on the incorrect verbs in the non-distributive sentences of the distributivity study since these sentences can be completed with a post-verbal subject. Importantly, the chance of having a post-verbal subject is thought to be larger for the non-distributive sentences compared to the distributive sentences. This can be tested with an ERP-study in which both kinds of sentences are completed with a post-verbal subject. It is expected to find a larger P600 in the case of the distributive sentences since the post-verbal subject is less expected. Another possibility is to test this with an eye-tracking study in which can be looked at the difference in fixation time on the post-verbal subject between the two kinds of sentences.

In the discussion of the lexical bias study we argued that there is no difference in N400 amplitude between the lexical error and the nonlexical error due to phonological overlap (see discussion Chapter 6). Of course we can only definitely conclude this if it has been proven that an error that is not phonologically related elicits a larger N400 than the lexical error and the nonlexical error. An experiment in which an unrelated condition and similar conditions as in the lexical bias study are used can examine this suggestion. Finally, it is also important to investigate if the P600 really reflects comprehension monitoring like Kolk and Chwilla (2007) suggest and if this is comparable to more general executive control. If we combine an executive task and a language task it is possible to see if both these tasks elicit similar ERP-components and more importantly we can check if these components have the same generator. Of course a similar study can be carried out in which fMRI is used.

Conclusion

The internal self-monitor plays a key role in the discussion about whether language production models are interactive (e.g., Dell, 1986) or discrete (e.g., Levelt, et al., 1999), therefore it is very important to investigate how and when the internal self-monitor works. The present dissertation gave us a better understanding of the way the internal self-monitor works; it is unlikely to be sensitive for phonological overlap. Additionally this dissertation also contributed to the investigation of which speech error patterns the internal self-monitor is responsible.

ge Samenvc

Nederlandstalige Samenvatting

Inleiding

Tijdens het spreken maken we soms fouten, heel vaak worden deze fouten al hersteld voordat we de fout helemaal hebben uitgesproken. Het foute woord wordt dan in het midden onderbroken en de fout wordt hersteld. Verondersteld wordt dat we ook fouten verbeteren die nooit uitgesproken worden, dit is te merken als er bijvoorbeeld een korte pauze in de spraak is. Deze fouten worden intern ontdekt en hersteld. Een toonaangevende theorie (Levelt, 1989) veronderstelt dat een interne code gecontroleerd wordt op fouten en dat dit interne zelfcontrolesysteem gebruik maakt van het begripssysteem.

In dit proefschrift werd de werking van het interne zelfcontrolesysteem in taal onderzocht. Het is belangrijk om de werking van dit interne zelfcontrolesysteem te onderzoeken omdat deze een sleutelrol speelt binnen de gaande discussie over de vraag of taalproductie modellen interactief (bv., Dell, 1986) of modulair (bv., Levelt, Roelofs, & Meyer, 1999) zijn. Het grote verschil tussen interactieve en modulaire modellen is de mogelijkheid dat activiteit kan terugstromen naar een hoger level in het model. Interactieve modellen staan het terugstromen van activiteit naar een hoger level toe en modulaire modellen veronderstellen dat deze terugstroom niet mogelijk is. Het bewijs voor terugstroom van activiteit berust alleen op foutenpatronen gevonden in spraak. Modulaire theorieën kunnen deze foutenpatronen ook verklaren mits ze gebruik maken van een intern zelfcontrolesysteem. In het eerste deel van het onderhavige proefschrift werd de werking van het interne zelfcontrolesysteem onderzocht. In het tweede deel werd voor drie foutenpatronen onderzocht of het intern zelfcontrolesysteem verantwoordelijk kan zijn voor deze foutenpatronen. De theoretische achtergronden en de resultaten zullen per deel besproken worden.

Fonologische gevoeligheid van het interne zelfcontrolesysteem

In het eerste deel van het proefschrift werd onderzocht of het interne zelfcontrolesysteem gevoelig is voor fonologische overeenkomsten tussen woorden. Roelofs (2004) suggereert dat voor het interne zelfcontrolesysteem het lastiger is om fouten te ontdekken als deze fouten fonologisch overeenkomen met het bedoelde woord. Dit komt doordat de fout een cohort van fonologisch gerelateerde woorden activeert, waarin ook het bedoelde woord zit. In het tweede hoofdstuk werden zwart-wit tekeningen genormeerd. Er werd gemeten met welk woord de tekening het meest benoemd werd, ook werd gekeken hoe lang het duurde voordat de tekening benoemd was. Deze tekeningen waren belangrijk voor het onderzoek dat in hoofdstuk 3 beschreven werd. In dat hoofdstuk werden zinnen aangeboden die een bepaald woord uitlokken (bv., *De vrouw die in het klooster werkt is een….*). Dit laatste woord (*non*) werd nooit gepresenteerd, in plaats van dat woord verscheen een tekening. Deze tekening was semantisch (*priester*) of fonologisch (*nok*) gerelateerd aan het laatste woord van de zin. De taak van de proefpersoon was om de tekeningen zo snel mogelijk te benoemen. In deze studie bleek dat als er een fonologische relatie was tussen de tekening en het laatste woord van de zin, dit geen invloed had op de benoeming van de tekening; de zin werd even vaak foutief afgemaakt met een niet gerelateerd woord als met een fonologisch gerelateerd woord. In de semantische gerelateerde conditie daarentegen werd gevonden dat meer zinnen afgemaakt werden dan in niet gerelateerde conditie. Er werd geconcludeerd dat de fonologische gelijkheid tussen de woorden geen invloed had op het interne zelfcontrole systeem.

Perceptuele overeenkomst

Het tweede deel van het proefschrift onderzocht of een bepaald foutenpatronen toe te schrijven is aan een intern zelfcontrolesysteem of aan productie-interneprocessen (bv., terugstroom). Dit is zeer moeilijk te achterhalen omdat beide verklaringen berusten op verscholen mechanismen waarvan alleen het resultaat gemeten kan worden. Hartsuiker (2006) stelt een manier voor om indirect te testen of een bepaald foutenpatroon verklaard kan worden door een intern zelfcontrolesysteem. Om dit te testen moet een foutenpatroon voldoen aan drie vereisten. De eerste eis houdt in dat het interne zelfcontrolesysteem functioneel moet zijn. Ten tweede moet het foutenpatroon veranderen als er manipulaties zijn die het interne zelfcontrolesysteem beïnvloeden. Ten derde moet een vergelijkbaar patroon gevonden worden in normaal begrip omdat er verondersteld wordt dat het interne zelfcontrolesysteem gebruik maakt van het begripssysteem (Levelt et al., 1999). De derde eis werd voor drie foutenpatronen onderzocht.

In Hoofdstuk 4 werd onderzocht of morfofonologische factoren invloed hebben op het begrip van onderwerp-persoonsvorm congruentie. In productiestudies werd gevonden dat ambiguïteit van het getal van het onderwerp invloed heeft op de hoeveelheid congruentiefouten dat gemaakt wordt. Het getal van het onderwerp ambigu kan ambigu zijn,

namelijk als het lidwoord *de* gebruikt wordt. Dit lidwoord kan namelijk gebruikt worden bij zelfstandige naamwoorden in het meervoud en in het enkelvoud. Het lidwoord *het* kan alleen voor enkelvoudige zelfstandige naamwoorden gebruikt worden, dus dan is het onderwerp onambigu. Gevonden werd dat als het getal ambigu was er meer congruentiefouten gemaakt werden (Hartsuiker, Schriefers, Bock, & Kikstra, 2003). Dit foutenpatroon kan verklaard worden door een intern zelfcontrolesysteem dat gevoelig is voor deze morfofonologische factor.

In een Event-Related Potentialen (ERP)-studie werd onderzocht of bij het lezen van zinnen, ambiguïteit van het getal van het onderwerp ook een invloed heeft op het begrip. Participanten moesten zinnen lezen waarin ambiguïteit, getal van het lokale zelfstandige naamwoord en het getal van de persoonsvorm gemanipuleerd werd (bv., *De straat/het plein bij de kerk/kerken is/*zijn mooi)*. Wanneer het lokale zelfstandige naamwoord enkelvoud was (*kerk*) was er een N400 voor de incorrecte persoonsvorm. Dit effect was groter wanneer de zin begon met een onambigu getal (*het*). In de conditie waar het zelfstandige naamwoord meervoud was (*kerken*) werd er een P600 uitgelokt door de incorrecte persoonsvorm. Wederom was het effect groter als de zin begon met een onambigu aantal. Deze resultaten werden geïnterpreteerd als bewijs voor de verantwoordelijkheid van een intern zelfcontrolesysteem bij morfofonologische invloeden op onderwerp-persoonsvorm berekening.

In Hoofdstuk 5 werd onderzocht of conceptuele factoren een invloed hebben op het begrip van onderwerp-persoonsvorm congruentiefouten. Er werden zinnen aangeboden waarvan het onderwerp een conceptueel meervoud (distributieve zinnen; bv., *Het etiquette op de flessen*) kan bevatten of niet (niet-distributieve zinnen; bv., *de baby op de dekens*). In productiestudies is gevonden dat als het onderwerp een conceptueel meervoud is er dan meer onderwerp-persoonsvorm congruentiefouten gemaakt worden (bv., Vigliocco, Hartsuiker, Jarema, & Kolk, 1996). Dit kan verklaard worden door een intern zelfcontrolesysteem dat gevoelig is voor conceptuele factoren. In de studie, beschreven in Hoofdstuk 5, werden ook fouten in de congruentie tussen het onderwerp en persoonsvorm aangeboden. In de distributieve zinnen werd een LAN en een P600 uitgelokt door de incorrecte persoonsvorm. In de niet-distributieve zinnen waren deze twee componenten niet zichtbaar, wel was er een LAN die uitgelokt werd door het woord na de incorrecte persoonsvorm. Deze LAN was ook zichtbaar in de distributieve zinnen echter in deze conditie was de LAN veel kleiner. We veronderstellen dat er in de niet-distributieve zinnen geen LAN en P600 zichtbaar zijn doordat deze zinnen afgemaakt kunnen worden met een onderwerp na de persoonsvorm (bv., *De kist met de flessen zullen wij brengen*). De kans dat een zin afgemaakt wordt is groter in de niet-distributieve zinnen door de fysische eigenschappen van het eerste zelfstandige naamwoord in de zin, in de niet-distributieve zinnen is zijn die eigenschappen vaak groter dan in de distributieve zinnen. Volgens een interne zelfcontroleverklaring is een fout in een niet-dis-

tributieve zin makkelijker te detecteren, daarom verwachtten we grotere effecten in deze conditie. Deze hypothese werd echter niet gesteund door de resultaten. Aan de derde eis werd dus niet voldaan voor de invloed van conceptuele factoren op het maken van congruentiefouten.

In de laatste studie werd onderzocht of er in begrip een analogie te vinden is voor het "lexicale bias effect" dat optreedt in spraakproductie. Dit is de bevinding dat fouten vaker echte woorden zijn dan nonwoorden dan verwacht mag worden op basis van kans (bv., Dell & Reich, 1981). Deze bevinding kan wederom verklaard worden door een intern zelfcontrolesysteem dat gevoelig is voor "lexicaliteit" (*Is dit een echt woord?*). In dit geval is het makkelijker voor het interne zelfcontrolesysteem om fouten te ontdekken die nonwoorden vormen in vergelijking met fouten die echte woorden vormen. Participanten moesten zinnen lezen waarin het correcte woord, een lexicale of een niet-lexicale fout te zien waren (bv., *Tijdens mijn slaap had ik een rare* ***droom/boom/noom*** *over een reis*). In het ERP-patroon was duidelijk een P600 te zien, die gemoduleerd werd door lexicaliteit. De P600 was het grootst voor de niet-lexicale fout, het kleinst voor het correcte woord en de amplitude van de P600 voor de lexicale fout lag tussen de andere twee. Deze resultaten ondersteunen de voorspellingen die gebaseerd zijn op een interne zelfcontroleverklaring. In deze studie werd aan de derde eis dus ook voldaan voor het "lexicale bias effect".

Conclusies

Het onderhavige proefschrift heeft het functioneren van een intern zelfcontrolesysteem onderzocht. Er is gevonden dat dit interne zelfcontrolesysteem niet gevoelig is voor fonologische overeenkomst tussen de fout en het bedoelde woord. In het tweede deel werd onderzocht of in het begripssysteem gelijkaardige patronen te vinden zijn als in drie foutenpatronen in productie. Het bleek dat voor zowel het lexicale bias effect en de morfofonologische invloed op onderwerp-persoonsvorm congruentie een gelijkaardig patroon te vinden is in het begripssysteem. Voor de conceptuele invloed op onderwerp-persoonsvorm congruentie is geen gelijkaardig patroon gevonden. Het is dus zeer belangrijk om te onderzoeken voor welke foutenpatronen het interne zelfcontrolesysteem verantwoordelijk is, omdat dit systeem niet elk foutenpatroon kan verklaren.

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Appendix A

Appendix A

file name	dominant name	Number of names	H-statistic	mean RT (ms)
accordion	accordeon	2	0,47	1067
acorn	eikel	2	0,77	1335
airplane	vliegtuig	1	0,07	832
alarmclock	wekker	3	1,18	1210
alligator	krokodil	1	0,04	979
anchor	anker	2	0,36	1162
ant	mier	5	1,19	1225
antlers	gewei	3	0,7	1285
anvil	aambeeld	5	1,14	1661
apple	appel	1	0,17	856
arm	arm	2	0,29	973
arrow	pijl	2	0,2	986
arrow2	pijl	1	0,07	850
artichoke	artisjok	7	1,64	1324
ashtray	asbak	3	0,75	1168
asparagus	asperge	10	2,02	1328
ax	bijl	4	0,82	1039
baby	baby	4	0,57	882
backpack	rugzak	2	0,35	911
badge	ster	9	2,04	1553
bag	zak	2	0,75	1034
bag2	zak	1	0,23	1136
balcony	balkon	6	1,78	1289
ball	bal	2	0,24	906
balloon	ballon	1	0,07	759
banana	banaan	1	0,04	778
band	orkest	10	2,46	1203
bandaid	pleister	2	0,57	981
banjo	banjo	7	1,94	1290
bar	bar	7	1,69	1132
barbecue	barbecue	2	0,27	1076
barrel	ton	3	0,79	826
basket	mand	3	0,52	911
bat	vleermuis	1	0,04	950
bat1	basebalbat	10	2,66	1224
bathtub	bad	5	0,93	1106

beak	bek	3	1,33	1107
bear	beer	2	0,8	1006
beard	baard	3	0,61	1042
beaver	bever	8	1,88	1395
bed	bed	2	0,36	830
bee	Bij	4	1,52	1252
bell	Bel	3	1,08	870
belt	riem	5	0,95	1019
bench	bank	3	0,55	877
bicycle	fiets	1	0,31	759
bicyclepump	pomp	3	0,93	1477
binoculars	verrekijker	2	0,24	910
bird	vogel	5	1,22	1030
bird2	duif	4	1,13	1288
blimp	zeppelin	3	0,72	1218
block	blok	6	1,53	1495
board	plank	8	1,51	1520
boat	boot	4	0,78	1061
boat1	boot	4	1,08	1095
boat2	boot	4	1,38	1073
bomb	bom	2	0,27	1104
bone	bot	5	1,6	1088
book	boek	1	0,2	903
boot	laars	4	1,5	1113
bottle	papfles	4	1,23	1215
bottle2	fles	1	0,07	856
bow	strik	3	0,47	833
bowl	kom	3	0,4	863
box	doos	1	0,1	871
boy	jongen	3	0,94	1033
bra	bh	2	0,27	986
branch	tak	3	0,81	984
bread	brood	3	0,43	829
bricks	muur	1	0,26	956
bride	bruid	11	2,06	1243
bridge	brug	2	0,24	985
broom	bezem	4	1,27	1106
brush	borstel	6	1,12	1015

brush2	borstel	4	0,96	1093
bucket	emmer	1	0,1	830
bug	kever	6	1,34	1240
bus	bus	1	0,04	955
busket	mand	3	0,49	881
butcher	slager	9	1,9	1822
butt	ton	3	0,7	905
butter	boter	5	1,37	1351
butterfly	vlinder	1	0,1	791
button	knoop	2	0,78	863
cactus	cactus	1	0,34	983
cage	kooi	4	0,63	1129
cake	taart	3	0,4	984
camel	kameel	3	0,43	1019
camera	fototoestel	5	0,93	1035
can	blik	5	1,07	1015
candle	kaars	1	0,07	784
cane	wandelstok	6	1,56	1343
cannon	kanon	1	0,17	1099
canoe	kano	7	1,83	1183
canopener	blikopener	5	0,86	1852
car	auto	1	0,1	694
caravan	caravan	3	0,55	1109
carousel	draaimolen	6	2,22	1200
carpet	tapijt	4	1,32	891
carrot	wortel	2	0,47	885
cast	gips	10	2,13	1435
castle1	kasteel	2	0,36	1038
cat	kat	2	0,94	937
celery	selder	5	1,34	1419
cell	gevangenis	3	1,15	1309
chain	ketting	3	0,61	1014
chair	stoel	1	0,07	672
chair1	zetel	4	1,25	1017
check	brief	9	2,22	1233
cheese	kaas	1	0,1	1021
cherry	kers	3	0,7	1019
chest	borstkast	6	1,75	1042

chest1	kist	3	1,15	1024
chicken	kip	2	0,56	855
chimney	schoorsteen	2	0,8	977
church	kerk	2	0,24	1033
church1	kerk	2	0,39	871
cigar	sigaar	2	0,3	1072
cigarette	sigaret	2	0,2	928
city	stad	9	1,42	1152
clamp	schroef	14	2,35	1374
clip	paperclip	3	0,61	1141
clock	klok	3	0,95	854
closet	kleerkast	2	0,93	981
clothespin	wasknijper	4	1,15	1183
cloud	wolk	4	0,79	1120
clown	clown	1	0	905
coat	jas	6	1,09	1067
comb	kam	2	0,17	809
cook	kok	2	0,59	1003
cookie	koekje	7	1,56	1595
cork	kurk	6	1,13	1359
corkscrew	kurketrekker	6	1,21	1625
corn	mais	3	0,49	1005
couch	zetel	5	1,3	958
cow	koe	2	0,64	909
cowboy	cowboy	5	0,84	1224
crab	krab	3	1,12	1009
crackers	koekjes	11	2,24	1307
crib	kinderbed	5	1,54	1261
cross	kruis	1	0	857
crown	kroon	2	0,24	987
cup	tas	4	1,6	957
cupboard	kast	3	0,43	998
curtains	gordijn	3	0,91	988
deck	kaarten	6	1,9	1158
deer	hert	4	0,82	1051
dentist	tandarts	2	0,24	1087
desert	cactus	3	1,17	892
desk	bureau	3	0,66	1118

devil	duivel	1	0,14	1034
diamond	diamant	4	0,6	1089
diaper	onderbroek	5	1,81	1172
dime	munt	7	2,08	1174
dinosaur	dinosaurus	1	0,14	1429
doctor1	dokter	5	0,89	1228
dog	hond	1	0	744
doll	pop	3	1,16	963
dolphin	dolfijn	1	0,14	899
donkey	ezel	4	1,06	1055
door	deur	1	0,04	812
doorknob	deurknop	7	1,81	1637
dragon	draak	1	0,04	1042
drawer	lade	6	1,83	1043
dress	jurk	4	1,32	1037
dresser	kast	5	1,04	1082
drill	boormachine	4	1,28	1294
drum	trommel	3	0,45	870
drumst1	drumstel	6	1,63	1241
duck	eend	4	0,57	909
dustpan	vuilblik	13	2,55	1408
eagle	arend	6	1,72	1153
ear	oor	2	0,2	723
earring	oorbel	11	2,22	1140
egg	ei	1	0,04	868
elephant	olifant	1	0,1	788
envelope	enveloppe	6	1,62	787
eskimo	eskimo	1	0,14	1221
eye	oog	1	0,14	774
factory	fabriek	10	1,66	1352
fan	ventilator	3	0,55	1310
fan2	supporter	11	2,33	1827
farm	boerderij	5	1,93	1376
faucet	kraan	4	0,65	961
feather	veer	2	0,8	935
fence	hek	4	1,18	977
fence1	hek	15	3,08	1252
fence2	hek	9	2,39	1330

file	map	7	1,44	1197
finger	vinger	3	0,69	855
fire	vuur	3	0,55	1056
firehydrant	brandkraan	15	2,89	1330
fireman	brandweerman	4	0,96	1114
firetruck	brandweerwagen	4	1,26	1318
fish	vis	2	0,24	793
fishingpole	hengel	5	1,8	1071
fishtank	aquarium	5	1,15	1019
fist	vuist	2	0,91	1028
flag	vlag	1	0,17	790
flashlight	zaklamp	6	1,84	1303
floor	vloer	10	2,29	1397
flower	bloem	1	0,17	856
flute	dwarsfluit	7	1,84	1320
fly	vlieg	5	0,89	1044
foot	voet	1	0,23	884
football	rugbybal	9	2,53	1056
fork	vork	1	0,1	813
fountain	fontein	2	0,39	1059
fox	vos	2	0,54	1011
frog	kikker	1	0,17	795
funnel	trechter	2	0,64	1006
gas	tankstation	10	2,61	1630
genie	geest	4	1,22	1507
ghost	spook	2	0,53	882
giraffe	giraffe	1	0,07	833
girl	meisje	3	0,66	997
glass	glas	2	0,2	818
glass2	glas	2	0,64	828
glasses	bril	1	0,04	829
globe	wereldbol	2	0,54	999
glove	handschoen	2	0,3	923
goat	geit	3	0,61	1107
gorilla	gorilla	3	1,15	1047
grapes	druiven	4	1,48	1005
grasshopper	sprinkhaan	5	1,62	1160
grave2	graf	5	1,49	1083

guitar	gitaar	1	0,28	835
gun	revolver	3	1,52	914
gun2	geweer	3	0,57	1001
hair	haar	7	1,22	1065
hamburger	hamburger	4	0,71	915
hammer	hamer	2	0,35	987
hammer2	hamer	2	0,27	1076
hammock	hangmat	4	0,6	1496
hand	hand	2	0,27	769
handcuffs	handboeien	3	1,02	1076
hanger	kapstok	3	1,14	1018
harp	harp	4	0,6	1083
hat	pet	1	0,46	908
hat2	hoed	1	0,31	862
hay	hooi	10	1,98	1175
heart	hart	2	0,45	758
heel	hak	5	1,27	1011
helicopter	helicopter	1	0,17	820
helmet	helm	1	0,07	982
highchair	kinderstoel	10	2,34	1412
hinge	scharnier	5	1,12	1412
hippo	nijlpaard	3	0,63	1277
hoe	hark	9	2,2	1307
hoof	hoef	3	0,89	1135
hook	haak	1	0,04	1093
horn	toeter	4	1,12	1350
horse	paard	1	0,04	817
horseshoe	hoefijzer	2	0,3	1117
hose	tuinslang	6	0,95	1181
house	huis	1	0,1	869
icecreamcone	ijsje	3	1,22	842
igloo	iglo	1	0,1	952
iron	strijkijzer	1	0,23	1021
ironingboard	strijkplank	5	0,87	1073
jack	krik	4	0,92	1371
jacket	jas	4	1,32	1117
jar	bokaal	6	1,98	1556
jumprope	springtouw	6	1,2	1252

kangaroo	kangoeroe	2	0,27	966
kano	kano	6	1,74	1371
kettle	waterkoker	13	2,69	1573
key	sleutel	1	0,1	773
king	koning	2	0,27	977
kite	vlieger	1	0,07	1060
knife	mes	1	0,17	861
knight	ridder	4	1,12	1176
knot	knoop	5	1,43	1137
ladder	ladder	2	0,45	899
ladle	pollepel	3	1,32	1348
ladybug	lieveheersbeestje	7	1,79	1452
lamp	lamp	5	1,07	876
lamp1	lamp	2	0,86	998
lawnmower	grasmachine	3	1,17	1106
leaf	blad	1	0,1	871
leg	been	5	1,21	1101
lemon	citroen	2	0,27	901
leopard	luipaard	7	2,03	1463
letter	brief	6	1,26	1124
lettuce	sla	7	1,69	986
lightbulb	lamp	2	0,8	813
lighthouse	vuurtoren	5	1,11	1310
lightning	bliksem	6	0,89	868
lightswitch	schakelaar	4	1,21	1286
lion	leeuw	1	0,07	837
lips	lippen	3	1,19	841
lipstick	lippenstift	5	1,3	973
lizard	hagedis	6	1,71	1432
llama	lama	5	0,82	1336
lobster	kreeft	2	0,54	1203
lock	slot	7	1,36	1059
log2	hout	10	2,79	1019
magnet	magneet	4	1,08	1377
mailbox	brievenbus	2	0,7	993
man	man	6	1,06	986
map	landkaart	4	1,39	1087
mask	masker	1	0	944

match1	lucifer	2	0,24	1049
medal	medaille	3	0,37	1168
microphone	micro	9	1,92	1296
microscope	microscoop	3	0,84	1545
mirror	spiegel	1	0,23	878
mitt	handschoen	3	1,15	911
mixer	mixer	2	0,45	1168
molar	tand	3	0,66	971
monkey	aap	2	0,24	851
moon	maan	2	0,35	862
moose	eland	5	1,46	1160
mop	bezem	5	1,76	1007
mosquito	mug	6	1,77	1240
motorcycle	brommer	5	2,1	990
mountain	berg	3	0,91	1033
mouse	muis	4	0,8	997
mousetrap	muizeval	4	0,78	1330
mug	tas	8	2,17	965
mushroom	paddestoel	2	0,29	872
music	notenbalk	10	2,74	1268
nail	nagel	5	1,61	1241
nailfile	mes	7	1,55	1188
napkin	zakdoek	4	1,38	1034
neck	hals	7	2,12	1394
necklace	ketting	4	1,63	984
needle	naald	7	1,45	1497
needle2	spuit	4	0,97	932
nest	nest	7	1,36	1025
net	net	4	1,36	1020
nose	neus	2	0,2	796
note	muzieknoot	2	1	990
nurse	verpleegster	6	1,31	1467
nut	schroef	5	1,96	1206
octopus	inktvis	3	1,17	966
onion	ajuin	2	0,95	1256
orange	appelsien	5	1,5	1218
organ	orgel	2	0,73	1181
ostrich	struisvogel	4	0,86	1392

owl	uil	1	0,04	890
package	pakje	6	2	1263
paint	pallet	16	3,19	1401
paintbrush	penseel	2	0,3	1051
palmtree	palmboom	3	0,37	931
pan	pan	2	0,27	910
panda	panda	4	1,69	1289
pants	broek	4	0,68	804
paper	papier	12	2,38	1145
paperclip	paperclip	4	0,78	1226
parachute	parachute	7	1,94	1577
parrot	papegaai	2	0,24	999
paw	poot	5	1,09	1156
peach	perzik	8	2,06	1495
peacock	pauw	1	0,14	999
peanut	pindanoot	6	1,95	1225
pear	peer	1	0,1	914
peas	erwten	8	2,27	1743
pelican	pelikaan	5	1,15	1114
pen	penseel	4	1,31	887
pencil	potlood	2	0,39	882
pencilsharpener	slijper	5	1,35	1242
penguin	pinguin	1	0,07	984
piano	piano	3	0,37	880
pick	houweel	10	2,22	1422
picture	schilderij	4	0,96	1008
pig	varken	1	0,1	986
piggybank	spaarvarken	3	1,02	1009
pillar	pilaar	5	1,66	1330
pillow1	kussen	2	0,36	1309
pineapple	ananas	1	0,04	859
pinecone	denneappel	5	1,04	1716
pipe	pijp	1	0,1	848
pirate	piraat	5	1,26	1207
pitcher	kan	7	1,46	1170
pitchfork	riek	4	1,38	1287
pizza	pizza	3	0,8	1237
plate	bord	2	0,2	937

pliers	tang	4	0,93	1226
plug	stop	9	1,9	1691
plug1	stekker	2	0,84	1206
poker	stok	9	1,73	1260
policeman	politieagent	9	2,48	1253
pool1	zwembad	2	0,3	901
popcorn	popcorn	1	0,31	1021
popsicle	stekker	11	1,61	1313
porcupine	egel	5	1,59	1449
pot	pot	7	1,99	1391
potato	aardappel	6	0,98	1364
present1	kado	4	1,07	988
priest	priester	9	2,4	1278
priest2	priester	4	1,25	1322
pumpkin	pompoen	2	0,55	1311
punch	kom	8	1,68	1952
purse	handtas	3	1,15	991
puzzle	puzzel	2	0,17	828
pyramid	piramide	2	0,17	939
queen	koningin	3	1,09	986
rabbit	konijn	1	0,07	813
raccoon	wasbeer	10	2,43	1710
rack	rek	10	2,11	1439
radio1	radio	1	0,04	862
radish	radijs	3	0,77	1582
raft	vlot	4	0,92	1228
railroadtracks	spoor	7	2,35	937
rain	regen	5	0,76	981
rainbow	regenboog	1	0,17	1078
rake	hark	7	1,45	1181
razor	scheermes	6	1,75	1627
record	plaat	12	2,22	1563
recordplayer	platenspeler	7	1,99	1376
refrigerator	ijskast	3	1,57	1093
rhinoceros	neushoorn	3	0,58	1217
ring	ring	1	0,14	851
road	weg	7	1,52	1049
robot	robot	1	0,14	942

rock	steen	5	1,33	1172
rocket	racket	2	0,39	960
rockingchair	schommelstoel	5	1,09	1025
rollerskate	rolschaats	4	0,99	1039
rollingpin	deegrol	4	0,71	1093
roof	dak	1	0,2	1013
rooster	haan	2	1,01	1148
rope	touw	2	0,38	916
rose	roos	3	0,93	1031
rug	tapijt	5	1,42	887
rugbyball	rugbybal	7	1,85	1423
ruler	lat	3	1,12	923
saddle	zadel	1	0,07	1101
safe	kluis	6	1,98	1330
safetypin	veiligheidsspeld	7	2,14	1480
sailboat	zeilboot	5	1,71	1118
sailor	matroos	5	1,17	1110
salt	zoutvat	6	1,75	1131
sandwich	boterham	7	1,41	1112
sausage	worst	1	0,07	1017
saw	zaag	1	0,14	969
saxophone	saxofoon	3	0,78	1230
scale1	weegschaal	1	0,14	982
scarf	sjaal	2	0,27	871
scissors	schaar	1	0,04	740
scorpion	schorpioen	3	0,78	1311
screw	schroef	5	1,68	1264
screwdriver	schroevendraaier	2	0,59	1158
seahorse	zeepaardje	4	1,28	1279
seal	zeehond	5	1,35	1217
seesaw	wipplank	5	1,66	1308
sewingmachine	naaimachine	2	0,38	1034
shark	haai	3	0,84	1207
shed	huis	12	2,65	1823
sheep	schaap	4	0,74	1095
shell	schelp	3	0,49	1014
shirt	hemd	6	1,47	1099
shoe	schoen	1	0,04	769

shoulder	schouder	4	0,97	1080
shovel	schop	3	0,88	951
shower1	douche	6	1,12	1064
sink	wasbak	10	2,61	1212
skateboard	skatebord	1	0,04	1009
skeleton	skelet	2	0,95	982
skirt	rok	6	1	1065
skis	skis	5	1,59	1092
skunk	stinkdier	10	2,13	1488
sled	slee	2	0,54	1285
slide	glijbaan	5	1,44	1087
slingshot	katapult	5	0,99	1410
slipper	pantoffel	5	1,3	1285
smoke	rook	5	1,36	1297
snail	slak	2	0,32	947
snake	slang	1	0	772
snowman	sneeuwman	3	0,67	955
sock	kous	2	0,99	733
soldier	soldaat	4	0,75	1114
spade	schoppe	13	2,42	1574
spaghetti	spaghetti	1	0,14	885
spatula	spatel	9	2,19	1828
speaker	boks	8	1,74	1286
spider	spin	1	0,28	924
spiderweb	spinneweb	3	1,12	900
spinning wheel	spinnewiel	7	1,49	1504
spoon	lepel	1	0,07	761
squirrel	eekhoorn	2	0,33	983
stairs	trap	2	0,27	950
stamp	postzegel	6	1,12	1250
star	ster	1	0,14	698
statue	beeld	7	1,72	1281
steeringwheel	stuur	2	0,63	961
step	step	6	1,53	1259
stethoscope	stethoscoop	3	0,63	1311
stocking	kous	8	2,15	1278
stool	kruk	7	1,92	991
stoplight	verkeerslicht	7	1,79	1127

stove	fornuis	5	1,8	1220
strawberry	aardbei	1	0,07	917
stroller	kinderwagen	7	1,44	1320
stroller2	kinderwagen	6	1,59	1267
submarine	duikboot	7	2,02	1186
suitcase	koffer	7	1,95	1038
suite	kostuum	4	1,08	1031
sun	zon	1	0,07	733
swan	zwaan	1	0,1	864
sweater	trui	4	1,02	977
swing	schommel	1	0,14	826
sword	zwaard	3	1,25	975
table	tafel	1	0,2	734
tail	staart	5	1,27	1192
tank1	tank	5	0,79	1233
tape	cassette	3	0,49	907
taperecorder	cassetterecorder	7	1,91	1361
teapot	theepot	6	2,09	1106
tear	traan	7	1,49	1066
teepee	wigwam	5	1,61	1329
teeth	gebit	3	1,1	956
telephone	telefoon	1	0,17	821
telescope	verrekijker	5	1,93	1315
tennisracket	tennisracket	2	0,88	1043
tent	tent	1	0,1	800
thermo	thermometer	3	0,47	901
thermos	thermos	6	1,43	1247
thimble	vingerhoed	8	1,7	1255
thread	draad	11	2,65	1681
thumb	duim	4	0,8	910
tie	das	3	0,63	921
tiger	tijger	2	0,27	990
tire1	wiel	4	1,44	1030
toaster	broodrooster	3	0,72	1110
toe	teen	10	2,28	1256
toilet	toilet	3	1,08	1016
tomato	tomaat	2	0,24	912
toothbrush	tandenborstel	2	0,29	859

top	tol	3	0,43	997
torch	fakkel	6	2,25	1138
towel	handdoek	3	0,75	981
tractor	tractor	3	0,6	1171
train	trein	1	0,04	966
trash	vuilnis	8	2,43	1430
trashcan	vuilbak	6	2,08	1103
tree	boom	1	0,07	825
tripod	statief	5	1,3	1556
trophy	beker	5	0,96	1088
truck	vrachtwagen	5	1,19	1083
trumpet	trompet	2	0,27	832
turkey	kalkoen	4	1,27	1379
turtle	schildpad	1	0,1	825
tv	televisie	3	1,23	942
tweezers	pincet	2	0,27	1190
typewriter	typemachine	3	0,71	1075
umbrella	paraplu	1	0,1	833
unicorn	eenhoorn	1	0,14	1165
unicycle	eenwieler	6	1,67	1245
vacuum	stofzuiger	2	0,2	900
vase	vaas	3	0,75	1123
vest	vest	10	2,51	1269
violin	viool	2	0,93	1128
volcano	vulkaan	4	0,68	1123
waffle	wafel	12	2,28	1822
wagon	kar	14	2,87	1499
waiter	ober	6	1,3	1198
wall	muur	3	0,5	911
wallet	portefeuille	3	0,75	1463
wallet1	portemonnee	7	2,04	1083
walnut	noot	3	0,79	1019
walrus	walrus	6	1,7	1194
washingmachine	wasmachine	8	1,47	1332
watch	horloge	4	1,46	1062
wateringcan	gieter	2	0,33	1018
watermelon	meloen	8	1,82	1381
well	waterput	3	0,75	1275

whale	walvis	7	1,76	1160
wheat	graan	7	2,13	1484
wheel	wiel	2	0,27	866
wheelbarrow	kruiwagen	2	0,27	970
wheelchair	rolstoel	3	0,49	978
whip	zweep	3	0,55	1266
whistle	fluit	2	1,02	1040
wig	pruik	4	0,83	1111
windmill	molen	2	1,02	977
window	raam	3	0,85	1026
wine	wijn	11	2,54	1363
Wing	vleugel	3	0,52	1144
Witch	heks	2	0,39	1076
Wizard	tovenaar	6	1,03	1090
Wolf	Wolf	3	1,19	1435
Woman	vrouw	6	1,58	1117
Wood	plank	9	2,04	927
Worm	worm	5	1,29	1072
Wrench	sleutel	8	1,97	1708
Yoyo	jojo	3	0,75	1487
Zebra	zebra	1	0,07	904
Zipper	rits	4	1,12	1083

Appendix B

Appendix B

	Last word of sentence	
Picture	Phonologically Related	Semantically Related
bord (plate)	bos (wood)	glas (glass)
lamp (lamp)	ladder (ladder)	kaars (candle)
eenhoorn (unicorn)	eend (duck)	zeemeermin (mermaid)
ster (star)	stad (city)	maan (moon)
jongen (boy)	yoghurt (yogurt)	man (man)
orgel (organ)	origineel (original)	drumstel (drums)
stethoscoop (stethoscope)	stank (smell)	thermometer (thermometer)
mier (ant)	microfoon (microphone)	spin (spider)
kooi (cage)	koning (king)	stal (stall)
spuit (needle)	spier (muscle)	boor (drill)
slak (snail)	sleutel (key)	worm (worm)
boterham (sandwich)	boom (tree)	croissant (croissant)
worst (sausage)	wolk (cloud)	hamburger (hamburger)
hoed (hat)	hoek (corner)	pet (hat)
sigaret (cigarette)	citroen (lemon)	vredespijp (calumet)
paraplu (umbrella)	panter (panther)	regenjas (raincoat)
voet (foot)	voeding (food)	enkel (ankle)
baard (beard)	baas (boss)	snor (moustache)
schelp (shell)	schotel ([flying] saucer)	kwal (jelly fish)
trommel (drum)	traan (tear)	blokfluit (recorder)
schaar (scissors)	schoen (shoe)	lijm (glue)
vlot (raft)	vlies (membrane)	schip (ship)
verrekijker (binoculars)	vensterbank (window-sill)	bril (glasses)
springtouw (jump rope)	spel (game)	poppenhuis (doll house)
stofzuiger (vacuum)	straf (punishment)	bezem (broom)
tijger (tiger)	tijd (time)	leeuw (lion)
fontein (fountain)	formule (formula)	waterval (waterfall)
mand (basket)	matras (mattress)	doos (box)
soldaat (soldier)	sok (sock)	generaal (general)
vinger (finger)	vis (fish)	teen (toe)
hond (dog)	honger (hunger)	poes (cat)
fiets (bicycle)	file (file)	step (scooter)
masker (mask)	magazijn (storage)	kostuum (costume)
bed (bed)	beste (best)	kussen (pillow)
gieter (watering can)	gier (vulture)	tuinslang (garden hose)
schildpad (turtle)	schedel (skull)	kikker (frog)
zak (bag)	zanger (singer)	mand (basket)
bliksem (lightning)	bloei (blossoming)	donder (thunder)
duivel (devil)	duim (thumb)	engel (angel)
doos (box)	doorn (thorn)	kist (chest)
schommel (swing)	schat (treasure)	zandbak (sandpit)
radio (radio)	raaf (raven)	televisie (television)
dennenappel (pinecone)	demper (silencer)	kokosnoot (coconut)
mes (knife)	merk (brand)	bord (plate)
popcorn (popcorn)	pomp (pump)	lolly (lollipop)

beer (bear)	bedevaart (pilgrimage)	wolf (wolf)
kangoeroe (kangaroo)	kassa (cash desk)	panda (panda)
pizza (pizza)	piercing (piercing)	spaghetti (spaghetti)
roos (rose)	room (cream)	tulp (tulip)
ketting (chain)	kerk (church)	touw (rope)
kom (bowl)	koffie (coffee)	pan (pan)
hart (heart)	halfuur (half a hour)	kruis (cross)
sneeuwman (snowman)	snaar (string)	iglo (igloo)
tovenaar (wizard)	toren (tower)	heks (witch)
bal (ball)	bas (bass)	kegel (cone)
schilderij (painting)	schot (shot)	beeld (sculpture)
tandenborstel (toothbrush)	tabak (tobacco)	flosdraad (dental floss)
wiel (wheel)	weekend (weekend)	stuur (steering-wheel)
pleister (band aid)	plicht (duty)	zalf (cream)
zaag (saw)	zaak (business)	hamer (hammer)
brug (bridge)	brand (fire)	tunnel (tunnel)
riem (belt)	rivier (river)	broek (trousers)
jojo (yoyo)	jood (jew)	tol (spinning top)
racket (rocket)	ramp (disaster)	duikboot (submarine)
slang (snake)	slee (sledge)	kameleon (chameleon)
ananas (pineapple)	ander (other)	meloen (melon)
spaarvarken (piggybank)	spook (ghost)	zakgeld (pocket money)
spiegel (mirror)	spar (spruce)	lippenstift (lipstick)
matroos (sailor)	magneet (magnet)	soldaat (soldier)
dolfijn (dolphin)	dochter (daughter)	haai (shark)
gitaar (guitar)	gynaecoloog (gynaecologist)	viool (violin)
eend (duck)	eencellige (unicellular)	zwaan (swan)
vlieg (fly)	vlam (flame)	mug (mosquito)
varken (pig)	vak (course)	schaap (sheep)
lepel (spoon)	lening (loan)	vork (fork)
auto (car)	auteur (author)	vrachtwagen (truck)
strik (bow)	staf (crosier)	knoop (button)
deur (door)	deuk (dent)	trap (stairs)
pan (pan)	partij (party)	schaal (dish)
citroen (lemon)	sigaar (cigar)	banaan (banana)
dokter (doctor)	dollar (dollar)	kapper (hairdresser)
trap (stairs)	tros (bunch)	lift (elevator)
dinosaurus (dinosaur)	dief (thief)	mammoet (mammoth)
fles (bottle)	flik (cop)	kan (can)
dak (roof)	dagboek (diary)	plafond (ceiling)
lamp (light bulb)	lasso (lasso)	schakelaar (switch)
poot (paw)	poort (gate)	snavel (beak)
slee (sled)	slak (snail)	koets (carriage)
diamant (diamond)	dierentuin (zoo)	parel (pearl)
kruiwagen (wheelbarrow)	kriek (cherry)	hark (shark)
zak (paper bag)	zalm (salmon)	tas (bag)

nest (nest)	net (net)	hol (burrow)
baby (baby)	beer (bear)	vader (father)
pauw (peacock)	paus (pope)	kalkoen (turkey)
regen (rain)	revolutie (revolution)	sneeuw (snow)
helikopter (helicopter)	hemel (heaven)	fiets (bike)
haak (hook)	haan (rooster)	spijker (nail)
leeuw (lion)	leeftijd (age)	tijger (tiger)
gordijn (curtains)	golf (golf)	behang (wallpaper)
been (leg)	beest (animal)	hoofd (head)
kurkentrekker (corkscrew)	kust (coast)	notenkraker (nutcracker)
ladder (ladder)	lawine (avalanche)	roltrap (escalator)
pruik (wig)	projector (projector)	baard (beard)
potlood (pencil)	pond (pound)	krijt (chalk)
stuur (steering wheel)	staal (steel)	wiel (wheel)
arm (arm)	ark (ark)	neus (nose)
kasteel (castle)	kalf (calf)	paleis (palace)
ridder (knight)	ring (ring)	prinses (princess)
man (man)	mast (mast)	vrouw (woman)
duim (thumb)	duik (dive)	vinger (finger)
schoorsteen (chimney)	schilder (painter)	haard (fireplace)
haar (hair)	hakenkruis (swastika)	oor (ear)
clown (clown)	kluis (safe)	leeuwentemmer (lion tamer)
pomp (bicycle pump)	pols (wrist)	ketting (bicycle chain)
barbecue (barbecue)	bakker (baker)	fondue (fondue)
palmboom (palm tree)	passer (compasses)	cactus (cactus)
konijn (rabbit)	koper (buyer)	lam (lamb)
pincet (tweezers)	pil (pill)	scalpel (scalpel)
wortel (carrot)	wok (wok)	kool (cabbage)
eekhoorn (squirrel)	economie (economy)	muis (mouse)
regenboog (rainbow)	rekening (bill)	zon (sun)
thermometer (thermometer)	tempel (shrine)	kompas (compass)
hamer (hammer)	haven (harbour)	tang (pliers)
kraan (tap)	krik (jack)	stop (plug)
vrachtwagen (truck)	vrucht (fruit)	tram (tram)
maan (moon)	maag (stomach)	ster (star)
vleugel (wing)	vlaming (Flemish man)	poot (leg)
tang (pliers)	tampon (tampon)	schroevendraaier (screwdriver)
bril (glasses)	broer (brother)	lens (lens)
haai (shark)	haak (hook)	dolfijn (dolphin)
koning (king)	cola (coke)	prins (prince)
bom (bomb)	bob (designated driver)	granaat (grenade)
stad (city)	stempel (stamp)	kolonie (colony)
kaas (cheese)	kano (canoe)	melk (milk)
mixer (mixer)	mist (mist)	deegrol (rolling pin)
boom (tree)	boon (bean)	struik (bush)
asbak (ashtray)	assistente (assistant)	lucifer (match)

pijl (arrow)	pijn (pain)	kogel (bullet)
kreeft (lobster)	kribbe (cradle)	schelp (shell)
schop (shovel)	schoorsteen (chimney)	emmer (bucket)
portefeuille (wallet)	postbode (postman)	handtas (purse)
cassette (tape)	kalender (calendar)	cd (cd)
wolk (cloud)	worst (sausage)	regenboog (rainbow)
kaars (candle)	kaas (cheese)	lamp (light)
peer (pear)	peter (godfather)	appel (appel)
telefoon (telephone)	tekenfilm (cartoon)	walkietalkie (walkie-talkie)
bijl (axe)	bijbel (bible)	schop (spade)
blik (can)	blad (magazine)	fles (bottle)
jas (coat)	jacht (hunt)	muts (cap)
kameel (camel)	kannibaal (cannibal)	ezel (donkey)
bank (bench)	balk (beam)	zetel (chair)
schouder (shoulder)	scheidsrechter (referee)	borst (breast)
cowboy (cowboy)	kous (stocking)	sheriff (sheriff)
postzegel (stamp)	porto (port wine)	brief (letter)
zon (sun)	zolder (attic)	melkweg (Milky way)
Naaimachine (sewing machine)	nagel (nail)	strijkplank (ironing board)
eskimo (eskimo)	estafette (relay)	indiaan (Indian)
meisje (girl)	mijnenveld (mine field)	kind (child)
vlinder (butterfly)	vlek (stain)	lieveheersbeestje (ladybird)
kok (cook)	kop (head)	ober (waiter)
hert (deer)	hek (fence)	konijn (rabbit)
sleutel (key)	sloop (pillowcase)	deur (door)
rolschaats (roller-skate)	romp (torso)	ski (ski)
accordeon (accordion)	accu (battery)	orgel (organ)
piramide (pyramid)	piste (piste)	eifeltoren (Eiffel tower)
eikel (acorn)	eicel (ovule)	noot (nut)
brief (letter)	brug (bridge)	kaart (postcard)
strijkplank (ironing board)	steen (stone)	droogkast (tumble dryer)
sjaal (scarf)	chef (chef)	handschoen (mitten)
banaan (banana)	bal (ball)	kiwi (kiwi)
zeppelin (blimp)	zes (six)	luchtballon (hot-air balloon)
olifant (elephant)	olijf (olive)	neushoorn (rhinoceros)
cactus (cactus)	camera (camera)	palm (palm tree)
medaille (medal)	meter (meter)	beker (goblet)
krokodil (alligator)	krant (paper)	slang (snake)
hoef (hoof)	hoest (cough)	staart (tail)
tafel (table)	taart (cake)	bank (couch)
sigaar (cigar)	sirene (siren)	pijp (pipe)
tent (tent)	tekst (text)	caravan (caravan)
bus (bus)	burgemeester (mayor)	trein (train)
pelikaan (pelican)	pedofiel (paedophile)	flamingo (flamingo)
kroon (crown)	krul (curl)	helm (helmet)
verpleegster (nurse)	vulkaan (volcano)	chirurg (surgeon)

pompoen (pumpkin)	post (post)	komkommer (cucumber)
schroevendraaier (screwdriver)	schaats (ice skate)	beitel (chisel)
trein (train)	tractor (tractor)	bus (bus)
vliegtuig (airplane)	vlees (meat)	ruimteschip (space craft)
vork (fork)	vos (fish)	lepel (spoon)
brood (bread)	bruidsmeisje (bridesmaid)	koekje (cookie)
broek (trousers)	bruidegom (groom)	kilt (kilt)

Appendix C

Appendix C

Picture	Last word of the Sentence	
	Phonologically Related	Homophone Related
moon	mood	star
envelope	invention	letter
money	monday	check
fly	flag	be
rabbit	rabbi	hair
glass	grass	bowl
toe	toast	heal
woman	wolf	mail
globe	glue	ball
leaf	leash	flour
pants	pans	genes
slide	slices	shoot
hoof	hook	pa
crayon	crater	pen
racquet	raccoon	bat
bridge	bricks	damn
clock	clot	watch
swan	swallow	duck
necklace	never	ring
angel	angles	ferry
ear	eat	I
lighter	license	match
priest	peach	none
dollar	dolphin	bill

Appendix D

Appendix D

Neuter-gender condition *(translation)*	Common-gender condition *(translation)*
Het bewijs tegen de boef/boeven is/*zijn zwak *(the evidence against the thieve/thieves is/*are weak)*	De aanklacht tegen de boef/boeven is/*zijn zwak *(the accusation against the thieve/thieves is/*are weak)*
Het offensief van de soldaat/soldaten is/*zijn verrassend *(the offensive of the soldier/soldiers is/*are surprising)*	De aanval van de soldaat/soldaten is/*zijn verrassend *(the attack of the soldier/soldiers is/*are surprising)*
Het conflict met de ambtenaar/ambtenaren is/*zijn vervelend *(the conflict with the officer/officers is/*are unpleasant)*	De aanvaring met de ambtenaar/ambtenaren is/*zijn vervelend *(the quarrel of the officer/officers is/*are unpleasant)*
Het idool van de fanaat/fanaten is/*zijn populair *(the idol of the fanatic/fanatics is/*are popular)*	De afgod van de fanaat/fanaten is/*zijn populair *(the idol of the fanatic/fanatics is/*are popular)*
Het been met de brandwond/brandwonden is/*zijn rood *(the leg with the burn/burns is*are red)*	De arm met de brandwond/brandwonden is/*zijn rood *(the arm with the burn/burns is*are red)*
Het horloge met de diamant/diamanten is/*zijn schitterend *(the watch with the diamond/diamonds is/*are glorious)*	De armband met de diamant/diamanten is/*zijn schitterend *(the bracelet with the diamond/diamonds is/*are glorious)*
Het circuit voor de atleet/atleten is/*zijn glibberig *(the racing-track fot the athlete/athletes is/*are slippery)*	De baan voor de atleet/atleten is/*zijn glibberig *(the racing-track fot the athlete/athletes is/*are slippery)*
Het doel van de behandeling/behandelingen is/*zijn onduidelijk *(the aim of the treatement/treatements is/*/are unclear)*	De bedoeling van de behandeling/behandelingen is/*zijn onduidelijk *(the purpose of the treatement/treatements is/*/are unclear)*
Het kerkhof aan de beukenboom/beukenbomen is/*zijn sfeervol *(the graveyard at the beech/beeches is/*are pleasant)*	De begraafplaats aan de beukenboom/beukenbomen is/*zijn sfeervol *(the cemetery at the beech/beeches is/*are pleasant)*
Het berghok voor de kist/kisten is/*zijn opgeruimd *(the shed for the chest/chests is/*are clean)*	De bergruimte voor de kist/kisten is/*zijn opgeruimd *(the accomodation for the chest/chests is/*are clean)*
Het besluit van de professor/professoren is/*zijn begrijpelijk *(the conclusion of the profesor/profesors is/*are understandable)*	De beslissing van de professor/professoren is/*zijn begrijpelijk *(the decission of the profesor/profesors is/*are understandable)*
Het einddoel van de toerist/toeristen is/*zijn onbekend *(the destination of the tourist/tourist is/*are unknown)*	De bestemming van de toerist/toeristen is/*zijn onbekend *(the destination of the tourist/tourist is/*are unknown)*

Het bezwaar van de erfgenaam/erfgenamen is/*zijn serieus *(the objection of the heir/heirs is/*are serious)*	De betwisting van de erfgenaam/erfgenamen is/*zijn serieus *(the dispute of the heir/heirs is/*are serious)*
Het boeket met de roos/rozen is/*zijn geurig *(the bouquet with the rose/roses is/*are fragrant)*	De bloemenkrans met de roos/rozen is/*zijn geurig *(the crown of flowers with the rose/roses is/*are fragrant)*
Het pand onder de boom/bomen is/*zijn afgelegen *(the building under the tree/trees is/*are remote)*	De boerderij onder de boom/bomen is/*zijn afgelegen *(the farm under the tree/trees is/*are remote)*
Het schip van de matroos/matrozen is/*zijn gezonken *(the ship of the sailor/sailors is/*are sunken)*	De boot van de matroos/matrozen is/*zijn gezonken *(the boat of the sailor/sailors is/*are sunken)*
Het ongeluk met de motor/motoren is/*zijn ernstig *(the accident with the motorcycle/motorcycles is/*are serious)*	De botsing met de motor/motoren is/*zijn ernstig *(the collision with the motorcycle/motorcycles is/*are serious)*
Het maximum van de opbrengst/opbrengsten is/*zijn vastgelegd *(the maximum of the output is/*are layed down)*	De bovengrens van de opbrengst/opbrengsten is/*zijn vastgelegd *(the maximum of the output is/*are layed down)*
Het telegram van de vijand/vijanden is/*zijn verontrustend *(the wire of the enamy/enamies is/*are alarming)*	De brief van de vijand/vijanden is/*zijn verontrustend *(the letter of the enamy/enamies is/*are alarming)*
Het nest van de eend/eenden is/*zijn droog *(the nest of the duck/ducks is/*are dry)*	De broedplaats van de eend/eenden is/*zijn droog *(the breeding-place of the duck/ducks is/*are dry)*
Het huwelijk van de allochtoon/allochtonen is/*zijn groots *(the mariage of the immigrant/immigrants is/* are grandiose)*	De bruiloft van de allochtoon/allochtonen is/*zijn groots *(the wedding of the immigrant/immigrants is/* are grandiose)*
Het fort bij de spoorweg/spoorwegen is/*zijn ingestort *(the forte near the railroad/railroads is/*are collapsed)*	De bunker bij de spoorweg/spoorwegen is/*zijn ingestort *(the pillbox near the railroad/railroads is/*are collapsed)*
Het paleis van de hertog/hertogen is/*zijn bezienswaardig *(the palace of the duke/dukes is/*are worth seeing)*	De burcht van de hertog/hertogen is/*zijn bezienswaardig *(the castle of the duke/dukes is/*are worth seeing)*
Het muziekalbum van de artiest/artiesten is/*zijn uitverkocht *(the album of the artist/artists is/*are sold out)*	De CD van de artiest/artiesten is/*zijn uitverkocht *(the CD of the artist/artists is/*are sold out)*
Het zwaard naast de zweep/zwepen is/*zijn scherp *(the sword next to the whip/whips is/*are sharp)*	De degen naast de zweep/zwepen is/*zijn scherp *(the sword next to the whip/whips is/*are sharp)*

Het debat over de nachtvlucht/nachtvluchten is/*zijn heftig *(the debate about the night flight/flights is/*are heated)*	De discussie over de nachtvlucht/nachtvluchten is/*zijn heftig *(the discussion about the night flight/flights is/*are heated)*
Het geschenk voor de patiënt/patiënten is/*zijn nuttig *(the gift for the patient/patients is/*are useful)*	De donatie voor de patiënt/patiënten is/*zijn nuttig *(the gift for the patient/patients is/*are useful)*
Het pakket met de hoed/hoeden is/*zijn beschadigd *(the packet with the head/heads is/*are damaged)*	De doos met de hoed/hoeden is/*zijn beschadigd *(the box with the head/heads is/*are damaged)*
Het bad bij de tennisbaan/tennisbanen is/*zijn netjes *(the bath near the tennis court/courts is/*are clean)*	De douche bij de tennisbaan/tennisbanen is/*zijn netjes *(the shower near the tennis court/courts is/*are clean)*
Het reuzenrad naast de schiettent/schiettenten is/*zijn drukbezocht *(the ferris wheel next to the rifle is/*are well visited)*	De draaimolen naast de schiettent/schiettenten is/*zijn drukbezocht *(the merry-go-round next to the rifle is/*are well visited)*
Het monster met de bult/bulten is/*zijn afgrijselijk *(the monster with the lump/lumps is/*are horrible)*	De draak met de bult/bulten is/*zijn afgrijselijk *(the dragon with the lump/lumps is/*are horrible)*
Het angstbeeld van de kernoorlog/kernoorlogen is/*zijn reëel *(the fear of the nuclear war/wars is/*are real)*	De dreiging van de kernoorlog/kernoorlogen is/*zijn reëel *(the threat of the nuclear war/wars is/*are real)*
Het ideaal van de perfectionist/perfectionisten is/*zijn onwerkelijk *(the ideal of the perfectionist/perfectionists is/*are unreal)*	De droom van de perfectionist/perfectionisten is/*zijn onwerkelijk *(the dreaml of the perfectionist/perfectionists is/*are unreal)*
Het individu tegenover de regering/regeringen is/*zijn machteloos *(the individual against the governement/governements is/*are powerless)*	De eenling tegenover de regering/regeringen is/*zijn machteloos *(the individual against the governement/governements is/*are powerless)*
Het verzinsel over de geest/geesten is/*zijn eeuwenoud *(the invention about the ghoast/ghoasts is/*are old)*	De fabel over de geest/geesten is/*zijn eeuwenoud *(the fable about the goast/goasts is/*are old)*
Het gezin van de bosjesman/bosjesmannen is/*zijn arm *(the family of the bushman/bushmen is/*are poor)*	De familie van de bosjesman/bosjesmannen is/*zijn arm *(the family of the bushman/bushmen is/*are poor)*
Het rijwiel met de tas/tassen is/*zijn praktisch *(the bike with the bag/bags is/*are practical)*	De fiets met de tas/tassen is/*zijn praktisch *(the bike with the bag/bags is/*are practical)*

Het pamflet over de sport/sporten is/*zijn eenzijdig *(the pamphlet about the sport/sports is/*are one-sided)*	De folder over de sport/sporten is/*zijn eenzijdig *(the brochure about the sport/sports is/*are one-sided)*
Het portret van de man/mannen is/*zijn overbelicht *(the portrait of the man/men is/*are over-exposed)*	De foto van de man/mannen is/*zijn overbelicht *(the picture of the man/men is/*are over-exposed)*
Het probleem van de beginneling/beginnelingen is/*zijn onvermijdelijk *(the problem of the novice/novices is/*are inevitable)*	De fout van de beginneling/beginnelingen is/*zijn onvermijdelijk *(the mistake of the novice/novices is/*are inevitable)*
Het feest voor de jubilaris/jubilarissen is/*zijn gezellig *(the party for the celebrator/celebrators of a jubilee is/*are enjoyable)*	De fuif voor de jubilaris/jubilarissen is/*zijn gezellig *(the party for the celebrator/celebrators of a jubilee is/*are enjoyable)*
Het ambt van de agent/agenten is/*zijn achtenswaardig *(the function of the agent/agents is/*are honourable)*	De functie van de agent/agenten is/*zijn achtenswaardig *(the function of the agent/agents is/*are honourable)*
Het voorval tijdens de verkiezing/verkiezingen is/*zijn afkeurenswaardig *(the incident during the election/elections is/*are reprehensible)*	De gebeurtenis tijdens de verkiezing/verkiezing is/*zijn afkeurenswaardig *(the event during the election/elections is/*are reprehensible)*
Het monument voor de oorlogsheld/oorlogshelden is/*zijn prachtig *(the monument for the warhero/warheros is/*are beautiful)*	De gedenksteen voor de oorlogsheld/oorlogshelden is/*zijn prachtig *(the memorial stone for the warhero/warheros is/*are beautiful)*
Het spook met de ketting/kettingen is/*zijn onheilspellend *(the ghoast with the chain/chains is/*are ominous)*	De geest met de ketting/kettingen is/*zijn onheilspellend *(the ghoast with the chain/chains is/*are ominous)*
Het schaap bij de sloot/sloten is/*zijn dorstig *(the sheep near the ditch/ditches is/*are thursty)*	De geit bij de sloot/sloten is/*zijn dorstig *(the ghoat near the ditch/ditches is/*are thursty)*
Het konijn naast de den/dennen is/*zijn klein *(the rabbit near the pinetree/pinetrees is/*are small)*	De haas naast de den/dennen is/*zijn klein *(the hare near the pinetree/pinetrees is/*are small)*
Het perron van de trein/treinen is/*zijn dichtbij *(the platform of the train/trains is/*are nearby)*	De halte van de trein/treinen is/*zijn dichtbij *(the stop of the train/trains is/*are nearby)*
Het tijdschrift naast de verfbus/verfbussen is/*zijn besmeurd *(the magazine near the paintbox/paintboxes is/*are stained)*	De hamer naast de verfbus/verfbussen is/*zijn besmeurd *(the hammer near the paintbox/paintboxes is/*are stained)*

Het vliegtuig van de gevechtseenheid/ gevechtseenheden is/*zijn hi-tech *(the airplane of the fighting unit/units is/*are hi-tech)*	De helikopter van de gevechtseenheid/ gevechtseenheden is/*zijn hi-tech *(the chopper of the fighting unit/units is/*are hi-tech)*
Het geheugen van de olifant/olifanten is/*zijn reusachtig *(the memory of the eliphant/eliphants is/*are huge)*	De herinnering van de olifant/olifanten is/*zijn reusachtig *(the memory of the eliphant/eliphants is/*are huge)*
Het medicijn van de arts/artsen is/*zijn effectief *(the medicine of the doctor/doctors is/*are effactive)*	De hoestdrank van de arts/artsen is/*zijn effectief *(the coughmixture of the doctor/doctors is/*are effactive)*
Het paard bij de geit/geiten is/*zijn rustig *(the horse near the ghoat/ghoats is/*are quiet)*	De hond bij de geit/geiten is/*zijn rustig *(the dog near the ghoat/ghoats is/*are quiet)*
Het opschrift boven de paragraaf/paragrafen is/*zijn verhelderend *(the superscription above the paragraph/paragraphs is/*are clarifying)*	De inscriptie boven de paragraaf/paragrafen is/*zijn verhelderend *(the inscription above the paragraph/paragraphs is/*are clarifying)*
Het vest naast de trui/truien is/*zijn grijs *(the cardigan next to the jersey/jerseys is/*are grey)*	De jas naast de trui/truien is/*zijn grijs *(the jacket next to the jersey/jerseys is/*are grey)*
Het meisje met de kruk/krukken is/*zijn zielig *(the girl with the crutch/crutches is/*are pitiful)*	De jongen met de kruk/krukken is/*zijn zielig *(the girl with the crutch/crutches is/*are pitiful)*
Het papier onder de krant/kranten is/*zijn gekreukt *(the paper under the newspaper/ newspapers is/*are wrinkeled)*	De kaart onder de krant/kranten is/*zijn gekreukt *(the postcard under the newspaper/ newspapers is/*are wrinkeled)*
Het snoer van de vijverpomp/vijverpompen is/*zijn defect *(the cord of the pump/pump is/*are broken)*	De kabel van de vijverpomp/vijverpompen is/*zijn defect *(the cable of the pump/pump is/*are broken)*
Het kantoor van de assistent/assistenten is/*zijn ruim *(the office of the assistent/assistents is/*are spacious)*	De kamer van de assistent/assistenten is/*zijn ruim *(the room of the assistent/assistents is/*are spacious)*
Het magazijn met de voorraad/voorraden is/*zijn goedgevuld *(the warehouse with the supply/supplies is/*are full)*	De kast met de voorraad/voorraden is/*zijn goedgevuld *(the cupboard with the supply/ supplies is/*are full)*
Het klooster met de klok/klokken is/*zijn vertrouwd *(the convent with the bell/bells is/*are familiar)*	De kerk met de klok/klokken is/*zijn vertrouwd *(the church with the bell/bells is/*are familiar)*
Het pretpark bij de school/scholen is/*zijn storend *(the amusement park near the school/ schools is/*are interfering)*	De kermis bij de school/scholen is/*zijn storend *(the fair near the school/schools is/*are interfering)*

Het bloemstuk naast de kaars/kaarsen is/*zijn fleurig *(the bouquet next to the candle/candles is/*are colourful)*	De kerstkrans naast de kaars/kaarsen is/*zijn fleurig *(the advent candle to the candle/candles is/*are colourful)*
Het varken met de vlooi/vlooien is/*zijn vetgemest *(the pig with the flea/fleas is/*are fatted)*	De kip met de vlooi/vlooien is/*zijn vetgemest *(the chicken with the flea/fleas is/*are fatted)*
Het karwei van de werkman/werkmannen is/*zijn vermoeiend *(the job of the workman/wordmen is/*are tiring)*	De klus van de werkman/werkmannen is/*zijn vermoeiend *(the job of the workman/wordmen is/*are tiring)*
Het kalf naast de hond/honden is/*zijn tam *(the calf next to the dog/dogs is/*are tame)*	De koe naast de hond/honden is/*zijn tam *(the cow next to the dog/dogs is/*are tame)*
Het rijtuig voor de prins/prinsen is/*zijn startklaar *(the carriage for the prince/princes is/*are ready to go)*	De koets voor de prins/prinsen is/*zijn startklaar *(the coach for the prince/princes is/*are ready to go)*
Het etui voor de pen/pennen is/*zijn versierd *(the case for the pen/pens is/*are decorated)*	De koker voor de pen/pennen is/*zijn versierd *(the pencil box for the pen/pens is/*are decorated)*
Het verblijf van de aap/apen is/*zijn vernieuwd *(the residence of the ape/apes is/*are renovated)*	De kooi van de aap/apen is/*zijn vernieuwd *(the cage of the ape/apes is/*are renovated)*
Het origineel van de overeenkomst/overeenkomsten is/*zijn kwijt *(the original of the agreement/agreements is/*are lost)*	De kopie van de overeenkomst/overeenkomsten is/*zijn kwijt *(the copy of the agreement/agreements is/*are lost)*
Het weekblad onder de map/mappen is/*zijn gescheurd *(the weekly underneath the file/files is/*are torn)*	De krant onder de map/mappen is/*zijn gescheurd *(the newspaper underneath the file/files is/*are torn)*
Het hemd naast de handdoek/handdoeken is/*zijn gestreken *(the shirt next to the towel/towels is/*are ironed)*	De kussensloop naast de handdoek/handdoeken is/*zijn gestreken *(the pillowcase next to the towel/towels is/*are ironed)*
Het fietspad onder de beuk/beuken is/*zijn hobbelig *(the cycle track under the beech/beeches is/*are bumpy)*	De laan onder de beuk/beuken is/*zijn hobbelig *(the avenue under the beech/beeches is/*are bumpy)*
Het mes naast de vork/vorken is/*zijn verzilverd *(the knive next to the fork/forks is/*are plated)*	De lepel naast de vork/vorken is/*zijn verzilverd *(the spoon next to the fork/forks is/*are plated)*
Het touw aan de paal/palen is/*zijn rekbaar *(the rope at the pole/poles is/*are elastic)*	De lijn aan de paal/palen is/*zijn rekbaar *(the line at the pole/poles is/*are elastic)*

Het banket voor de gast/gasten is/*zijn lekker *(the banquet for the guest/guests is/*are delicious)*	De lunch voor de gast/gasten is/*zijn lekker *(the lunch for the guest/guests is/*are delicious)*
Het ontbijt in de zaal/zalen is/*zijn heerlijk *(the breakfast in the room/rooms is/*are delicious)*	De maaltijd in de zaal/zalen is/*zijn heerlijk *(the meal in the room/rooms is/*are delicious)*
Het schrift voor de cursus/cursussen is/*zijn goedkoop *(the note book for the course/courses is/*are cheap)*	De map voor de cursus/cursussen is/*zijn goedkoop *(the course material for the course/courses is/*are cheap)*
Het tapijt onder de stoel/stoelen is/*zijn schoon *(the carpet under the chair/chairs is/*are clean)*	De mat onder de stoel/stoelen is/*zijn schoon *(the mat under the chair/chairs is/*are clean)*
Het bericht over de aanslag/aanslagen is/*zijn gecensureerd *(the messages about the attack/attacks is/*are censored)*	De mededeling over de aanslag/aanslagen is/*zijn gecensureerd *(the announcement about the attack/attacks is/*are censored)*
Het meetlint voor de stof/stoffen is/*zijn geijkt *(the tape measure for the fabric/fabrics is/*are calibrated)*	De meetlat voor de stof/stoffen is/*zijn geijkt *(the ruler for the fabric/fabrics is/*are calibrated)*
Het gebed van de monnik/monniken is/*zijn vroom *(the prayer of the monk/monks is/*are devouted)*	De mis van de monnik/monniken is/*zijn vroom *(the Mass of the monk/monks is/*are devouted)*
Het delict van de antisemiet/antisemieten is/*zijn barbaars *(the delict of the anti-Semite/anti-Semites is/*are barbarous)*	De misdaad van de antisemiet/antisemieten is/*zijn barbaars *(the crime of the anti-Semite/anti-Semites is/*are barbarous)*
Het gebedshuis van de Islamiet/Islamieten is/*zijn groot *(the mosque of the Islamite/Islamites is/*are huge)*	De moskee van de Islamiet/Islamieten is/*zijn groot *(the mosque of the Islamite/Islamites is/*are huge)*
Het voertuig van de militair/militairen is/*zijn snel *(the vehicle of the soldier/soldiers is/*are fast)*	De motor van de militair/militairen is/*zijn snel *(the motorcycle of the soldier/soldiers is/*are fast)*
Het toneelstuk in de schouwburg/schouwburgen is/*zijn komisch *(the play in the theatre/theatres is/*are comical)*	De musical in de schouwburg/schouwburgen is/*zijn komisch *(the musical in the theatre/theatres is/*are comical)*
Het orkest van de politieagent/politieagenten is/*zijn uitstekend *(the orchestra from the cop/cops is/*are excellent)*	De muziekkapel van de politieagent/politieagenten is/*zijn uitstekend *(the band from the cop/cops is/*are excellent)*
Het gevolg van de oorlog/oorlogen is/*zijn triest *(the outcome of the war/wars is/*are sad)*	De nasleep van de oorlog/oorlogen is/*zijn triest *(the aftermath of the war/wars is/*are sad)*

Het nijlpaard bij de pelikaan/pelikanen is/*zijn zwaar *(the hippo near the pelican/pelicans is/*are heavy)*	De neushoorn bij de pelikaan/pelikanen is/*zijn zwaar *(the rhino near the pelican/pelicans is/*are heavy)*
Het milieu rond de fabriek/fabrieken is/*zijn bedorven *(the environment round the factory/factories is/*are bad)*	De omgeving rond de fabriek/fabrieken is/*zijn bedorven*(the environment round the factory/factories is/*are bad)*
Het formaat van de afdruk/afdrukken is/*zijn afwijkend *(the format of the printing/printings is/*are deviant)*	De omvang van de afdruk/afdrukken is/*zijn afwijkend *(the size of the printing/printings is/*are deviant)*
Het verhoor van de spion/spionnen is/*zijn gewelddadig *(the interrogation of the spy/spies is/*are violent)*	De ondervraging van de spion/spionnen is/*zijn gewelddadig *(the interrogation of the spy/spies is/*are violent)*
Het verschil in de uitkomst/uitkomsten is/*zijn opvallend *(the difference in the answer/answers is/*are striking)*	De ongelijkheid in de uitkomst/uitkomsten is/*zijn opvallend *(the dissimilarity in the answer/answers is/*are striking)*
Het onthaal door de gastheer/gastheren is/*zijn hartelijk *(the welcome by the host/hosts is/*are warm)*	De ontvangst door de gastheer/gastheren is/*zijn hartelijk *(the welcome by the host/hosts is/*are warm)*
Het diploma van de vakopleiding/vakopleidingen is/*zijn vereist *(the diploma of the vocational training/trainings is/*are required)*	De oorkonde van de vakopleiding/vakopleidingen is/*zijn vereist *(the certificate of the vocational training/trainings is/*are required)*
Het saldo van de verkoop/verkopen is/*zijn geweldig *(the balance of the sail/sails is/*are enormous)*	De opbrengst van de verkoop/verkopen is/*zijn geweldig *(the profit of the sail/sails is/*are enormous)*
Het bevel aan de brandweerman/brandweermannen is/*zijn moeilijk *(the order for the fireman/firemen is/*was hard)*	De opdracht aan de brandweerman/brandweermannen is/*zijn moeilijk *(the task for the fireman/firemen is/*was hard)*
Het opinieonderzoek over de doelstelling/doelstellingen is/*zijn twijfelachtig *(the opinion poll about the aim/aims is/*are doubtful)*	De opiniepeiling over de doelstelling/doelstellingen is/*zijn twijfelachtig *(the opinion poll about the aim/aims is/*are doubtful)*
Het standpunt van de docent/docenten is/*zijn doorslaggevend *(the viewpoint of the teacher/teachers is/*are decisive)*	De opvatting van de docent/docenten is/*zijn doorslaggevend *(the opinion of the teacher/teachers is/*are decisive)*
Het bevelschrift aan de luitenant/luitenanten is/*zijn onmenselijk *(the warrant at the lieutenant/lieutenant is/*are inhuman)*	De order aan de luitenant/luitenanten is/*zijn onmenselijk *(the order at the lieutenant/lieutenant is/*are inhuman)*
Het verdrag met de oliestaat/oliestaten is/*zijn wankel *(the treaty with the oil state/states is/*are unstable)*	De overeenkomst met de oliestaat/oliestaten is/*zijn wankel *(the agreement with the oil state/states is/*are unstable)*

Het proefwerk van de leerling/leerlingen is/*zijn makkelijk *(the test of the student/students is/*are easy)*	De overhoring van de leerling/leerlingen is/*zijn makkelijk *(the test of the student/students is/*are easy)*
Het regenscherm bij de wandelstok/wandelstokken is/*zijn nat *(the umbrella near the cane/canes is/*are wet)*	De paraplu bij de wandelstok/wandelstokken is/*zijn nat *(the umbrella near the cane/canes is/*are wet)*
Het potlood naast de kwast/kwasten is/*zijn nieuw *(the pencil near the brush/brushes is/*are new)*	De pen naast de kwast/kwasten is/*zijn nieuw *(the pen near the brush/brushes is/*are new)*
Het mos onder de spar/sparren is/*zijn dor *(the moss under the spruce/spruces is/*are withered)*	De plant onder de spar/sparren is/*zijn dor *(the plant under the spruce/spruces is/*are withered)*
Het verband voor de snijwond/snijwonden is/*zijn steriel *(the bandage for cut/cuts is/*are sterile)*	De pleister voor de snijwond/snijwonden is/*zijn steriel *(the band-aid for cut/cuts is/*are sterile)*
Het ven met de zwaan/zwanen is/*zijn vervuild *(the mere with the swan/swans is/*are filthy)*	De poel met de zwaan/zwanen is/*zijn vervuild *(the pool with the swan/swans is/*are filthy)*
Het gazon met de kruidenplant/kruidenplanten is/*zijn exotisch *(the lawn with the herb/herbs is/*are exotic)*	De pot met de kruidenplant/kruidenplanten is/*zijn exotisch *(the jar with the herb/herbs is/*are exotic)*
Het spel met de denkvraag/denkvragen is/*zijn leerzaam *(the game with the question/questions is/*are instructive)*	De quiz met de denkvraag/denkvragen is/*zijn leerzaam *(the quiz with the question/questions is/*are instructive)*
Het ruimteschip van de astronaut/astronauten is/*zijn supersonisch *(the spaceship of the astronaut/astronauts is/*are supersonic)*	De raket van de astronaut/astronauten is/*zijn supersonisch *(the rocket of the astronaut/astronauts is/*are supersonic)*
Het geding over de crimineel/criminelen is/*zijn onbeslist *(the lawsuit about the criminal/criminals is/*are undecided)*	De rechtszaak over de crimineel/criminelen is/*zijn onbeslist *(the lawsuit about the criminal/criminals is/*are undecided)*
Het bewind van de tiran/tirannen is/*zijn streng *(regime of the tyrant/tyrants is/*are rigorous)*	De regering van de tiran/tirannen is/*zijn streng *(governement of the tyrant/tyrants is/*are rigorous)*
Het kanaal met de vaargeul/vaargeulen is/*zijn breed *(the canal with the waterway/waterways is/*are wide)*	De rivier met de vaargeul/vaargeulen is/*zijn breed *(the river with the waterway/waterways is/*are wide)*
Het boek over de piraat/piraten is/*zijn avontuurlijk *(the book about the pirate/pirates is/*are adventurous)*	De roman over de piraat/piraten is/*zijn avontuurlijk *(the novel about the pirate/pirates is/*are adventurous*

Het glas met de barst/barsten is/*zijn kostbaar *(the glass with the crack/cracks is/*are expensive)*	De ruit met de barst/barsten is/*zijn kostbaar *(the window with the crack/cracks is/*are expensive)*
Het gevecht met de boer/boeren is/*zijn bloedig *(the fight with the farmer/farmers is/*are bloody)*	De ruzie met de boer/boeren is/*zijn bloedig *(the quarrel with the farmer/farmers is/*are bloody)*
Het bord met de banaan/bananen is/*zijn onvindbaar *(the plate with the banana/bananas is/*are untraceable)*	De schaal met de banaan/bananen is/*zijn onvindbaar *(the plate with the banana/bananas is/*are untraceable)*
Het stopcontact van de tuinlamp/tuinlampen is/*zijn stuk *(the socket of the garden light/lights is/*are broken)*	De schakelaar van de tuinlamp/tuinlampen is/*zijn stuk *(the switch of the garden light/lights is/*are broken)*
Het klimrek bij de wipplank/wipplanken is/*zijn leuk *(the climbing frame near the seesaw/seesaws is/*are fun)*	De schommel bij de wipplank/wipplanken is/*zijn leuk *(the swing near the seesaw/seesaws is/*are fun)*
Het kwartet van de jaargenoot/jaargenoten is/*zijn muzikaal *(the quartet of the contemporary/contemporaries is/*are musical)*	De schoolband van de jaargenoot/jaargenoten is/*zijn muzikaal *(the school band of the contemporary/contemporaries is/*are musical)*
Het vaartuig op de gracht/grachten is/*zijn alledaags *(the vessel in the canal/canals is/*are ordinary)*	De schuit op de gracht/grachten is/*zijn alledaags *(the barge in the canal/canals is/*are ordinary)*
Het hek om de tuin/tuinen is/*zijn verrot *(the fence around the garden/garden is/*are rotten)*	De schutting om de tuin/tuinen is/*zijn verrot *(the fence around the garden/garden is/*are rotten)*
Het verslag over de paus/pausen is/*zijn vaag *(the report about the pope/popes is/*are vague)*	De scriptie over de paus/pausen is/*zijn vaag *(the thesis about the pope/popes is/*are vague)*
Het parfum met de bloemengeur/bloemengeuren is/*zijn bedwelmend *(the perfume with the flower scent/scents is/*are stunning)*	De shampoo met de bloemengeur/bloemengeuren is/*zijn bedwelmend *(the shampoo with the flower scent/scents is/*are stunning)*
Het vraagstuk van de kandidaat/kandidaten is/*zijn ingewikkeld *(the problem of the candidate/candidates is/*are complicated)*	De som van de kandidaat/kandidaten is/*zijn ingewikkeld *(the sum of the candidate/candidates is/*are complicated)*
Het zwembad met de glijbaan/glijbanen is/*zijn fantastisch *(the pool with the slide/slides is/*are fantastic)*	De speeltuin met de glijbaan/glijbanen is/*zijn fantastisch *(the playground with the slide/slides is/*are fantastic)*

Het dorp bij de berg/bergen is/*zijn schilderachtig *(the village near the mountain/ mountains is picturesque)*	De stad bij de berg/bergen is/*zijn schilderachtig *(the city near the mountain/ mountains is picturesque)*
Het weiland met de koe/koeien is/*zijn rustiek *(the meadow with the cow/cows is/*are rural)*	De stal met de koe/koeien is/*zijn rustiek *(the cowhouse with the cow/cows is/*are rural)*
Het lied van de zangeres/zangeressen is/*zijn zuiver *(the song of the singer/singers pure)*	De stem van de zangeres/zangeressen is/*zijn zuiver *(the voice of the singer/singers pure)*
Het humeur van de banneling/bannelingen is/*zijn gedaald *(the mood of the exile/exiles is/*are dropped)*	De stemming van de banneling/bannelingen is/*zijn gedaald *(the mood of the exile/exiles is/*are dropped)*
Het zeilschip van de handelaar/handelaren is/*zijn verouderd *(the craft of the trader/ traders is/*are dated)*	De stoomboot van de handelaar/handelaren is/*zijn verouderd *(the steamboat of the trader/traders is/*are dated)*
Het springtij tijdens de wintermaand/wintermaanden is/*zijn riskant *(the spring tide during the winter month/months is/*are risky)*	De stormvloed tijdens de wintermaand/wintermaanden is/*zijn riskant *(the storm flood during the winter month/months is/*are risky)*
Het plein bij de kerk/kerken is/*zijn leeg *(the square near the church/churches is/*are empty)*	De straat bij de kerk/kerken is/*zijn leeg *(the street near the church/churches is/*are empty)*
Het winkelcentrum langs de autoweg/ autowegen is/*zijn enorm *(the shoppingmall near the highway/highways is/*are enormous)*	De supermarkt langs de autoweg/autowegen is/*zijn enorm *(the supermarket near the highway/highways is/*are enormous)*
Het gebak naast de bloem/bloemen is/*zijn verrukkelijk *(the pastry next to the flower/ flowers is/*are delicious)*	De taart naast de bloem/bloemen is/*zijn verrukkelijk *(the cake next to the flower/flowers is/*are delicious)*
Het verhaal met de tekening/tekeningen is/*zijn duidelijk *(the story with the drawing/drawings is/*are clear)*	De tekst met de tekening/tekeningen is/*zijn duidelijk *(the text with the drawing/drawings is/*are clear)*
Het experiment met de pil/pillen is/*zijn wreed *(the experiment with the drug/drugs is/*are cruel)*	De test met de pil/pillen is/*zijn wreed *(the test with the drug/drugs is/*are cruel)*
Het ritueel van de indiaan/indianen is/*zijn oud *(the ritual of the Indian/Indians is/*are ancient)*	De totempaal van de indiaan/indianen is/*zijn oud *(the ritual of the Indian/Indians is/*are ancient)*

Het park met de kastanjeboom/kastanjebomen is/*zijn schaduwrijk *(the park with the chestnut/chestnuts is/*are shady)*	De tuin met de kastanjeboom/kastanjebomen is/*zijn schaduwrijk *(the garden with the chestnut/chestnuts is/*are shady)*
Het resultaat van de test/testen is/*zijn bevredigend *(the result of the test/tests is/*are satisfying)*	De uitslag van de test/testen is/*zijn bevredigend *(the outcome of the test/tests is/*are satisfying)*
Het vonnis over de dief/dieven is/*zijn onherroepelijk *(the verdict of the thieve/thieves is/*are irrevocable)*	De uitspraak over de dief/dieven is/*zijn onherroepelijk *(the verdict of the thieve/thieves is/*are irrevocable)*
Het voorwendsel van de deugniet/deugnieten is/*zijn sluw *(the pretext of the rogue/rogues is/*are sly)*	De uitvlucht van de deugniet/deugnieten is/*zijn sluw *(the excuse of the rogue/rogues is/*are sly)*
Het perk met de zonnebloem/zonnebloemen is/*zijn kleurrijk *(the bed with the sunflower/sunflowers is/*are colourful)*	De vaas met de zonnebloem/zonnebloemen is/*zijn kleurrijk *(the vase with the sunflower/sunflowers is/*are colourful)*
Het gif voor de rat/ratten is/*zijn dodelijk *(the possion for the rat/rats is/*are mortal)*	De val voor de rat/ratten is/*zijn dodelijk *(the trap for the rat/rats is/*are mortal*
Het misverstand over de uitspraak/uitspraken is/*zijn logisch *(the misunderstanding about the verdict/verdicts is/*are logic)*	De vergissing over de uitspraak/uitspraken is/*zijn logisch *(the mistake about the verdict/verdicts is/*are logic)*
Het lesgeld voor de opleiding/opleidingen is/*zijn gering *(the tuition fee for the training/trainings is/*are small)*	De vergoeding voor de opleiding/opleidingen is/*zijn gering *(the compensation for the training/trainings is/*are small)*
Het oordeel van de advocaat/advocaten is/*zijn overduidelijk *(the judgment of the lawyer/lawyers is/*are evident)*	De verklaring van de advocaat/advocaten is/*zijn overduidelijk *(the explanation of the lawyer/lawyers is/*are evident)*
Het vermoeden van de pessimist/pessimisten is/*zijn uitgekomen *(the suspicion of the pessimist/pessimists is/*are correct)*	De verwachting van de pessimist/pessimisten is/*zijn uitgekomen *(the expectation of the pessimist/pessimists is/*are correct)*
Het aquarium met de vis/vissen is/*zijn besmet *(the aquarium with the fish/fishes is/*are contaminated)*	De vijver met de vis/vissen is/*zijn besmet *(the pond with the fish/fishes is/*are contaminated)*
Het landhuis naast de krottenwijk/krottenwijken is/*zijn beeldig *(the countryhouse near the slum/slums is/*are gorgeous)*	De villa naast de krottenwijk/krottenwijken is/*zijn beeldig *(the villa near the slum/slums is/*are gorgeous)*
Het droombeeld van de Freudiaan/Freudianen is/*zijn absurd *(the fantasy of the Freudian/Freudians is/*are ridiculous)*	De waan van de Freudiaan/Freudianen is/*zijn absurd *(the delusion of the Freudian/Freudians is/*are ridiculous)*

Het alarm voor de luchtaanval/luchtaanvallen is/*zijn schel *(the alarm for the raid/raids is/*are shrill)*	De waarschuwing voor de luchtaanval/luchtaanvallen is/*zijn schel *(the warning for the raid/raids is/*are shrill)*
Het pad door de vallei/valleien is/*zijn smal *(the trail through the valley/valleys is/*are small)*	De weg door de vallei/valleien is/*zijn smal *(the roud through the valley/valleys is/*are small)*
Het rendement uit de investering/investeringen is/*zijn minimaal *(the return of the investment/investments is/*are minimal)*	De winst uit de investering/investeringen is/*zijn minimaal *(the profit of the investment/investments is/*are minimal)*
Het eiland met de rots/rotsen is/*zijn ontoegankelijk *(the island with the rock/rocks is/*are inaccessible)*	De woestijn met de rots/rotsen is/*zijn ontoegankelijk *(the desert with the rock/rocks is/*are inaccessible)*
Het appartement naast de parkeerplaats/parkeerplaatsen is/*zijn verbouwd *(the appartment next to the parking lot/lots is/*are remodelled)*	De woning naast de parkeerplaats/parkeerplaatsen is/*zijn verbouwd *(the house next to the parking lot/lots is/*are remodelled)*
Het woordenboek naast de encyclopedie/encyclopedieën is/*zijn informatief *(the dictionary next to the cyclopedia/cyclopedias is/*are informative)*	De woordenlijst naast de encyclopedie/encyclopedieën is/*zijn informatief *(the wordlist next to the cyclopedia/cyclopedias is/*are informative)*
Het lokaal voor de les/lessen is/*zijn kaal *(the room for the class/classes is/*are sober)*	De zaal voor de les/lessen is/*zijn kaal *(the room for the class/classes is/*are sober)*
Het zeekalf bij de dolfijn/dolfijnen is/*zijn gewond *(the harbour seal near the dolphin/dolphins is/*are wounded)*	De zeekoe bij de dolfijn/dolfijnen is/*zijn gewond *(the sea cow near the dolphin/dolphins is/*are wounded)*
het weekend van de chirurg/chirurgen is/*zijn bezet *(the weekend of the surgeon/surgeons is/*are full)*	De zondag van de chirurg/chirurgen is/*zijn bezet *(the sunday of the surgeon/surgeons is/*are full)*

Appendix E

Appendix E

Distributive sentences (translation)	Non-distributive sentences (translation)
De pet van de honkballers moet/*moeten gemakkelijk zitten (the cap of the baseball player has/have to sit comfortably)	De bank van de honkballers moet/*moeten gemakkelijk zitten (the bench of the baseball player has/have to sit comfortably)
De batterij voor de gsms kan/*kunnen gevaarlijk zijn (the battery of the cellphones can_{sg}/can_{pl} be dangerous)	De zendmast voor de gsms kan/*kunnen gevaarlijk zijn (the mast for the cellphones can_{sg}/can_{pl} be dangerous)
De staart van de apen wordt/*worden nagekeken (the tail of the monkey $will_{sg}$/$will_{pl}$ be checked)	De kooi van de apen wordt/*worden nagekeken (the cagel of the monkey $will_{sg}$/$will_{pl}$ be checked)
De dop van de flessen zal/*zullen ingeleverd worden (the cap of the bottles $will_{sg}$/$will_{pl}$ be turned in)	De kist met de flessen zal/*zullen ingeleverd worden (the box with the bottles $will_{sg}$/$will_{pl}$ be turned in)
De code op de bankkaarten moet/*moeten verborgen blijven (the code on the bank cards has/have to stay hidden)	De map voor de bankkaarten moet/*moeten verborgen blijven (the file for the bank cards has/have to stay hidden)
Het deksel op de kisten wordt/*worden gepoetst (the lid on the chests $will_{sg}$/$will_{pl}$ be cleaned)	Het opberghok voor de kisten wordt/*worden gepoetst (the shed for the chests $will_{sg}$/$will_{pl}$ be cleaned)
De pasfoto van de personeelsleden moet/*moeten in de gids staan (the passport photo of the staff members has/*have to be in the directory)	De groepsfoto van de personeelsleden moet/*moeten in de gids staan (the group photo of the staff members has/*have to be in the directory)
De pit van de kersen blijft/*blijven rood afgeven (the seed of the cherries keeps/*keep running red)	De confiture van de kersen blijft/*blijven rood afgeven (the jam of the cherries keeps/*keep running red)
De schoen van de voetballers kan/*kunnen naar zweet ruiken (the shoe of the soccer players can_{sg}/can_{pl} smell to sweat)	De kleedkamer van de voetballers kan/*kunnen naar zweet ruiken (the changing room of the soccer players can_{sg}/can_{pl} smell to sweat)
De voordeur van de huizen zal/*zullen mooi verlicht worden (the front door of the houses $shall_{sg}$/*$shall_{pl}$ be nicely lit)	De straat met de huizen zal/*zullen mooi verlicht worden (the street with the houses $shall_{sg}$/*$shall_{pl}$ be nicely lit)
De voortuin van de nieuwbouwhuizen moet/*moeten verzorgd uitzien (the front garden of the new houses has/*have to look well)	De architect van de nieuwbouwhuizen moet/*moeten verzorgd uitzien (the architect of the new houses has/*have to look well)

Het shirt van de jongens mag/*mogen sportief uitzien (the shirt of the boys may_{sg}/may_{pl} look sporty)	Het elftal van de jongens mag/*mogen sportief uitzien (the team of the boys may_{sg}/may_{pl} look sporty)
De pen van de leerlingen moet/*moeten goed functioneren (the pen of the students has/*have to function well)	De mentor van de leerlingen moet/*moeten goed functioneren (the tutor of the students has/*have to function well)
De kroon van de koningen kan/*kunnen zeer mooi ogen (the crown of the kings can_{sg}/*can_{pl} look very nice)	De kamer met de koningen kan/*kunnen zeer mooi ogen (the room with the kings can_{sg}/*can_{pl} look very nice)
De sleuf van de geldautomaten wordt/*worden bewaakt (the slot of the cash dispensers $will_{sg}$/$will_{pl}$ be watched)	De bank met de geldautomaten wordt/*worden bewaakt (the bank with the cash dispensers $will_{sg}$/$will_{pl}$ be watched)
De vulling in de tanden lijkt/*lijken rot te zijn (the filling in the teeth seems/*seem to be decayed)	De mond met de tanden lijkt/*lijken rot te zijn (the mouth with the teeth seems/*seem to be decayed)
De lont van de kaarsen is/*zijn kapot (the taper of the candles is/*are broken)	De kandelaar met de kaarsen is/*zijn kapot (the candleholder with the candles is/*are broken)
De muil van de nijlpaarden kan/*kunnen stinken (the mouth of the hippo can_{sg}/*can_{pl} smell)	De zoo met de nijlpaarden kan/*kunnen stinken (the zoo with the hippo can_{sg}/*can_{pl} smell)
De klep van de brievenbussen kan/*kunnen veel lawaai maken (the lid of the mailboxes can_{sg}/*can_{pl} make a lot of noise)	De hal met de brievenbussen kan/*kunnen veel lawaai maken (the lid of the mailboxes can_{sg}/*can_{pl} make a lot of noise)
De schoorsteen van de boerderijen kan/*kunnen warm aanvoelen (the chimney of the farms can_{sg}/*can_{pl} feel warm)	De zon boven de boerderijen kan/*kunnen warm aanvoelen (the sun above the farms can_{sg}/*can_{pl} feel warm)
Het bed van de kinderen blijft/*blijven mooi gekleurd (the bed of the children stays/*stay nicely coloured)	Het plein met de kinderen blijft/*blijven mooi gekleurd (the square with the children stays/*stay nicely coloured)
De kaars op de taarten zal/*zullen warmte afgeven (the candle on the cakes $shall_{sg}$/$shall_{pl}$ give heat)	De oven voor de taarten zal/*zullen warmte afgeven (the oven for the cakes $shall_{sg}$/$shall_{pl}$ give heat)
De knalpijp van de motorfietsen heeft/*hebben overlast veroorzaakt (the exhaust of the motorcycles has/*have cause trouble)	De botsing van de motorfietsen heeft/*hebben overlast veroorzaakt (the collision of the motorcycles has/*have cause trouble)
De das voor de clowns zal/*zullen veel kleuren bevatten (the tie for the clowns $will_{sg}$/*$will_{pl}$ have color)	De tent met de clowns zal/*zullen veel kleuren bevatten (the tent with the clowns $will_{sg}$/*$will_{pl}$ have color)

De sneeuwbril van de skiërs kan/*kunnen niet gemist worden (the goggles of the skiers can$_{sg}$/*can$_{pl}$ not be missed)	De lift voor de skiërs kan/*kunnen niet gemist worden (the lift of the skiers can$_{sg}$/*can$_{pl}$ not be missed)
De rits van de tenten is/*zijn nat geworden (the zipper of the tents has/*have become wet)	De weide met de tenten is/*zijn nat geworden (the meadow with the tents has/*have become wet)
Het lunchpakket voor de gasten wordt/*worden klaargemaakt (the lunch for the guests is/*are being made)	Het diner voor de gasten wordt/*worden klaargemaakt (the dinner for the guests is/*are being made)
De chip van de computers wordt/*worden streng beveiligd (the chip of the computers is/*are being secured)	De zaak met de computers wordt/*worden streng beveiligd (the chip of the computers is/*are being secured)
De buidel van de kangoeroes zal/*zullen veel bekijks trekken (the pouch of the kangaroos will$_{sg}$/*will$_{pl}$ attrack visitors)	De dierentuin met de kangoeroes zal/*zullen veel bekijks trekken (the zoo with the kangaroos will$_{sg}$/*will$_{pl}$ attrack visitors)
De stop van de baden wordt/*worden gemaakt (the plug of the bathtubs is/*are being made)	De sauna met de baden wordt/*worden gemaakt (the sauna with the bathtubs is/*are being made)
De achterband van de fietsen moet/*moeten onderhouden worden (the tire of the bikes has/*have to be maintained)	De stalling van de fietsen moet/*moeten onderhouden worden (the shelter of the bikes has/*have to be maintained)
De trui van de turners moet/*moeten schoon zijn (the sweater of the gymnasts has/*have to be clean)	De kleedkamer van de turners moet/*moeten schoon zijn (the dressing room of the gymnasts has/*have to be clean)
De antenne van de radio's is/*zijn vernield (the antenna of the radios is/*are destroyed)	De etalage met de radio's is/*zijn vernield (the shop-window with the radios is/*are destroyed)
Het handvat van de pannen kan/*kunnen niet roesten (the handle of the pans can$_{sg}$/*can$_{pl}$ not rust)	Het rek voor de pannen kan/*kunnen niet roesten (the rack with the pans can$_{sg}$/*can$_{pl}$ not rust)
De toga van de professoren blijft/*blijven opvallen (the robe of the professor keeps/*keep standing out)	De uitvinding van de professoren blijft/*blijven opvallen (the invention of the professor keeps/*keep standing out)
De lijst om de schilderijen lijkt/*lijken modern te zijn (the frame of the painting seems/*seem to be modern)	De exhibitie van de schilderijen lijkt/*lijken modern te zijn (the exhibition of the painting seems/*seem to be modern)
De postzegel op de brieven is/*zijn bedrukt (the stamp on the lettres is/*are printed)	De fietstas met de brieven is/*zijn bedrukt (the bag with the lettres is/*are printed)

De propeller van de helikopters moet/*moeten in orde zijn (the propeller of the chopper has/*have to be good)	De landplaats van de helikopters moet/*moeten in orde zijn (the landing ploint of the chopper has/*have to be good)
De hoed van de cowboys blijft/*blijven bekijks trekken (the head of the cowboys keeps/*keep drawing looks)	De rodeo van de cowboys blijft/*blijven bekijks trekken (the rodeo of the cowboys keeps/*keep drawing looks)
De staf van de bisschoppen blijft/*blijven rijk versierd (the staff of the bishops stays/*stay decorated)	De kathedraal met de bisschoppen blijft/*blijven rijk versierd (the cathedral of the bishops stays/*stay decorated)
De toets van de telefoons heeft/*hebben goed gewerkt (the button of the phones has/*have worked well)	De fabrikant van de telefoons heeft/*hebben goed gewerkt (the factory of the phones has/*have worked well)
De tong van de slangen kan/*kunnen nat zijn (the tongue of the snakes can_{sg}/*can_{pl} be wet)	De mand voor de slangen kan/*kunnen nat zijn (the basket for the snakes can_{sg}/*can_{pl} be wet)
De tuinbroek van de werkmannen blijft/*blijven liggen (the dungarees of the workmen stays/*stay there)	De klus van de werkmannen blijft/*blijven liggen (the job of the workmen stays/*stay undone)
De pamper van de zuigelingen wordt/*worden vernieuwd (the diaper of the infants $will_{sg}$/$will_{pl}$ be refreshed)	De crèche voor de zuigelingen wordt/*worden vernieuwd (the day-care centre of the infants $will_{sg}$/$will_{pl}$ be refreshed)
De kraag van de truien is/*zijn verkleurd (the collar of the sweaters has/*have lost colour)	De plank met de truien is/*zijn verkleurd (the shelf with the sweaters has/*have lost colour)
De broek van de matrozen zal/*zullen bewegen in de wind (the pants of the sailors $will_{sg}$/*$will_{pl}$ move in the wind)	De boot van de matrozen zal/*zullen bewegen in de wind (the boat of the sailors $will_{sg}$/*$will_{pl}$ move in the wind)
De rugzak van de wandelaars kan/*kunnen te zwaar blijken (the backpack of the hikers can_{sg}/*can_{pl} be heavy)	De route van de wandelaars kan/*kunnen te zwaar blijken (the route of the hikers can_{sg}/*can_{pl} be heavy)
De lens van de fototoestellen lijkt/*lijken goed te zijn (the lens of the cameras seems/*seem to be good)	De speciaalzaak van de fototoestellen lijkt/*lijken goed te zijn (the specialist shop of the cameras seems/*seem to be good)
De noot op de bonbons lijkt/*lijken gebroken (the nut on the chocolate seems/*seem to be broken)	De vitrine met de bonbons lijkt/*lijken gebroken (the case with the chocolate seems/*seem to be broken)
De schil van de bananen is/*zijn snel verslapt (the peel of the bananas has/*have become slack)	De tros met de bananen is/*zijn snel verslapt (the bunch of the bananas has/*have become slack)

De snaar van de violen is/*zijn uit Italië gekomen (the string of the violins has/*have arrived from Italy)	De bouwer van de violen is/*zijn uit Italië gekomen (the builder of the violins has/*have arrived from Italy)
De pij van de monniken mag/*mogen eenvoudig lijken (the habit of the monks may_{sg}/*may_{pl} look simple)	De mis van de monniken mag/*mogen eenvoudig lijken (the mass of the monks may_{sg}/*may_{pl} look simple)
De staart van de vissen blijft/*blijven bewegen (the tail of the fishes keeps/*keep moving)	De vijver van de vissen blijft/*blijven bewegen (the pond of the fishes keeps/*keep moving)
De lamp van de taxi's wordt/*worden gerepareerd (the light of the taxis is/*are being repared)	De garage voor de taxi's wordt/*worden gerepareerd (the garage for the taxis is/*are being repared)
De badkamer van de appartementen wordt/*worden aangepast (the bathroom of the appartments is/*are being adjusted)	De lift van de appartementen wordt/*worden aangepast (the elevator of the appartments is/*are being adjusted)
De helm van de soldaten moet/*moeten bescherming bieden (the helmet of the soldiers has/*have to give protection)	De tank met de soldaten moet/*moeten bescherming bieden (the tank of the soldiers has/*have to give protection)
De verlichting van de fietsen moet/*moeten verbeterd worden (the lighting on the bikes has/*have to be improved)	De stalling voor de fietsen moet/*moeten verbeterd worden (the shelter of the bikes has/*have to be improved)
De handtas van de stewardessen is/*zijn volgepakt (the bag of the stewardess has/*have been packed)	De ruimte voor de stewardessen is/*zijn volgepakt (the room for the stewardess has/*have been packed)
De kers in de glazen is/*zijn rood gekleurd (the cherry in the glasses has/*have been coloured red)	De tafel met de glazen is/*zijn rood gekleurd (the table with the glasses has/*have been coloured red)
De deur van de treinen mag/*mogen niet open staan (the door of the trains can_{sg}/*can_{pl} not be open)	De loods van de treinen mag/*mogen niet open staan (the shed for the trains can_{sg}/*can_{pl} not be open)
De boerka van de Islamieten kan/*kunnen wit gekleurd zijn (the burka of the Islamites can_{sg}/*can_{pl} be coloured white)	De moskee van de Islamieten kan/*kunnen wit gekleurd zijn (the mosque of the Islamites can_{sg}/*can_{pl} be coloured white)
De muts voor de koks wordt/*worden schoon gemaakt (the hat for the cooks $will_{sg}$/*$will_{pl}$ be cleaned)	De keuken van de koks wordt/*worden schoon gemaakt (the kitchen for the cooks $will_{sg}$/*$will_{pl}$ be cleaned)
De neus van de vliegtuigen wordt/*worden geverfd (the nose of the plains $will_{sg}$/*$will_{pl}$ be painted)	De hangar met de vliegtuigen wordt/*worden geverfd (the hangar for the plains $will_{sg}$/*$will_{pl}$ be painted)

Het zeil van de surfplanken kan/*kunnen omvallen (the sail of the sailboard can_{sg}/*can_{pl} fall)	Het opslagrek voor de surfplanken kan/*kunnen omvallen (the rack for the sailboard can_{sg}/*can_{pl} fall)
De kurk van de wijnflessen mag/*mogen vochtig zijn (the cork of the winebottles $might_{sg}$/*$might_{pl}$ be damped)	De kelder voor de wijnflessen mag/*mogen vochtig zijn (the cellar for the winebottles $might_{sg}$/*$might_{pl}$ be damped)
Het leerboek van de leerlingen is/*zijn verouderd (the textbook for the students is/*are old-fashioned)	Het toneelstuk van de leerlingen is/*zijn verouderd (the play of the students is/*are old-fashioned)
De titelpagina van de boeken heeft/*hebben indruk gemaakt (the title page of the books has/*have made an impression)	De oplage van de boeken heeft/*hebben indruk gemaakt (the edition of the books has/*have made an impression)
De pyjama voor de patiënten zal/*zullen vies worden (the pyjama for the patient $will_{sg}$/*$will_{pl}$ become dirty)	De kamer van de patiënten zal/*zullen vies worden (the room of the patient $will_{sg}$/*$will_{pl}$ become dirty)
De stengel van de planten kan/*kunnen gauw breken (the stalk of the plants $will_{sg}$/$will_{pl}$ break fast)	De serre voor de planten kan/*kunnen gauw breken (the greenhouse for the plants $will_{sg}$/$will_{pl}$ brake fast)
De klink op de deuren is/*zijn van metaal gemaakt (the handle on the doors is/*are made of methal)	De auto met de deuren is/*zijn van metaal gemaakt (the car with the doors is/*are made of methal)
De vin van de haaien is/*zijn grijs gekleurd (the fin of the sharks is/*are coloured grey)	De verblijfplaats van de haaien is/*zijn grijs gekleurd (the pool for the sharks is/*are coloured grey)
Het meetlint van de naaisters moet/*moeten vervangen worden (the tape measure of the seamstress has/*have to be replaced)	Het atelier van de naaisters moet/*moeten vervangen worden (the workshop of the seamstress has/*have to be replaced)
De hals van de zwanen kan/*kunnen langgerekt zijn (the neck of the swans can_{sg}/*can_{pl} be long)	De poel van de zwanen kan/*kunnen langgerekt zijn (the ponds of the swans can_{sg}/*can_{pl} be long)
De jurk van de zangeressen blijft/*blijven goed verkopen (the dress of the singers keeps/*keep selling well)	De hit van de zangeressen blijft/*blijven goed verkopen (the hit of the singers keeps/*keep selling well)
De schroef van de boten moet/*moeten tegen vocht kunnen (the screw of the boats has/*have to be water restistant)	De haven met de boten moet/*moeten tegen vocht kunnen (the harbour with the boats has/*have to be water restistant)

De stamper van de bloemen zal/*zullen heerlijk ruiken (the pistil of the flowers will$_{sg}$/will$_{pl}$ smell good)	De vaas met de bloemen zal/*zullen heerlijk ruiken (the vase of the flowers will$_{sg}$/will$_{pl}$ smell good)
De muts van de feestgangers is/*zijn versierd (the hat of the partygoers is/*are decorated)	De zaal met de feestgangers is/*zijn versierd (the room with the partygoers is/*are decorated)
De revolver van de flikken wordt/*worden gecontroleerd (the revolver of the cops will$_{sg}$/will$_{pl}$ be checked)	De bar voor de flikken wordt/*worden gecontroleerd (the bar for the cops will$_{sg}$/will$_{pl}$ be checked)
Het vel van de druiven zal/*zullen de smaak beïnvloeden (the skin of the grapes will$_{sg}$/will$_{pl}$ influences the flavour)	Het vat voor de druiven zal/*zullen de smaak beïnvloeden (the barrel for the grapes will$_{sg}$/will$_{pl}$ influences the flavour)
De slurf van de olifanten kan/*kunnen groot worden (the trunk of the elephants can$_{sg}$/*can$_{pl}$ become large)	De kudde van de olifanten kan/*kunnen groot worden (the herd of the elephants can$_{sg}$/*can$_{pl}$ become large)

Appendix F

Appendix F

Correct sentence, the bold word is the correct word *(translation)*	Lexical error	Nonlexical error
Tegen de kou draag je op je hoofd een gebreide **muts** met oorkleppen *(against the cold you wear on your head a knitted **hat** with earflaps)*	kluts dab	wuts
Toen de ridder de draak zag, trok hij zijn **zwaard** ter verdediging *(when the knight saw the dragon he pulled his **sword** to defend himself)*	paard horse	nard
Om te zorgen dat je auto naar rechts gaat draai je aan het **stuur** nadat je geremd hebt *(to make sure that your car goes to the right you have to turn the stearing **wheel** after you have braked)*	vuur fire	wuur
Ik kan niet lezen zonder **bril** of lenzen *(I can not read without **glasses** or lenses)*	pil pill	zil
Het kind verzamelde al haar gevonden paaseieren in een grote **mand** op de tafel *(the child collected all her easter egg in a big **basket** on the table)*	hand hand	jand
Bier met een kersensmaak heet **kriek** en smaakt zoet *(a beer with a cherry flavour is called **kriek** and tastes sweet)*	piek peak	tiek
Het aardappel gerecht waar België om bekend staat is de **friet** met mayonaise *(the patatoo dish that is famous in Belgium are **fries** with mayonnaise)*	piet geezer	hiet
Iemand die steelt noemt men een **dief** of een boef *(someone who steals is called a **thief** or a burglar)*	bief steak	wife
Jezus Christus stierf aan het **kruis** voor de mensheid *(Jesus christ died at the **cross** for humanity)*	huis house	xuis
De commissaris voelt de verdachte aan de **tand** over de moordzaak *(the commissioner puts the suspect through the **mill** about the murder case)*	rand edge	qand
Kettingbotsingen gebeuren vaak vanwege slecht zicht in dichte **mist** of bij regen *(multiple collisions often happen when there is a bad view trough thick **fog** or with rain)*	kist coffin	bist
Ken je het sprookje van de gelaarsde **kat** van buiten *(do you know the fairy tale of the **puss** in boots by heart)*	lat slat	xat

De band van mijn fiets is zacht, pak eens een **pomp** dan pomp ik hem vol *(my bike has a flat tire, give me a **pump** so that I can fill it)*	klomp clog	tomp
Je moet die bloem omplanten in een grotere bloem **pot** zodat ze kan groeien *(you have to replant that flower into a larger **pot** so that it can grow)*	zot fool	fot
Het schip sloeg om vanwege één huize hoge **golf** en zonk *(the boat capsized because of one high **wave** and sank)*	wolf wolf	folf
Ze was aan het huilen over haar wang liep een **traan** naar beneden *(she was crying a **tear** rolled down over her cheek)*	haan rooster	raan
s Winters stonden de koeien op **stal** met wat stro *(during the winter the cows were in the **shed** with some straw)*	hal hall	nal
Als je te voet naar boven moet ga je via de **trap** omhoog *(if you want to go upstairs walking you have to take the **stairs**)*	hap bite	bap
De koeien liepen door het groene **gras** te grazen *(the cows were walking over the green **grass** while grazing)*	ras race	nas
In België heb je geen stemrecht, maar stem **plicht** vanaf je achttiende *(in Belgium you don't have the right to vote, but you have the **duty** from when you turn 18)*	nicht niece	ficht
Om een slang te bezweren blies de fakir op zijn **fluit** en maakte een mooi geluid *(to charm a snake the fakir played his **fluit** and made a beautiful sound)*	ruit diamond	juit
In het paradijs was de appel de verboden **vrucht** voor Adam en Eva *(in paradise the apple was the fordidden **fruit** for Adam and Eve)*	tucht law	mucht
Als je een huis binnen gaat kom je eerst in de **hal** daar hang je je jas op *(when you enter a house you first come into the entrance **hall** here you can put away your jacket)*	bal ball	cal
Ter bescherming tegen zwangerschap slikken veel vrouwen de **pil** dagelijks in *(to protect themselves against pregnancy a lot of women take the **pill** daily)*	bil cheek	nil
Na mijn eerste worp bij bowlen viel alles om behalve één **kegel** die helemaal links stond *(after my first throw almost all the **pins** except one fell)*	regel rule	jegel
In zijn revolver zat nog maar één **kogel** om mee te schieten *(in the revolver there was only one **bullet** left to shoot)*	vogel bird	logel

Om vliegen weg te jagen slaat de koe met haar **staart** om zich heen *(to chase off flies cows move their **tail** around)*	kaart map	jaart
Om mijn broek op te houden gebruik ik een **riem** met een grote gesp *(to keep my pants from falling of I use a **belt** with a large buckle)*	kiem germ	wiem
Het meisje speelt met haar spring **touw** in de tuin *(the girl plays with her jump **rope** in the garden)*	bouw building	plouw
De vogel die symbool staat voor de vrede is de **duif** met een palmtak in zijn snavel *(the bird that serves as a symbol of peace is the **pigeon** with a palm in his beak)*	fuif party	puif
Joris bakte eieren in een **pan** op het vuur *(Joris baked the eggs in the **pan** on the fire)*	kan jug	gan
Een kilt is een Schotse **rok** met ruiten *(a kilt is a scottisch **skirt** with checks)*	nok ridge	qok
Dankzij mijn nieuwe wasmiddel zie je niks meer van die grote **vlek** op de mouw *(thanks to my new detergent that big **stain** on the sleeve is invisible)*	plek spot	jek
Het water van het dak wordt opgevangen in een houten regen **ton** en weggevoerd *(the water of the roof is collected in a big wooden **barrel** and then it is drained away)*	bon ticket	son
De surfers werden aangevallen door een grote **haai** van 10 meter lang *(the boarders were attacked by a big **shark** of at least 10 metres long)*	kaai pinch	vaai
Hij schonk de cola in een groot **glas** voor zijn gast *(he poured out a large **glass** of coke for his guest)*	ras race	vas
De gorilla schreeuwde en sloeg op zijn eigen **borst** uit woede *(the gorialla yelled and beated his own **chest** out of anger)*	korst crust	zorst
Het geld van de bank zit allemaal veilig in een **kluis** opgeborgen *(the money in the bank is safely put away in the **safe**)*	muis mouse	wuis
Om het papier vast te plakken haalde het kind een tube **lijm** uit de kast *(to glue the paper the child got a tube of **glue** out of the closet)*	tijm thyme	sijm
Het hoofd van een koe is zijn **kop** en is soms gevlekt *(the cows **head** is sometimse stained)*	pop doll	vop
Over de rivier ligt een **brug** naar de andere kant *(over the River there is a **bridge** to reach the other side)*	mug mosquito	wug

Weerwolven zie je met volle **maan** verschijnen *(werewolves can be seen during full **moon**)*	baan job	saan
Vers brood haal ik bij de **bakker** op de hoek *(I get fresh bread at the **baker** around the corner)*	kakker toffe-nose	gakker
Ik ben met de auto door glas gereden en nu heb ik een lekke **band** gekregen *(I drove with my car trough glass and now I have a flat **tire**)*	hand hand	jand
De fietser wilde inhalen en rinkelde de **bel** en riep *(the biker wanted to pass therefor he jingled the **bell** and yelled)*	tel moment	mel
De maatschappelijk assistent droeg aan elke voet een geiten wollen **sok** en sandaal *(the social worker wore on every foot a woollen **sock** and a sandal)*	lok lock	qok
Om de tuin stond een ijzeren **hek** als afrastering *(around the garden there was an iron **fence** that served as rail off)*	rek rack	sek
Een liter frisdrank zit in een plastic **fles** met een etiquette er op *(there is a litre of soda in that plastic **bottle** with the label on it)*	les class	ses
Een varken heeft in zijn staart een **krul** met wat haar *(a pig has a **curl** in his tail with some hair)*	nul zero	wul
Soep eet je met een **lepel** uit een kom *(you eat soup with a **spoon** out of a bowl)*	tepel nipple	bepel
Op de middelbare school was wiskunde mijn lievelings **vak** en biologie ook *(during high school math was my favourite **class** and biology too)*	pak suit	fak
Voordat ik naar het werk ga lees ik altijd eerst de ochtend **krant** tijdens het ontbijt *(before I go to work I always read the **paper** while I am having breakfast)*	plant suit	nant
Tijdens mijn slaap had ik een rare **droom** over een reis *(During my sleep I had a weird **dream** about a journey)*	boom tree	noom
Ober, ik wil gaan, mag ik de **rekening** hebben *(waiter, I want to leave can I have the **bill** please)*	tekening drawing	nekening
De turnster deed evenwichtsoefeningen op de evenwichts **balk** in de gymzaal *(the gymnast did balance exercises on the balance **beam** in the gym room)*	kalk plaster	dalk

Om de band te verwisselen tilde hij de auto op met een **krik** in de garage *(to exchange the tire he lifted the car with a **jack** in the garage)*	tik tap	gik
De secretaresse deed de brief op de **post** en ging naar huis *(the secretary put the letter on the **mail** and went home)*	kost cost	jost
Een knaagdier dat in de riool leeft is een **rat** met een staart *(a rodent that lives in the sewer is a **rat** and has a tail)*	mat mat	qat
BMW is een bekend auto **merk** en volvo ook *(BMW is a famous car **brand** and Volvo too)*	perk bed	serk
Hans en Grietje werden gevangen genomen door een **heks** om vet gemest te worden *(Hansel and Gretel were captured by a **witch** to be fattened)*	seks sex	peks
Hij laat een sik groeien aan zijn **kin** voor een wedstrijd *(He is grewing a goatee on his **chin** for a game)*	zin mood	lin
Met kerstmis organiseert men vaak een gala **bal** voor een goed doel *(with christmas people often organise a **ball** for a good cause)*	val trap	kal
Grote ronde Chinese braadpan is de **wok** en wordt vaak gebruikt *(a huge Chinese cooking pot is the **wok** and it is often used)*	rok skirt	xok
Een bepantserd legervoertuig met rupsbanden is een **tank** en rijdt op alle terreinen *(an armoured army vehicle with caterpillars is a **tank** and it can ride on all terrains)*	bank couch	fank
De bruidegom droeg een prachtig kostuum en de bruid een mooie **jurk** met sleep *(the groome wore a beautiful suit and the bride a **dress** with train)*	Turk turk	durk
Vlinders vang je met een vang **net** in de tuin *(you catch butterflies with a **net** in the garden)*	vet fat	fet
Toen Armstrong op de maan landde plaatste hij de Amerikaanse **vlag** in de grond *(when Armstrong landed on the moon he planted the American **flag**)*	dag day	kag
De jager gebruikte pijl en **boog** om te schieten *(the hunter used arrow and **bow** to shoot)*	toog bar	yoog
s Avonds gaan de kippen op **stok** om te slapen *(at night the chickens went to **roost**)*	gok guess	qok

De visser deed een worm aan een **haak** als aas *(the fisher put the worm on a **hook** as bait)*	kaak jaw	paak
De postbode bezorgt een **brief** en een pakket *(the mailman delivered a **letter** and a packet)*	dief thief	tief
Een koe en een geit geven **melk** waarmee je kaas kan maken *(a cow and a goat give **milk** and you can make chees with this)*	kelk goblet	velk
Aan het gezicht van Sinter Klaas groeit een lange witte **baard** en snor *(Sint Nicholas has a long white **beard** and a moustache)*	waard landlord	faard
De waarzegster keek in haar glazen **bol** naar de toekomst *(the fortune-teller looked in her crystal **ball** to see the furture)*	mol mole	xol
Als waarschuwing loste hij met zijn revolver een **schot** in de lucht *(as a warning he fired a **shot** in the air with his gun)*	bot bone	fot
Die oude boom heeft een hele dikke **stam** en is heel groot *(the old tree has a huge **trunk** and is very large)*	kam comb	zam
Een groene kwakende amfibie is een **kikker** of een pad *(a green quacking amphibian is a **frog** or a toad)*	tikker typist	vikker
Die bloemen staan in volle **bloei** in de tuin *(those flowers in the garden are in **bloom**)*	knoei mess	toei
Een vuurspuwend monster noemt men ook wel een **draak** in veel sprookjes *(the fire-spitting monster is also called a **dragon** and appears in a lot of fairy tales)*	haak hook	jaak
Om zijn nek te beschermen tegen de kou droeg hij een **sjaal** van wol *(to protect his neck from the cold he wore a woolen **scarf**)*	zaal room	jaal
Jong belegen Gouda is haar favoriete **kaas** naast brie *(new matured Gouda is her favoroute kind of **cheese** besides brie)*	haas hare	saas
Om te windsurfen gebruik je een surfplank met daarop een **zeil** voor de wind *(to windsurf you use a board on which there is a **sail** for the wind)*	peil level	jeil
Ga maar sleeën, er ligt genoeg **sneeuw** op de helling *(go on sledging, there is enough **snow** on the hill)*	meeuw gull	beeuw
Na de vaat zette hij de schone borden in de **kast** boven de oven *(after doing the dishes he put the clean plates in the **cupboard** above the oven)*	gast guest	nast

In Nederland rijdt de koningin in de gouden **koets** op prinsjesdag *(in the Netherlands the Queen rides in a golden **coach** on day of the Queen's)*	poets trick	foets
Het was druk in de winkel er stond een lange rij aan de **kassa** te wachten *(it was very crowded in the store there was a long line at the **cashpoint**)*	massa mass	fassa
Ik maak een scheiding in mijn haar met een **kam** en wat gel *(I make a parting in my hair with a **comb** and some hairproduct)*	ram ram	zam
Om even te rusten staat er in het park een houten **bank** en een tafel *(to take a rest there is a wooden **bench** and table in the park)*	dank thanks	nank
Hij plukte alleen maar bramen van die ene volle **struik** en at ze op *(he picked only berries from that one full **bush** and he ate them)*	pruik wig	wuik
Het hoofd van het katholieke geloof is de **paus** in het Vaticaan *(the head of the Catolic religion is the **pope** in Vatican city)*	saus sauce	laus
De scouts gaan iedere zomer op **kamp** in de natuur *(the boyscouts go on a summer **camp** in the nature)*	damp steam	gamp
Bij een huwelijk belooft men elkaar eeuwige **trouw** tot aan de dood *(in a wedding people promise eachother eternal **fidelity** till death)*	bouw building	xouw
Een kaalhoofdige roofvogel soort die restanten van prooien eet is de aas **gier** en leeft in droge gebieden *(a bold headed animal that lives from remains of preys is the **vulture** and lives in dry areas)*	kier slit	xier
In 1993 besteeg koning Albert de **troon** van België *(in 1993 king Albert ascended the **throne**)*	boon bean	poon
De krant rolt vers van de **pers** op dit moment *(the paper is hot of the **press**)*	kers cherry	lers
Ken je de fabel van Reynaert de **vos** uit je hoofd *(do you know the fable of Reynard the **fox** by heart)*	mos moss	wos
Ik ga naar de groente boer voor een krop **sla** en wat wortels *(I will go to the greengrocer for a head of **lettuce** and some carrots)*	ra yard	ca
De humo is mijn favoriete week **blad** ik lees het altijd *(the humo is my favourite weekly **magazin** I always read it)*	pad path	tad

Ik was me altijd met water en **zeep** aan de wastafel *(I wash myself with some water and **soap** at the sink)*	reep strip	veep
Als je klaar bent met eten leg je mes en vork op het **bord** naast elkaar *(when you are done eating put your knife and fork next to your **plate**)*	fort fort	rord
Hij hakte de boom om met een grote **bijl** zonder te stoppen *(he chopped the tree with a large **axe** without taking a break)*	pijl arrow	lijl
Een studenten kamer noemt men ook wel een **kot** in het Vlaams *(a students room is also called a **digs** in English*	lot ticket	wot
Een achtpotig insect waar veel mensen bang voor zijn is de **spin** met lange haren *(an eight legged insect for which a lot of people are afraid is the **spider** with long hairs)*	kin chin	rin
De gepassioneerde jongen stond in vuur en **vlam** voor het meisje *(the passionated boy was on fire for his the girl)*	dam dam	zam
Hij knipte het papier met een **schaar** in stukken *(he cut the paper with a pair **scissors**)*	haar hair	taar
Trivial pursuit is een gezelschap **spel** dat lang duurt *(trivial pursiot is a party **game** that can take a while)*	vel skin	kel
Als je iemand begroet schud je zijn **hand** en zeg je hallo *(when you meet someone you shake his **hand** and say hello)*	band tire	nand
De piraten vonden op het onbewoonde eiland een grote **schat** in een grot *(the pirates found on the desert island a huge **treasure** in a cave)*	kat cat	yat
In de zomer schijnt de **zon** vaak fel *(during the summer the **sun** is often shining)*	ton barrel	lon
Johan snuit zijn **neus** in een zakdoek *(Johan blows his **nose** in a handkerchief)*	keus choice	feus
Een roze vis die veel gegeten wordt is de **zalm** uit Schotland *(a pink fish that is eaten a lot is the **salmon** form Scotland)*	palm palm	valm
Roodkapje werd opgegeten door een boze **wolf** die uit het bos kwam *(little red riding hood is being eaten by an angry **wolf** who came out of the wood)*	kolf butt	holf
Tonijn is een **vis** uit de zee *(tuna is a **fish** from the sea)*	mis Mass	kis

Een leraar staat voor de **klas** les te geven *(the teacher is in front of the **class** teaching)*	pas step	has
Om bovenaan de piste te komen moet je een pas kopen voor de ski **lift** in dat hokje *(to get at the beginning of the piste you have to by a ticket for the ski lift at that cabbin)*	gift gift	pift
Voor het begin van de vossen jacht blies de jager op de jacht **hoorn** volgens de traditie *(before the start of the hunting on the foxes the hunter blew his **horn** tradiotionally)*	doorn thorne	goorn
We moeten nog parket leggen op de betonnen **vloer** en nog verven *(we have to lay the parquet on the concrete **floor** and then we have to paint)*	toer trip	zoer
Alvorens hem te begraven legt men een dode in een **kist** van hout *(before burying the death corps is put in a **coffin** of wood)*	list trick	jist
Het zwembad nodigt uit tot een frisse **duik** in het water *(the pook is inviting for a fresh **dive** in the water)*	buik belly	tuik
Een stekel op de stengel van een roos heet een **doorn** en is scherp *(a prickle on the stalk of a rose is called a **thorn** and is sharp)*	hoorn horn	noorn