Article:
Gregory, E., Varley, R. and Herbert, R. (2012) Determiner Primes as Facilitators of Lexical Retrieval in English. Journal of Psycholinguistic Research, 41 (6). pp. 439-453. ISSN: 0090-6905

https://doi.org/10.1007/s10936-012-9207-5

Determiner Primes as Facilitators of Lexical Retrieval in English

Emma Gregory
Rosemary Varley
Ruth Herbert

Department of Human Communication Sciences
University of Sheffield
Claremont Crescent
Sheffield
S10 2TA

ABSTRACT

Gender priming studies have demonstrated facilitation of noun production following pre-activation of a target noun's grammatical gender. Findings provide support for models in which syntactic information relating to words is stored within the lexicon and activated during lexical retrieval. Priming effects are observed in the context of determiner plus noun phrase production. Few studies demonstrate gender priming effects in bare noun production (i.e., nouns in isolation). We investigated the effects of English determiner primes on bare mass and count noun production. In two experiments, participants named pictures after exposure to primes involving congruent, incongruent and neutral determiners. Facilitation of noun production by congruent and neutral determiner primes was found in both experiments. The results suggest that noun phrase syntax is activated in lexical retrieval, even when not explicitly required for production. Post hoc analysis of the relative frequency of congruent and incongruent prime-target pairs provides support for a frequency-based interpretation of the data.

Keywords

Spoken word production; Priming; Determiner; Syntax; Noun phrase; Frequency

Introduction

Research in language production has explored the degree to which syntactic information influences spoken word production (e.g., Alario et al., 2004; Bates et al., 1996; Federmeier & Bates, 1997; Jacobsen, 1999; Jescheniak, 1999; La Heij et al., 1998; Schriefers, 1993). A number of theories propose an obligatory role for syntax, prior to activation of word forms (e.g., Levelt et al., 1999; Dell et al., 1997; Dell et al., 1999; Goldrick & Rapp, 2002; Rapp & Goldrick, 2006). The intermediary syntactic level has been termed the lemma (Kempen & Huijbers, 1983; Levelt et al., 1999) or word (Dell et al., 1997; Dell et al., 1999) level. These two-stage accounts propose that syntactic information linked to single words is represented within the lexical architecture. Evidence for this claim comes from three main sources. Studies of speech errors in healthy and impaired speakers have found preservation of grammatical gender in errors (e.g., Berg, 1992; Kulke & Blanken, 2001; Marx, 1999; Vinson & Vigliocco, 1999). A number of experiments have found facilitatory effects of syntactic primes on naming latencies in healthy speakers (e.g., Jacobsen, 1999; La Heij et al., 1998; Schriefers, 1993; van Berkum, 1997). Finally, single case studies of aphasic speakers have found retained knowledge of syntactic properties of nouns when the phonological form was not available and facilitatory effects of syntax on noun production (e.g., Bachoud-Lévi, & Dupoux, 2003; Badecker et al., 1995; Henaff Gonon et al., 1989; Herbert & Best, 2005; 2010; Macoir & Béland, 2004; Scarna & Ellis, 2002; Vigliocco et al., 1999). Furthermore, a small number of Event Related Potentials (ERP) studies suggest independence and serial processing of lexical-syntactic and phonological information (e.g., van Turennout et al., 1997; 1998; 1999).

Gender Priming

Grammatical gender is a syntactic property of the noun in most languages. For some nouns it can be predicted from natural gender (French: woman – la *(fem.)* femme) or from phonological form (e.g., nouns ending in *-a* in Italian are usually feminine). However, in many instances grammatical gender is arbitrary and must be learned with the noun form. Grammatical gender governs both determiner selection and the form of other lexical items such as adjectives and verb particles. Levelt et al. (1999) view grammatical gender as a lexical-syntactic property which is represented at the lemma level. Gender priming experiments investigate the influence of the syntactic information in a prime such as a determiner or a gender marked adjective on subsequent noun processing. A prime is presented and the effect on the accuracy and naming latencies of a target word is determined. Congruent primes are expected to facilitate production, while incongruent primes may inhibit production. Control conditions used in these experiments may include a determiner which does not mark grammatical gender, e.g., the plural form *les* in French, or a carrier phrase, e.g., *Please say now*.

Several studies have found facilitatory effects of gender congruent primes and inhibitory effects of incongruent primes on noun production (e.g., Bentrovato et al., 1999; Jacobsen, 1999; La Heij et al., 1998; Schriefers, 1993; Vigliocco et al., 2002). Inhibition is viewed as resulting from a post-lexical checking mechanism in which it takes time to resolve the conflict between the prime and the target (Friederici & Jacobsen, 1999). Facilitatory effects are interpreted as evidence of activation of syntax in noun retrieval. In terms of the Levelt et al. (1999) model of spoken word production, the effect is explained by increased

activation of the lemma node for a given target noun. Levelt et al propose that nouns of the same grammatical gender are linked to a corresponding gender node. Exposure to a prime containing gender information, e.g., the feminine noun *bouteille* in French, results in activation of the corresponding gender node and subsequently activation spreads to other noun lemmas of the same gender, i.e., feminine noun lemmas, increasing their activation levels. Alario et al. (2004) suggest that increased activation of gender-matched nouns constrains lexical selection by significantly reducing the set of co-activated nouns to those of feminine gender.

Most evidence of gender priming comes from experiments where the noun was produced in a context demanding explicit surface marking of gender, for example, in a determiner plus noun phrase or in computing adjectival agreement (La Heij et al, 1998; Levelt et al., 1999; Roelofs, 2000; Schriefers, 1993). However, there is less evidence of priming in bare noun production. A small number of studies have demonstrated facilitatory effects of gender primes on bare noun production (e.g., Alario et al., 2004; Cubelli et al., 2005; Jacobsen, 1999). These findings suggest that lexical-syntactic information is activated and selected in fast automatic retrieval of the lexeme, even when that information is not explicitly required. Gender priming effects observed in bare noun production are accounted for by the assumption of bi-directional flow between gender and lexical nodes (Alario et al., 2004).

Noun Phrase Priming in English

Priming studies exploring the effects of exposure to syntactic information on spoken word production have thus far focused primarily on manipulating grammatical gender information. The influence of other aspects of lemma level lexical-syntax on noun production has received less attention. English does not mark grammatical gender. Syntactic distinctions are, however, made between count and mass nouns. These distinctions have been manipulated in a number studies (e.g., Biedermann et al., 2008; Gillon et al., 1999; Herbert & Best, 2005, 2010; Mondini et al., 2004; Semenza et al., 1997; Taler & Jarema, 2007; Vigliocco et al., 1999). It has been questioned whether information which differentiates mass and count nouns is primarily conceptual (e.g., Jackendoff, 1991; Middleton et al., 2004) or syntactic (Vigliocco et al., 1999; Warrington & Crutch, 2005). In some languages, including English, mass nouns represent measurable entities (e.g., substances) which in combination make more of the same, whilst count nouns are discrete, countable entities (e.g., objects). However, a conceptual system of classification is not comprehensive and becomes problematic when applied to certain semantic categories, e.g. abstract nouns such as *opinion* (count noun) and *knowledge* (mass noun). There is also significant cross-linguistic variability, for example, in Italian, objects appearing in bunches (e.g., hair) are count, and in Japanese all nouns are mass. Evidently the semantic distinction between mass and count nouns is neither consistent within or between languages. Such variability has been interpreted as support for the differentiation of mass and count nouns on syntactic grounds (e.g., Vigliocco et al., 1999). In English, syntactic rules govern the structure of noun phrases containing mass and count nouns. Singular count nouns combine with the definite article (e.g., the cat), the indefinite article (e.g., a cat), and with numerals and quantifiers that denumerate (e.g., each cat). Count nouns combine much less frequently with quantifiers that do not denumerate (e.g., *some cat) and then only to convey a very specific sense. Mass nouns combine with the definite article (e.g., the rice) and with

quantifiers that do not denumerate (e.g., some/little rice), but infrequently with the indefinite article (e.g., *a rice) and with quantifiers that denumerate (*one/each rice). Access to information relating to a noun's count or mass status has been explored in studies of tip of the tongue state (e.g., Biedermann et al., 2008). However, few investigations into online processing of this lexical-syntactic property in healthy speakers have been conducted.

In a two-stage model (e.g., Levelt et al., 1999), the count or mass status of a noun is specified at the lemma level. Similar to grammatical gender, nouns which share this syntactic property (count or mass) will link to corresponding lexical-syntactic nodes. Effects similar to those observed in gender priming experiments are likely to be shown for count and mass nouns in a primed picture naming paradigm. Provision of a congruent count/mass determiner prime will facilitate noun production. In naming a picture of the count noun *spoon* a set of relevant lexical terms are activated (e.g., spoon, metal, eat, cutlery etc.). Provision of a congruent determiner prime, such as *each*, limits the set of activated words to count nouns. The same would be true for mass nouns. By limiting the number of activated words facilitation is achieved.

Research Aims and Hypotheses

We investigated the interaction between lexicon and syntax through two priming experiments, addressing the influence of lexical-syntax on bare noun production. The effects of determiner primes on speed and accuracy of production of mass and count nouns were explored. In Experiment 1, primes were syntactically congruent (count: *each*; mass: *some*), incongruent (count: *some*; mass: *each*) or neutral (*that*). A non-linguistic control prime which alerted participants to the subsequent stimulus (noise) was also included. Experiment 2 examined the effects of congruent, neutral and noise primes noun production.

Two-stage models of spoken word production predict that a prime containing congruent lexical-syntactic information, e.g., the count noun determiner, *each*, spreads activation to lemmas sharing the same count feature node, i.e., all count nouns, increasing the activation of the target count noun. Facilitation of noun production by congruent determiner primes, and inhibition from incongruent primes was predicted Alario et al. (2004), Jacobsen (1999) and Cubelli et al. (2005) found priming effects even in bare noun production, and in this study we explored whether this occurred in English.

Experiment 1

Experiment 1 investigated whether mass/count determiner primes facilitate word production in English.

Method

Participants

Participants were healthy native speakers of British English and had normal or corrected-to-normal vision. They were recruited via email distribution lists and adverts, and gave written informed consent to participate in the experiment. Ethical clearance for the

study was obtained from the Ethics Review Panel in the Department of Human Communication Sciences at The University of Sheffield.

In Experiment 1 there were 78 participants, 40 undergraduate students with an average age of 25 years (standard deviation: 4.8; range: 18 to 35), of whom 30 were female; and 38 older participants with an average age of 57.1 (standard deviation: 10.4; range: 40 to 80), of whom 28 were female. Studies exploring cognitive aging indicate differences in the speech and language production of older adults compared to younger controls (e.g., Brown & Nix, 1996; Nicholas, Obler, Albert & Goodglass, 1985; Thomas, Fozard, & Waugh, 1977). The inclusion of the two age groups allowed exploration of possible age effects. Furthermore, in subsequent studies we investigated determiner priming in individuals with aphasia. Consequently, data from the older group provided control data for this population.

Materials

The materials consisted of a set of pictures, and pre-recorded auditory prime stimuli. The picture set consisted of 80 colour digital photographs, 40 depicting mass noun targets and 40 depicting count noun targets developed for a previous research study (Herbert & Best, 2005; 2010). The photographs depicted common objects or substances and excluded collective nouns, super-ordinate terms, compound nouns, and plurals. A complete list of the target words is provided in Appendix A. The mass and count noun sets were matched for imageability, concreteness, familiarity, age of acquisition, log CELEX frequency (Baayen et al., 1995), number of syllables, number of phonemes and number of letters. Naming agreement had been established in a previous study (95% or greater agreement with adult controls, *n* = 15, Herbert & Best, 2010).

The auditory prime stimuli consisted of three determiner primes, *each*, *some*, and *that* and a noise condition (Table 1). Determiners were single syllable words of two or three phonemes length and were of similar frequency. Determiners *some* and *each* had log frequencies of 3.23 and 2.71 respectively and determiner *that* had a log frequency of 3.58 (British National Corpus; Leech et al., 2001). The noise prime consisted of a pure tone at 150Hz embedded in a burst of Gaussian noise, created using the Praat computer programme (Boersma & Weenink, 2008). The determiner prime sound files were produced and recorded by one female native English speaker. Each determiner prime and noise consisted of a separate WAV file of 650ms duration.

Design

Each stimulus picture was presented with all four primes. Four lists of 80 items were generated, with each stimulus item appearing once in a list. There were 20 items from each prime condition (congruent, incongruent, neutral, noise) in a list. Equal numbers of mass and count items were present in each condition and in each list. Items in the four sets of 20 contained within each list were matched for imageability, concreteness, familiarity, age of acquisition, frequency, number of syllables and number of phonemes.

The order of presentation of the 80 items in each list was pseudo-randomised such that a maximum of three items in any one condition, and a maximum of three mass or count items, appeared consecutively. None of the primes appeared in three consecutive trials. The lists were also checked to ensure that a minimum of three items appeared between

semantically related or phonologically related items. Participants were presented with one of the four lists.

Apparatus

Picture stimuli were presented centred on a laptop screen. The digital images were all 102 x 76mm with a light grey background. Participants sat approximately 60cms from the screen. Auditory stimuli were presented via headphones with pre-set volume. Naming responses were recorded as WAV files via external microphone on a headset.

Automated measurement of speech onset time for each WAV file was implemented using the Praat program (Boersma & Weenink, 2008). Software developed by Cunningham (2008) processed each recording by extracting the intensity contour and determining the mean intensity. The mean intensity value was then used to determine a threshold value. The threshold value was typically 10% greater than the mean due to the presence of silent regions, generally at the beginning and end of each sound file. The signal was then searched for the first instance when the intensity value exceeded the threshold. This time point was then stored as the estimated onset for the response. The script also checked over a 50ms window after the estimated onset. If the average intensity in this window was less than the threshold value, then it was assumed the onset was incorrect, and the script continued searching. Visual inspection of the estimated onsets from a subset of 80 signals from five participants showed that these estimates reliably identified the onset of speech. Bivariate correlational analysis showed a positive correlation between visual inspection of sound files and the automatic method with a coefficient of $r = 0.998$, which was significant at $p<0.0005$.

Procedure

Testing took place in a quiet room and in a session lasting approximately 30 minutes. Participants saw a picture on the computer screen. The picture was preceded by one of four auditory stimuli dependent on the prime condition (see Table 1). There was zero delay between offset of the auditory stimulus and onset of the target picture. A sample trial is depicted in Figure 1. Participants were asked to name each picture as quickly as possible with the single best word that described the picture.

Insert Table 1 about here

Insert Figure 1 about here

Participants completed eight practice trials. The practice set contained equal numbers of mass and count nouns and all types of prime conditions.

Results

Responses were discarded if an incorrect name or no response occurred, or if the naming latency exceeded 3000ms. Eleven pictures elicited an error rate of 25% or over and were discarded from the analysis (see Appendix A for detail). Naming latencies which deviated from an item's or a participant's mean in each condition by +/- 2 standard deviations were replaced with item or participant mean +/- 2 standard deviations.

Naming latencies were subjected to 2 (noun type: count, mass) x 4 (condition: noise, congruent, neutral, incongruent) x 2 (age: younger, older) repeated measures ANOVAs, one by participants and one by items. *t*-tests were used for pair-wise comparisons. Mean naming latencies and error rates for each experimental condition collapsed over noun type and age are given in Table 2.

Insert Table 2 about here

A significant main effect of condition was found in both participant and item analyses ($F_1[3, 228] = 6.887$, $p < 0.0005$; $F_2[3, 201] = 7.534$, $p < 0.0005$). Five paired samples *t*-tests were carried out with the alpha level set at $p < 0.01$ (with Bonferroni correction). Mean naming latencies for the congruent condition were significantly shorter than the noise condition (34.5ms difference; $t_1[77] = 2.726$, $p = 0.008$; $t_2[68] = 3.213$, $p = 0.002$) and the incongruent condition for the item analysis (28.9ms difference; $t_2[68] = 3.384$, $p = 0.001$) but not the participant analysis ($t_1[77] = 2.252$, $p = 0.03$). These results indicated a significant congruency effect. Mean naming latencies were shorter in the neutral condition compared to the noise condition (46.9ms difference; $t_1[77] = 3.409$, $p = 0.001$; $t_2[68] = 4.081$, $p = 0.0005$) and the incongruent condition (41.4ms difference; $t_1[77] = 3.698$, $p = 0.0005$; $t_2[68] = 3.480$, $p = 0.001$). No significant differences were found between naming latencies in the congruent and neutral conditions ($t < 1$).

There was a significant main effect of noun type ($F_1[1, 76] = 284.799$, $p < 0.0005$; $F_2[1,67] = 16.173$, $p < 0.0005$) with shorter naming latencies for count (M=847.5ms) than for mass nouns (M= 968.4ms). There was no interaction between condition and noun type ($F_1[3,228] = 0.697$, $p = 0.555$; $F_2[3,201] = 1.317$, $p = 0.270$). There was a significant main effect of age ($F_1[1, 76] = 15.979$, $p < 0.0005$) with shorter naming latencies for younger (M=849.1ms) than older participants (M=966.8ms). There was no interaction between condition and age ($F[3,228] = 0.635$, $p = 0.593$).

Error rates for age groups and noun types were compared using independent samples *t*-tests and for condition using paired samples *t*-tests. Older adults produced significantly more naming errors (M= 1.3) than the younger adults (M= 0.8), $t[76] = 2.144$, $p = 0.035$. More errors were made to mass noun targets than count noun targets by both younger ($t[78] = 4.74$, $p < 0.0005$) and older adults ($t[74] = 3.287$, $p = 0.002$). Accuracy did not vary significantly across the four priming conditions (all *t*s<1).

Discussion

A priming effect of lexical-syntax on speed and accuracy of bare noun production was found. Compared to incongruent and noise conditions, neutral and congruent determiner primes facilitated production to a similar degree. No inhibitory or facilitatory effects were observed from incongruent primes. Noun type affected naming latency and error rate, with mass nouns named more slowly and less accurately than count nouns. Older participants were slower and less accurate in naming than younger participants. There was no interaction between noun type, age or condition.

Contrary to claims of Levelt and colleagues (e.g., Levelt et al., 1999; Roelofs, 1992), the data show a facilitation of bare noun production following determiner priming, indicating that noun phrase syntactic information is activated in lexical retrieval. The observed priming effects replicate the findings of Alario et al. (2004), Jacobsen (1999) and Cubelli et al. (2005) with regard to gender priming in French, German and Italian. The data support the notion of close integration of syntactic and lexical processing in retrieval of nouns.

We found no advantage for congruent over neutral determiners. This finding is at odds with two-stage processing accounts which predict speeded noun production when the prime pre-activates mass or count noun nodes at the lemma level. The results suggest that lexical retrieval is facilitated by exposure to any determiner that appropriately pairs with the target noun. No additional facilitation is achieved by mass or count congruent determiners. The hypothesis that such determiners eliminate a set of noun competitors was not supported.

The lack of inhibition from incongruent primes within this experiment is a novel finding which conflicts with gender priming studies (e.g., Jacobsen, 1999; Jescheniak, 1999). One explanation of the discrepant findings might lie in the different relationship between prime and stimulus in gender priming studies as compared to that in our investigation. Gender priming experiments use words whose co-occurrence is regular, in that pairing a noun with the wrong gender determiner represents a violation, not just an unusual occurrence. Pairings of determiners with nouns in English are only quasi-regular. Certain determiners occur with certain types of nouns more frequently than others, but there are no illegal co-occurrences. A speaker may use the less usual pairing depending upon the sense to be conveyed. For example, the incongruent determiner for count nouns (some) *can* combine with the noun type in question (e.g., it's just some dog barking), but speakers produce this combination less frequently than the noun with the congruent determiner. Thus 'incongruent' determiners, which combine less frequently with a particular noun, do not inhibit production. This will be discussed further in the General Discussion.

With regard to the lack of difference in priming from congruent and neutral determiners, a possible explanation for this effect may be that two of the determiners appeared in two conditions (*some* was mass noun-congruent and count noun-incongruent, and *each* was mass noun-incongruent and count noun-congruent). In contrast, the neutral determiner *that* appeared in one condition only. Exposed to either *some* or *each* participants could not predict whether the following noun would be congruent or incongruent. Such ambiguity did not occur after exposure to the neutral determiner. The lack of an advantage for the congruent condition over the neutral condition might therefore be an artefact of the experimental design. This is supported by Alario et al. (2004), who suggest that participants may employ task-specific strategies due to the presence of the incongruent condition, and Friederici & Jacobsen (1999) who propose that participants might attempt to match prime and target prior to responding. Therefore in Experiment 2 the incongruent condition was removed in order to explore the pattern of facilitation when prime-target relationships are unambiguous.

Experiment 2

Method

Participants

Forty-five students participated in the experiment (30 female). The average age for participants was 22.4 years (standard deviation: 4.9; range: 18 to 35). Participants were healthy native speakers of British English and had normal or corrected-to-normal vision. No participants had taken part in Experiment 1. The process of recruitment, obtaining informed consent and ethical clearance was as described in Experiment 1.

Materials, Design, and Procedure

The materials, apparatus and procedure were the same as those used in Experiment 1, with minor changes, as outlined below.

The same 80 target stimuli from Experiment 1 were used. Three prime stimuli conditions were used: noise, neutral and congruent. Each of the 80 target items appeared once in each condition. Three lists of 80 items were generated, and each target item appeared once in each list. Equal numbers of mass and count items appeared in every condition. Within each list all three types of prime appeared with 26 or 28 occurrences of each prime type.

Results

Data were prepared for analysis as in Experiment 1. Seven pictures elicited an error rate of 25% or over and were discarded from the analysis (see Appendix A for detail).

Naming latencies were subjected to 2 (noun type: count, mass) x 3 (condition: noise, congruent, neutral) repeated measures ANOVAs, one by participants and one by items. *t*-tests were used for pair-wise comparisons. Mean naming latencies and error rates for each experimental condition collapsed over noun type are given in Table 3.

Insert Table 3 about here

A significant main effect of condition was found in both participant and item analyses ($F_1[2, 88] = 9.297$, $p < 0.0005$; $F_2[2,142] = 5.679$, $p < 0.004$). Paired samples *t*-tests were carried out comparing all conditions with the alpha level set at $p < 0.02$ (Bonferroni correction). Naming latencies in the congruent condition were significantly shorter than for noise (34.1ms difference; $t_1[44] = 4.281$, $p < 0.0005$; $t_2[44] = 3.137$, $p < 0.003$). Naming latencies were also significantly shorter for the neutral conditions than for noise (34.6ms difference; $t_1[44] = 3.483$, $p = 0.001$; $t_2[44] = 2.757$ $p < 0.009$). Naming latencies between neutral and congruent conditions were not significantly different ($t_1[44] = 0.060$, $p = 0.952$; $t_2[44] = 0.867$ $p = 0.392$).

There was a significant main effect of noun type ($F_1[1, 44] = 126.057$, $p < 0.0005$; $F_2[1,71] = 11.053$, $p < 0.001$) with shorter naming latencies for count nouns than for mass nouns (90.7ms difference; $t_1[44] = 11.228$, $p < 0.0005$; $t_2[71] = 3.325$, $p = 0.001$).

Independent samples *t*-tests were carried out to compare the error rates for noun types. Participants produced more errors to mass noun targets (M= 2.3) than for count noun targets (M= 1.6) and this was significant ($t[45] = 2.167$, $p < 0.04$). Accuracy did not vary significantly across the four different conditions (all *t*s>1).

Discussion

We found similar determiner priming effects across Experiments 1 and 2. A significant priming effect was observed for both neutral and congruent determiners compared to noise. There was no advantage for congruent determiners compared to neutral determiners. The results of Experiment 2 indicated that differential demands in processing the primes or task-specific strategies could not account for similarity in priming across congruent and neutral conditions. These results support claims that strong associations exist between syntactic and lexical elements of the noun phrase, e.g., between determiners and nouns. However, the data do not support accounts which predict constraint of lexical selection due to spreading activation from count or mass nodes to lexical nodes.

There is an alternative explanation for the observed effects which is based on frequency of co-occurrence of the determiner and noun pairs. The determiners we used were matched for individual word factors including frequency and length, and the count and mass noun sets were matched for a range of relevant variables. However, there may be differences in the frequency of the collocations of determiners and nouns, with *some milk* occurring more frequently than *each milk or that milk*. An interpretation of the data which considers the relative strength of priming in relation to frequency of co-occurrence warrants consideration. Post hoc analyses were carried out to compare frequency values for the paired words for each condition. The same set of determiners and nouns were used in both Experiments 1 and 2, therefore the following analyses relate to both experiments.

British National Corpus (BNC) database (British National Corpus, 2007) values for each pair were obtained. For each condition 80 frequency values were derived. Mean values and standard deviations for each condition were: neutral 23.48 (44.9), congruent 21.36 (42.5), incongruent 1.18 (1.9). One-way related ANOVA was significant ($F(2,79) = 13.53$, $p<0.0005$). Pairwise comparisons revealed that the incongruent condition values were significantly less frequent than the other two conditions (congruent vs incongruent, $t(79) = 4.27$, $p< 0.0005$; neutral vs incongruent, $t(79) = 4.52$, $p<0.0005$). Neutral and congruent did not differ significantly, $t(79) = 0.47$, $p=0.64$, n.s.

The frequency analysis mirrors the findings from the reaction time analysis. The congruent and neutral conditions differ from the incongruent condition in terms of both reaction times and frequency of co-occurrence of the prime-target pairs. These data provide a possible alternative explanation for the findings in our experiments. We propose that the effects seen here and in previous studies are attributable to frequency of co-occurrence and may not be due to priming of syntactic representations or structures.

General Discussion

In two related experiments we explored the effects of determiner primes on naming latencies for bare noun production in healthy adults. The primes consisted of either noise, or determiners which were congruent, neutral or incongruent with target nouns. We found facilitation when participants were exposed to determiners which were congruent or neutral in relation to the target noun. There was no advantage for naming with congruent determiner primes when compared to neutral determiner primes. We found no inhibition from incongruent determiner primes.

Related findings include longer naming latencies and more errors for mass than count nouns, and longer naming latencies and more errors for older than younger adults. The finding that older adults were slower and less accurate at naming pictures is in line with previous research (Au et al., 1995; Bowles, 1994; Feyereisen et al., 1998; Thomas et al., 1977). Longer response latencies for mass nouns compared to count nouns has been found previously in lexical decision tasks (e.g., Gillon et al., 1999). However, such findings are not consistent across studies (e.g., Mondini et al., 2008). This study extends the finding of faster responses to count noun stimuli compared to mass noun stimuli to picture naming. These findings are not of direct relevance to the research and will not be discussed further.

The finding of priming effects in both experiments supports the claim that syntactic information is activated in bare noun production (Alario et al., 2004; Jacobsen, 1999; Cubelli et al., 2005). The majority of studies where gender priming was found involved production of explicitly marked grammatical agreement, for example, within a determiner + adjective + noun phrase (La Heij et al, 1998; Levelt et al., 1999; Roelofs, 2000; Schriefers, 1993). This has led many researchers to claim that syntax plays no or little part in production of bare nouns. In this regard, Levelt et al. (1999) state that syntax is activated but not selected. In terms of a two-stage model, our data provide support for the view that syntax is activated *and* selected in noun production regardless of whether it is required explicitly.

This study extends the scope of research into syntactic influences on noun production to another language (English) and to another syntactic relationship (mass and count). Whilst many studies have manipulated grammatical gender information within priming experiments, the effects of priming noun production with count and mass noun information have not been previously explored. In the case of gender, the relationship between determiners and nouns in gender-marked languages is unambiguous and regular. There are no instances where a noun in one gender would be paired with a determiner of the other gender. Priming effects can be expected, as strong links exist between the determiner and the noun. In English, the relationship between determiners and mass and count nouns is only quasi-regular. Consequently priming effects can be expected to be weaker. However, we found priming effects even with these quasi-regular pairings providing strong evidence for the role of syntax in production. Unlike the findings from gender priming studies, no inhibition from incongruent primes was found. Inhibition in priming experiments is a robust finding (Friederici & Jacobsen, 1999). However, the incongruent prime-target pairs in the current study were different from those used in gender priming studies in that they are not null occurrences but rare occurrences in natural language.

Contrary to our predictions, in both experiments we found no difference in priming between neutral and congruent determiners: both determiners which appropriately combined with the target noun facilitated lexical access. The finding of equal facilitation by congruent and neutral determiners does not support a model in which there is differential representation for mass and count nouns on the basis of their syntax. An alternative explanation is that of frequency of co-occurrence or collocation of the prime-target pairs. The frequency explanation has been previously considered in analysis of gender priming effects. In a speech perception study, Dahan et al. (2000) suggested that the influence of a gender marked prime on speed of noun recognition might be explained in terms of distributional regularities between the phonological forms of determiners and nouns. Alario et al. (2004) asked whether this interpretation could explain the gender priming effects they found in a series of picture naming experiments. They performed post-hoc analysis of the frequency of the individual determiner primes and found differential facilitation effects relating to determiner frequency, with faster naming to higher frequency primes. Although they did not investigate this they also proposed that frequency of co-occurrence may partially account for their findings.

Our post-hoc of analysis of frequency of co-occurrence of prime-target pairs mirrored the reaction time data. There was no significant difference in naming latencies for items in the congruent and neutral conditions and there was likewise no difference in the frequency of co-occurrence of these prime-target pairs. Naming latencies in the incongruent condition were significantly longer than in the congruent and neutral conditions, and the frequencies of the determiner and noun pairs were significantly lower in this condition. Determiners which are frequently produced together in a noun phrase with a given noun act as effective facilitators of production of the noun. Those which pair infrequently with a given noun do not facilitate its production. We propose that the amount of facilitation is commensurate with the frequency of the determiner-noun pairings. Further research including more determiner noun pairings with varying frequencies is indicated.

In light of our findings, and in line with the proposals of Dahan et al. (2000) and Alario et al. (2004), previously observed gender priming effects may be explained in terms of frequency of co-occurrence of prime and target form. Unfortunately few studies report frequency values for either the determiner primes or nouns so reanalysis of frequency of co-occurrence is not possible.

Summary

There has been a significant shift away from the idea that language subsystems operate independently (Goldberg, 1995; 2003; Jackendoff, 2007; Bates & Goodman, 1999). This study provides evidence that syntactic information influences bare noun production, and that determiners and nouns have a privileged relationship. We propose that syntax plays a crucial role in production even of bare nouns, but that frequency of occurrence of particular structures and the lexical items within them plays an equally significant role. More evidence of this is needed to support the claim.

References

Alario, F.-X., Matos, R. E., & Segui, J. (2004). Gender congruency effects in picture naming. *Acta Psychologica, 117,* 185–204.

Au, R., Joung, P., Nicholas, M., Obler, L.K., Kaas, R. & Albert, M.L. (1995). Naming ability across the adult life span. *Aging and Cognition, 2*(4), 300-311.

Bowles, N. L. (1994). Age and rate of activation in semantic memory. *Psychology and Aging*, *9*, 414–429.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). The CELEX lexical database (CD-ROM), Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA.

Bachoud-Lévi, A.-C., & Dupoux, E. (2003). An influence of syntactic and semantic variables on word form retrieval. *Cognitive Neuropsychology*, *20*(2), 163-188.

Badecker, W., Miozzo, M., & Zanuttini, R. (1995). The 2-stage model of lexical retrieval - evidence from a case of anomia with selective preservation of grammatical gender. *Cognition, 57*(2), 193-216.

Bates, E., Devescovi, A., & Hernandez, A. & Pizzamiglio, L. (1996). Gender priming in Italian. *Perception and Psychophysics*, *58*(7), 992-1004.

Bates, E., & Goodman, J. (1997). On the inseparability of grammar and the lexicon: Evidence from acquisition, aphasia and real-time processing. In G. Altmann (Ed.), Special issue on the lexicon, *Language and Cognitive Processes, 12*(5/6), 507-586.

Bentrovato, S., Devescovi, A., D'Amico, S., & Bates, E. (1999). Effect of grammatical gender and semantic context on lexical access in Italian. *Journal of Psycholinguistic Research, 28*(6), 677-693.

Berg, T. (1992). Prelexical and postlexical features in language production. *Applied Psycholinguistics, 13*(2), 199-235.

Biedermann, B., Ruh, N., Nickels, L., & Coltheart, M. (2008). Information retrieval in tip of the tongue states: New data and methodological advances. *Journal of Psycholinguistic Research, 37*(3), 171-198.

Boersma, P. & Weenink, D. (2008). Praat: doing phonetics by computer (Version 5.0.26) [Computer program]. Last retrieved 24 June 2008, from http://www.praat.org/.

The British National Corpus, version 3 (BNC XML Edition) (2007). Distributed by Oxford University Computing Services on behalf of the BNC Consortium. URL: http://www.natcorp.ox.ac.uk/

Brown, A. S., & Nix, L. A. (1996). Age-related changes in the tip-of-the-tongue experience. *American Journal of Psychology, 109*(1), 79–91.

Cubelli, R., Lotto, L., Paolieri, D., Girelli, M., & Job, R. (2005). Grammatical gender is selected in bare noun production: Evidence from the picture-word interference paradigm. *Journal of Memory and Language, 53*, 42-59.

Cunningham, S. (2008). Measurement of speech onset. Unpublished, personal communication.

Dahan, D., Swingley, D., Tanenhaus, M. K., & Magnuson, J. S. (2000). Linguistic gender and spoken-word recognition in French. *Journal of Memory and Language, 42*, 465-480.

Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review, 104*(4), 801-838.

Dell, G. S., Chang, F., & Griffin, Z. M. (1999). Connectionist models of language production: Lexical access and grammatical encoding. *Cognitive Science*, *23*(4), 517-542.

Federmeier, K.D., & Bates, E. (1997). Contexts that pack a punch: Lexical class priming of picture naming. *Center for Research in Language Newsletter*, *11*(2)*.* La Jolla: University of California, San Diego.

Feyereisen, P., Demaeght, N., & Samson, D. (1998). Why do picture naming latencies increase with age: General slowing, greater sensitivity to interference, or task-specific deficits? *Experimental Aging Research, 24*, 21–47.

Friederici, A.D., & Jacobsen, T. (1999). Processing grammatical gender during language comprehension. *Journal of Psycholinguistic Research, 28*(5), 467-484.

Gillon, B., Kehayia, E., & Taler, V. (1999). The mass/count distinction: Evidence from on-line psycholinguistic performance. *Brain & Language, 68,* 205-211.

Goldberg, A.E. (1995). *Constructions: A construction grammar approach to argument structure.* Chicago: University of Chicago Press.

Goldberg, A. E. (2003). Constructions: a new theoretical approach to language. *TRENDS in Cognitive Sciences, 7*(5), 219-224.

Goldrick*,* M. & Rapp*,* B. (2002). A restricted interaction account (RIA) of spoken word production: The best of both worlds. *Aphasiology, 16*, 20-55.

Henaff Gonon, M., Bruckert, R., & Michel, F. (1989). Lexicalisation in an anomic patient. *Neuropsychologia, 27*, 391-407.

Herbert, R. & Best, W. (2005). A deficit in noun syntax representations in aphasia. *Brain and Language, 95*(1), 94-95.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex, 46,* 329-342.

Jacobsen, T. (1999). Effects of grammatical gender on picture and word naming: Evidence from German*. Journal of Psycholinguistic Research, 28(*5), 499-514.

Jackendoff, R. (1991). Parts and boundaries. In B. Levin & S. Pinker (Eds.) *Lexical and conceptual semantics*, Blackwell, Oxford.

Jackendoff, R. (2007). A parallel architecture perspective on language processing. *Brain Research, 1146*, 2-22.

Jescheniak, J. D. (1999). Gender priming in picture naming: Modality and baseline effects. *Journal of Psycholinguistic Research, 28*(6), 729-737.

Kempen, G., & Huijbers, P. (1983). The lexicalisation process in sentence production and naming: Indirect election of words. *Cognition, 14*, 185-209.

Kulke, F., & Blanken, G. (2001). Phonological and syntactic influences on semantic misnamings in aphasia. *Aphasiology, 15*(1), 3-15.

La Heij, W., Mark, P., Sander, J., & Willeboorsde, E. (1998). The gender-congruency effect in picture word task. *Psychological Research, 61*, 209–219.

Leech, G., Rayson, P., & Wilson, A. (2001). *Word frequencies in written and spoken English based on the British National Corpus*. Longman; London.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22*(1), 1-75.

Macoir, J., & Beland, R. (2004). Knowing its gender without knowing its name: Differential access to lexical information in a jargonaphasic patient. *Neurocase, 10*(6), 471-482.

Marx, E. (1999). Gender processing in speech production: Evidence from German speech errors. *Journal of Psycholinguistic Research, 28*(6), 601-621.

Middleton, E. L., Wisniewski, E. J., Trindel, K. A., & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language, 50*(4), 371-394.

Mondini, S., Jarema, G., & Liguori, F. (2004). Semantic and syntax of mass and count nouns: data from aphasia and dementia. *Brain and Language, 91*, 138-139.

Mondini, S., Angrilli, A., Bisiacchi, P., Spironelli, C., Marinelli, K., & Semenza, C. (2008). Mass and count nouns activate different brain regions: an ERP study on early components. *Neuroscience Letters, 430*, 48–53.

Nicholas, M., Obler, L., Albert, M., & Goodglass, H. (1985). Lexical retrieval in healthy aging. *Cortex*, *21*, 595–606.

Rapp, B., & Goldrick, M. (2006). Speaking words: Contributions of cognitive neuropsychological research. *Cognitive Neuropsychology, 23*, 39-73.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition, 42*(1-3), 107-142.

Roelofs, A. (2000). Weaver ++ and other computational models of lemma retrieval and word-form encoding. In L. Wheeldon (Ed.), *Aspects of language production* (pp. 71-114). Birmingham, UK: Psychology Press.

Scarna, A., & Ellis, A. W. (2002). On the assessment of grammatical gender knowledge in aphasia: The danger of relying on explicit, meta-linguistic tasks. *Language and Cognitive Processes, 17*(2), 185-201.

Schriefers, H. (1993). Syntactic processes in the production of noun phrases. *Journal of Experimental Psychology-Learning Memory and Cognition, 19*(4), 841-850.

Semenza, C., Mondini, S., & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Taler, V. & Jarema, G. (2007). Lexical access in younger and older adults: the case of the mass/count distinction. Canadian *Journal of Experimental* Psychology, *61*(1), 21-34.

Thomas, J. C., Fozard, J. L., & Waugh, N. C. (1977). Age-related differences in naming latency. *American Journal of Psychology, 90*, 499–509.

van Berkum, J. J. A. (1997). Syntactic processes in speech production: The retrieval of grammatical gender. *Cognition, 64*, 115-152.

van Turennout, M., Hagoort, P., & Brown, C. M. (1997). Electrophysiological evidence on the time course of semantic and phonological processes in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 787-806.

van Turennout, M., Hagoort, P., & Brown, C. M. (1998). Brain activity during speaking: From syntax to phonology in 40 milliseconds. *Science, 280,* 572-574.

van Turennout, M., Hagoort, P., & Brown, C. (1999). The time course of grammatical and phonological processing during speaking: Evidence from event-related brain potentials. *Journal of Psycholinguistic Research, 28*(6), 649-676.

Vigliocco, G., Vinson, D. P., Martin, R. C., & Garrett, M. F. (1999). Is "count" and "mass" information available when the noun is not? An investigation of tip of the tongue states and anomia. *Journal of Memory and Language, 40*(4), 534-558.

Vigliocco, G., Lauer, M., Damian, M. F., & Levelt, W. J. M. (2002). Semantic and syntactic forces in noun phrase production. *Journal of Experimental Psychology: Human Perception and Performance, 28*, 46-58.

Vinson, D. P., & Vigliocco, G. (1999). Can independence be observed in a dependent system? *Brain and Language, 68*, 118-126.

Warrington, E.K. & Crutch, S.J. (2005). The semantic organisation of mass nouns and the representational locus of the mass/count distinction. *Brain and Language, 95*, 90-91.

Table 1. Prime Stimuli Conditions for Target Items.

	Mass noun target	Count noun target
Noise (xxxx)	xxxx	xxxx
Neutral determiner	that	that
Congruent determiner	some	each
Incongruent determiner	each	some

Table 2. Mean Naming Latencies (in ms), Mean Error Rates by Condition and Difference Between Noise and Prime (in ms).

Prime condition	M	SE	Error rate %	Noise/prime difference
Noise	929.7	19	0.9	0
Neutral	882.8	14.4	1.2	-46.9
Congruent	895.2	15.4	1.0	-34.5
Incongruent	924.1	16.8	1.1	-5.6

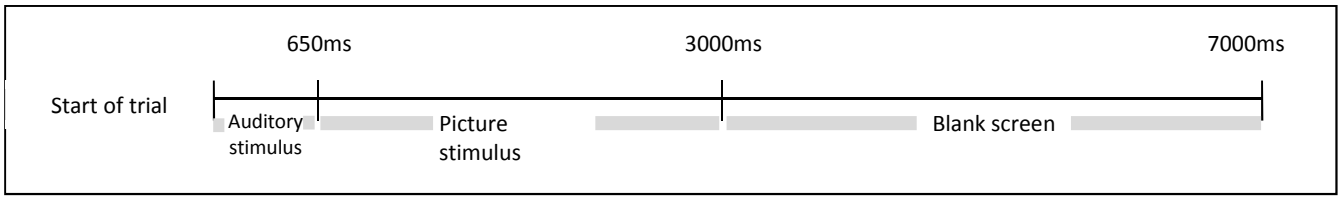
M = mean, SE = standard error. Noise/prime difference = mean noise naming latency - mean naming latency for each of the other primes.

Table 3. Mean Naming Latencies (in ms) and Mean Error Rates by Condition and Difference Between Noise and Prime (in ms).

Prime condition	M	SE	Error rate %	Noise/prime difference
Noise	878.8	22.8	1.2	0
Neutral	844.2	19.9	1.3	-34.6
Congruent	844.7	19.3	1.4	-34.1

M = mean, SE = standard error. Noise/prime difference = mean noise naming latency - mean naming latency for each of the other primes.

Figure 1. A sample trial in the picture naming task for Experiment 1.



Appendix A

Experimental targets (n = 80)

Count nouns		Mass nouns	
aerial	hedge^	asparagus	lightning
ankle*	hose	bark^	meat
arm*	jacket*^	beer	milk
axe	kite	blossom*	money
belt	label*^	bread	oil
bench	net	butter	paint
bike	nose	chocolate	paper
book	pencil	coal	rice
bowl	pocket*	coffee	smoke*
bubble	potato	cotton*^	soap
bulb	radio	cream	soup
candle	ring	garlic	steam
carrot	sandwich	ginger*^	string
coat*	shoulder	grass	sugar
door	sleeve*	honey	tea
egg	tank	ice	toast
flag	tent	ink	tobacco
fountain	tie	jam	water
glove	tractor	jelly	wine
hammer	window	lace^	wool

* items discarded from analysis in Experiment 1

^ items discarded from analysis in Experiment 2