Is Structural Priming Sensitive to the Phrase-Clause Distinction?
Concealed Question NPs versus Embedded Interrogatives and Declaratives

Gözde Bahadır (gozde@ii.metu.edu.tr)
Department of Cognitive Science, Informatics Institute,
Middle East Technical University, 06800 Ankara TURKEY

Maria Polinsky (polinsky@fas.harvard.edu)
Department of Linguistics, 318 Boylston Hall, Harvard University,
Cambridge, MA 02138 USA

Abstract
Structural priming (Bock, 1986) has become a fundamental phenomenon in psycholinguistics over the last few decades (Pickering & Ferreira, 2008). Still, the exact nature of the level of representation that it taps has yet to be fully understood (e.g. Pickering & Branigan, 1999). The present paper aims to further this understanding by investigating whether structural priming is sensitive to the linguistic distinction between phrases and clauses. To that end, we have tested structural priming in concealed questions (CQs) (Grimshaw, 1979; Heim, 1979). CQs are constructions that involve shifting the meaning of a functional NP to a question-like meaning. Although traditional views of this shifted meaning (e.g. Grimshaw, 1979) assume an interrogative interpretation for CQs, more recent proposals argue for a propositional interpretation (e.g. Nathan, 2006). Taking both views into consideration, we tested functional NPs in comparison with both embedded questions and embedded declaratives. Experiment 1 revealed how frequently each of these three structures appears as an argument of a matrix predicate. Experiments 2 and 3 tested priming in CQ NPs and embedded questions using a paper-based and an internet-based task, respectively. Experiment 4 tested CQ NPs and embedded declaratives in an internet-based task. The results suggest that structural priming is sensitive to the phrase-clause distinction when we compare NPs with embedded declaratives. There is also some priming for the NPs vs. embedded questions pair; however, this effect is significant only in the offline paper-based task, suggesting that the nature of the task might influence the observed effects. For embedded interrogatives, the effects of priming become visible only when the task makes it plausible. To conclude, priming seems to be sensitive to the phrase-clause distinction.

Keywords: structural priming; concealed questions; embedded declaratives; embedded interrogatives.

Introduction
Structural priming, also known as syntactic priming or persistence (Pickering & Branigan, 1999), has become a central and widely examined phenomenon in psycholinguistics in the past few decades (Pickering & Ferreira, 2008). The aim of the present paper is to find out whether structural priming is sensitive to the linguistic distinction between phrases and clauses. To this end, we examine constructions known as Concealed Questions (CQs). In this section, we provide a brief review of the structural priming paradigm and introduce CQs and the theoretical debate surrounding their analysis.

Structural Priming
Structural priming is the facilitating effect of a certain syntactic form (experienced through parsing or production) on the subsequent processing of the same form or of a similar structure (Bock, 1986; Pickering & Branigan, 1998; Pickering & Branigan, 1999; Pickering & Ferreira, 2008, among others).

In a pioneering study (Bock, 1986), participants were first asked to repeat one of two alternative sentences under the guise of a memory test. One alternate was an active sentence such as “One of the fans punched the referee”, and the other was its passive counterpart expressing the same truth-conditional meaning: “The referee was punched by one of the fans”. This was the priming phase. In the experimental phase, subjects were shown a semantically unrelated picture that could be described using either a passive or an active sentence, for example, a picture depicting a church being struck by lightning. The subjects tended to describe the picture by uttering the sentence “Lightning is striking the church” after having been exposed the active prime, and “The church is being struck by lightning” after having been to the passive prime. Thus, the participants’ production was primed by the syntactic structure they had previously processed. The same result holds for alternations involving ditransitive verbs, which take two objects. Such verbs can either take two unmarked objects, with the recipient expressed as a direct object (DO; e.g., give someone something), or a direct object and a prepositional object (PO) recipient (e.g., give something to someone).

Similar results have also been obtained using other methodologies. One such methodology is the written sentence completion task. In a study investigating structural priming in written language production (Pickering & Branigan, 1998), participants read and completed prime fragments which could accept either a passive or an active sentence, for example, a picture depicting a church being struck by lightning. The subjects tended to describe the picture by uttering the sentence “Lightning is striking the church” after having been exposed the active prime, and “The church is being struck by lightning” after having been to the passive prime. Thus, the participants’ production was primed by the syntactic structure they had previously processed. The same result holds for alternations involving ditransitive verbs, which take two objects. Such verbs can either take two unmarked objects, with the recipient expressed as a direct object (DO; e.g., give someone something), or a direct object and a prepositional object (PO) recipient (e.g., give something to someone).

In conclusion, structural priming is sensitive to the linguistic distinction between phrases and clauses. This sensitivity is not absolute, however, as the nature of the task might influence the observed effects. For embedded interrogatives, the effects of priming become visible only when the task makes it plausible. To conclude, priming seems to be sensitive to the phrase-clause distinction.
participants tended to produce another PO in the target; the same situation holds for the DO primes.

Despite the growing number of studies on structural priming, the exact nature of the level of representation that it accesses is still not fully understood (e.g. Pickering & Branigan 1999). The present study aims to contribute to this understanding by investigating whether structural priming is sensitive to the distinction between phrases and clauses. The traditional structural alternations used in priming studies, namely active-passive and PO-DO alternations, convey the same meaning with either clauses (active or passive sentences) or phrases (a prepositional phrase in PO and two noun phrases in DO). We propose to use two structures that also carry the same meaning, but one of them is syntactically a noun phrase and the other is a clause with an overt subject and a verbal predicate. Thus, these competing structures belong to different syntactic categories. The specific linguistic phenomenon that will enable us to test whether priming is sensitive to such a phrase-clause distinction is that of concealed questions.

Concealed Questions

Certain NPs in English and other languages are capable of acting as concealed questions (CQs below; e.g. Nathan, 2006). When a noun phrase appears as the object of certain embedding predicates, its meaning shifts from the meaning of a simple verbal argument (1a), referring to an individual, to a question-like meaning (1b); this meaning shift characterizes CQs (Grimshaw, 1979; Heim, 1979; Nathan, 2006, among others). For instance, the object NP in (1a) below can be roughly paraphrased using an embedded interrogative like in (1b).

1a. The committee announced [the winner of the award].
1b. The committee announced [who had won the award].

The NP that is used in (1a) can receive an individual-denoting interpretation when it occurs as the object of a different predicate (2) (e.g. Harris, Pylkännen, McElree & Frisson, 2008).

2. The committee praised [the winner of the award].

The difference in meaning between (1a) and (2) shows that the interpretation of the object NP as an individual vs. as a CQ depends on the governing verb. Only specific predicates such as guess that also take clausal arguments can enable the CQ-interpretation of NPs. In addition, not all nominals can act as CQs. Only relational or functional NPs, such as the winner of the award above can appear as CQs (Caponigro & Heller, 2007). To sum up, a question-like interpretation is only available with the right kinds of NPs and predicates.

Anaphora serves as a diagnostic to distinguish CQ NPs from individual-denoting NPs (Harris, et al., 2007; Romero, 2005): In English, the types of anaphora referring to CQ interpretations and individual interpretations are different. A noun which denotes a person is referred back to by an agreeing pronoun (he, she); CQs are referred back to by the neuter pronoun it or by the situational anaphor that, just like clausal complements.

Although these constructions have been traditionally called concealed “questions” (since they were considered to have the same denotation as plain embedded interrogatives (e.g. Grimshaw, 1979)), it has recently been proposed that they may instead behave more like embedded declarative “that-clauses” conveying the complete true answer to the question under discussion (Nathan, 2006; Romero, 2006). Hence, sentence (3) may be a more appropriate paraphrase of (1a).

3. The committee announced [that John/someone had won the award].

The idea here is that CQs can only be embedded under those verbs that allow both propositional and question complements. The theoretical debate is ongoing, and we will not review the alternative formal analyses here. Despite the abundance of semantic studies analyzing CQs, those examining it from a psycholinguistic perspective are rather scarce. An eye-tracking study (Harris, et al., 2008) has demonstrated that the processing of verbs taking CQ NP arguments imposes a higher processing load than the processing of regular NP argument-taking verbs. Supporting MEG data suggest further that the processing is taking place at the sentential and not the lexical level (Harris, et al., 2008).

The investigation of structural priming with CQs has never been done before. In the meantime, unlike the previously studied alternations, CQs offer novel insight in priming studies because they tap into those properties of priming that the other studies could not have revealed, by allowing us to study an alternation between a phrase and a clause.

The experiments presented below investigate structural priming in CQs; our goal is to understand whether priming is sensitive to the grammatical distinction between phrases and clauses; this in turn will shed new light on the level or levels of representation accessed by structural priming.

Experiment 1

Method

Participants

19 adult native English speakers volunteered to participate in the study.

Design and Materials

This preliminary study, which was designed to test the natural frequencies of co-occurrence of CQ NPs and overt embedded questions with certain matrix predicates, was an offline computer-based cloze test. Participants read sentence fragments that consisted of a subject NP and a matrix predicate, as in (4). The fragments could be completed with an NP (such as “their results”), an embedded interrogative (such as “what she had seen”) or an embedded declarative (“that the conditions were favorable”).
Procedure
The participants received an e-mail explaining the study. An instructional text file, an informed consent document and a 2-page electronic form containing the fragments were attached to this message. There was also a link to an online questionnaire asking for basic demographic information, language background, and digital reading/writing habits. The participants’ task was to complete the sentence fragments by typing in the first completions that came to mind. There were three empty boxes following each sentence fragment. The participants were asked to complete at least the first box, filling it in with at least one word. Completion of the second and third boxes with alternative endings was optional. After completing the task, the participants saved the file and sent it back to the experimenter via e-mail.

Results and Discussion
We coded the completions provided by the participants in the target fragment as “NP”, “Question”, “That-Clause”, “Omitted That Clause” and “Other” (e.g. “The student learned of the earthquake”). The count of these completion types provided their natural frequencies of co-occurrences with the 12 target verbs. Overall, most of the completions were embedded declaratives with the complementizer that (41.07%). In addition, there were embedded declaratives in which the complementizer that was omitted (2.38%). The proportion of NP completions was also quite high (33.93%). Embedded questions, on the other hand, were relatively infrequent (11.90%). The rest of the completions were of different types; we coded these completions as “Other” (10.71%). These proportions indicate the natural frequencies of co-occurrence of these types with the target verbs in a neutral context without any manipulation and therefore present a basis for the following studies.

Figure 1: Percentages of completion types in Experiment 1

Method
Participants
44 native English speakers were recruited to complete the pen-and-paper-based sentence completion task.

Design and Materials
This is a structural priming study from comprehension to production, which means that participants first read a prime sentence and then filled in an immediately following target sentence fragment. At issue is whether participants’ productions are influenced by the form of the preceding (prime) sentence. The prime sentences either contain a CQ NP (4a) or an overt embedded interrogative (4c). The target fragments contain only a subject NP and a verb that can take both CQ NPs and clauses as its argument (4b, d). If there is priming, then participants should provide more NP completions following “NP-Primes” and more embedded interrogative completions following “Question-Primes”.

4a. The police disclosed the identity of the assassin.
4b. The committee announced…………………………… .
4c. The officer disclosed who had assassinated the minister.
4d. The board announced…………………………… .

We used the same 12 matrix verbs as in Experiment 1. As we didn’t want participants to see the same verb 4 times during the task, we divided our main verbs into two sets of stimuli so that each verb appeared twice throughout the experiment. In both sets, half of the verbs appeared twice in prime sentences: once in an NP-Prime sentence and once in a Question-Prime sentence. The other half appeared twice in target fragments: once following an NP-Prime with a different verb and once following a Question-Prime. In the first set, the verbs disclose, find out, explain, figure out, report, and learn appeared in prime sentences and the verbs announce, determine, estimate, guess, discover, and predict appeared in the target fragments (e.g. 4a-d). In the second set, prime and target predicates reversed roles (e.g. 5a-d). Participants were randomly assigned to one of the two stimulus sets. 21 participants completed SET 1, and 23 participants completed SET 2.
5a. The committee announced the winner of the award.
5b. The police disclosed ...........................................
5c. The board announced who had won the prize.
5d. The officer disclosed ...........................................

In addition to the experimental prime-target pairs, there were also syntactically unrelated fillers. There were three fillers per prime-target pair. To make the fillers look similar to the prime-target pairs and thus ensure that the participants do not recognize the pattern of interest, half of the fillers were complete sentences and the other half were incomplete fragments to be completed by the participants.

The sentences were randomized for each participant according to the following criteria: there were three fillers (including at least one complete and one incomplete filler) between prime-target pairs. The last of these three fillers, i.e. the one immediately preceding the upcoming prime-target pair, was always a complete filler. There were five different prime-target pairs between each occurrence of the two pairs that contain the same matrix verb (e.g. between 4a,b and 4c,d). Also, consequent prime-target pairs alternated in argument type.

Each version of the stimulus set was thus comprised of 60 items: 6 NP Prime-Target pairs (12 items), 6 Question Prime-Target pairs (12 items), and 3 fillers per prime-target pairs (36 items).

Procedure
Participants were invited either to the Polinsky Language Sciences Lab or to the Harvard Decision Science Lab. They were given the instructions both orally and in writing. The instructions specified that they should read the sentences and fill in the blanks in the empty fragments however they wanted, as quickly as possible, using the first completion that came to mind. They were also asked to follow the given order, reading the sentences that were already complete.

Before starting the main task, participants were requested to fill out a questionnaire similar to the one in Experiment 1 and to read and sign the informed consent form. The sentence completion task consisted of 4 pages, each with 15 items. When they finished the task, participants handed in the completed forms to the experimenter.

Results and Discussion
We coded completions to the target fragments as “NP”, “Question”, “That-Clause”, “Omitted That Clause” and “Other”. The two stimulus sets were included in the analysis as the between subjects factor “SET”. The mixed ANOVA results indicate a significant main effect of Completion Type: $F(1,42)=32.082, p=.00, \eta_p^2=.433$. Irrespective of the condition, the count of NP-Completions is greater than that of Question-Completions (see Figure 2). In this regard, this finding is consistent with the results of Experiment 1.

There is also a significant two-way interaction between Prime Type and Completion Type: $F(1,42)=5.897, p<.05, \eta_p^2=.123$. Participants produced more NP-Completions after NP-Primes than after Question-Primes and more Question-Completions after Question-Primes than after NP-Primes. This suggests that despite the general high frequency of NPs, there seems to be priming in the alternation between CQ NPs and embedded questions, which is an indication that structural priming is sensitive to the phrase-clause distinction: Although the two forms are identical in meaning, we observe the differential effects described above. This means that at the level of representation accessed by structural priming, NPs and interrogative clauses must have been already differentiated.

Experiment 3

Method
Participants
Twenty native English speakers were recruited to complete the internet-based task through Amazon’s Mechanical Turk1.

Design and Materials
In Experiment 2, the participants were handed out printed booklets and asked to fill in the fragments by hand. In order to test whether the observed effects would persist in a computerized task, we ran the same experiment with a different methodology. This time, the same stimuli, prepared with the same design and randomization criteria, were presented to new participants in an internet-based task through Amazon’s Mechanical Turk.

Procedure
The participants, who were registered workers of Mechanical Turk, were informed about the study via the web site. When they started the task, they first read the instructions, which were similar to those in Experiment 2. They were then requested to fill in the online questionnaire. When they read the informed consent information and gave their consent by ticking a box, the experiment started. They read the first item, and when they finished reading they clicked on a box marked “Next” to call for the following item. If the item was an incomplete fragment, they completed it by typing in words. The sentences were presented, one by one, in black letters on a white background and the blank section to be completed by the participants was an empty text box below the fragment. All the items were presented in the middle of the screen in center alignment.

Results and Discussion
As before, we coded the completions as “NP”, “Question”, “That-Clause”, “Omitted That Clause” and “Other”. The two stimulus sets were again included in the analysis as the between subjects factor “SET”. The mixed ANOVA results indicate a significant main effect of Completion Type:

1 Amazon’s Mechanical Turk is a website for the exchange of tasks and work requiring human intelligence. It can be accessed at: https://www.mturk.com/mturk/welcome.
Results and Discussion

Completions were coded in a manner identical to the previous studies and the between subjects factor “SET” was also included in the analysis. The mixed ANOVA results revealed a marginally significant two-way interaction between Prime Type and Completion Type: $F(1,18)=4.286$, $p=.053$, $\eta_p^2=.192$. Participants produced more NP-Completions after NP-Primes than after That-Primes and more That-Completions after That-Primes than after NP-Primes. These results suggest the presence of priming effects in the alternation between CQ NPs and embedded declaratives with the complementizer that, which is another indication that structural priming could be sensitive to the phrase-clause distinction. This again shows that the structural difference between NPs and semantically identical declarative clauses is visible, at the level of representation activated by priming. This result is comparable to the results of Experiment 2, yet different from the results of Experiment 3. If we assume that the paper-based task is more sensitive to priming effects, as the comparison of Experiments 2 and 3 implies, then we can conclude that priming might be more persistent with declaratives than with interrogatives. We may also hypothesize that if Experiment 4 were re-run with the paper-based paradigm, we would get significant priming. This is an open question to be further investigated.

General Discussion

CQs, in which the truth-conditional meaning of a declarative or interrogative clause is expressed by an NP, provide a unique testing ground to investigate whether structural priming is sensitive to this sentential-phrasal distinction.

We will start with the less impressive results, namely the results of Experiment 3. Experiment 3 was an online task, and it revealed the prominence of NPs over embedded questions but no significant priming. When compared with Experiment 2, the internet-based task does not seem as sensitive to priming effects as the traditional typing-based paradigm. In the latter, the prime sentence may still be in the visual field of the reader, although not in the foveal position. Handwriting might also be more cognitively engaging than typing, even though all the participants were computer-literate. A full comparison of the methodologies is beyond the scope of the present paper, but overall it could be concluded that different methods can be sensitive to priming to different degrees.

Experiment 1 showed that the matrix predicates that we chose are indeed used with all the argument types in question. It provided us with a general distribution of these types produced in a neutral context with the target predicates. Overall, declarative that-clauses are the most frequent completions in this context. The proportion of NPs is very close but just a little smaller than the proportion of declaratives. Interrogatives, on the other hand, are relatively infrequent. These proportions should be kept in mind while interpreting the results of the consecutive experiments. Experiment 2 showed that the NPs are still more frequent than the interrogatives.

Experiment 4

Method

Participants
Twenty native English speakers were recruited to complete the internet-based task through Mechanical Turk.

Design and Materials
In this experiment the aim was to investigate priming in CQ NPs and embedded declaratives as opposed to interrogatives. Accordingly, the design and materials were identical to those in Experiment 3 except that all the embedded question primes were replaced with sentences containing that-clauses. For instance, sentences (4c) and (5c) were replaced with sentences (6) and (7) respectively.

6. The officer disclosed that the lunatic had assassinated the minister.
7. The board announced that the former president had won the prize.

Procedure
The procedure was identical to that of Experiment 3.
than interrogatives in a structural priming context. However, we also found a significant priming effect. Despite a general frequency disadvantage, Question-Primes prime Question-Completions. This is the first piece of evidence in support of the hypothesis that structural priming is sensitive to the difference between clausal and phrasal structures. The representations activated during priming must be encoded to register the difference between clausal and phrasal structures.

The second piece of evidence for the sensitivity of priming to the phrase-clause distinction comes from Experiment 4. For that-clauses, we get the priming effect even in the task that is supposedly less sensitive to such effects, namely online sentence completion. As a result, priming seems to be stronger for embedded declaratives than interrogatives. As suggested above, if the NP-declarative alternation is tested with the paper-based task and the same or even greater effect is observed, then it would be safe to reach more definitive conclusions.

Overall, the structural priming effects observed in the present study seem to be based on the interaction of semantic and syntactic structures, a conclusion compatible with previous literature on the influence of conceptual structure on structural priming (Griffin & Weinstein-Tull, 2003). Such an influence can be very subtle, but the crucial observation is that the differences in conceptual complexity can be reflected in the extent of priming.

These results also have implications for the processing and interpretation of CQs. The observation that significant priming effects are revealed for declaratives whereas only partial effects are found for interrogatives, provides indirect support for the question-like interpretation of CQs. Declaratives show priming in the online task and are thus clearly distinct from NPs, whereas interrogatives remain indistinguishable from NPs in the same task. When a that-clause is activated in the prime, the tendency to produce an NP in the target is overridden and that takes over. When a “question” prime is activated, it cannot always overcome the alternative NP. At some level the structural difference between embedded questions and NPs is overlooked. This might suggest that although both declaratives and questions carry a meaning similar to a CQ NP, at some level of representation the interrogative is closer to the CQ NP than the declarative.

Another noteworthy finding is that whenever we compare NPs with embedded interrogatives, most of the completions had the form of an NP. However, such NP supremacy was not observed when the alternatives to NPs were embedded declaratives. This reflects the frequency differences we had found between embedded declaratives and interrogatives, suggesting that frequency might have a considerable impact on our results. It will therefore be beneficial to design a corpus study to further investigate the frequencies of these types in natural language.

Taken together, the results of these four experiments indicate that structural priming seems to be sensitive to the distinction between phrases and clauses.

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