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

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Abstract
Structural priming (Bock, 1986) is known to tap into a level of syntactic representation that is shared with the production and comprehension systems (Branigan, Pickering & Cleland, 2000). However, the exact nature of this common level of representation has not been fully uncovered (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. There is a theoretical debate regarding this shifted meaning. Although traditional views (e.g. Grimshaw, 1979) assume an interrogative interpretation for CQs, more recent proposals argue for a propositional meaning (e.g. Nathan, 2006). To take both views into consideration, we tested functional NPs in comparison with both embedded questions and embedded declaratives. Experiment 1 revealed natural frequencies of co-occurrences of these types with a set of target predicates. Experiment 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; but this effect is significant only in the online paper-based task, suggesting that the nature of the task might influence the observed effects: For embedded interrogatives, the effects get 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 the following two sections, we will provide a brief review of the structural priming paradigm and will introduce CQs and the theoretical debate regarding 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 or a similar structure (Bock, 1986; Branigan, Pickering, Liversedge, Stewart & Urbach, 1995; 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 “The boat carried five people”, and the other was its passive counterpart expressing the same truth-conditional meaning: “Five people were carried by the boat”. This was the priming phase. In the experimental phase, the subjects were shown a semantically unrelated picture that could be described using either a passive or an active sentence, for instance: a picture depicting a boy awakened by an alarm clock. The subjects tended to describe the picture by uttering the sentence “The alarm clock awakened the boy” after having repeated the active prime, and “The boy was awakened by the alarm clock” after having repeated the passive prime in the previous phase. Thus, the participants’ production was primed by the syntactic alternative they had previously processed. The same result holds for prepositional object (PO)-double object (DO) alternations of ditransitive verbs.

Similar results have also been obtained in studies employing different 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 be completed with either a PO (e.g. “The messenger handed an unsigned note ……” or a DO (e.g. “The messenger handed the countess ……”). Then, in the target fragment they read a smaller portion of a sentence which could be completed with both structures (e.g. The head waiter gave ……”). Again, similar priming effects were observed; having completed a prime fragment with a PO, participants tended to produce another PO in the target although it was also
grammatically acceptable to use a DO. The same situation holds for the DO primes, as well.

Structural priming does not only happen during language production, but is also present in language comprehension and, more crucially, is observed between production and comprehension (e.g. Branigan, Pickering & Cleland, 2000). The fact that priming carries over from production to comprehension suggests that priming taps into a level of syntactic representation that is shared between the two systems (Branigan, et al., 1995; Branigan, Pickering & Cleland, 2000).

Despite the great 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, a clause with an overt subject and a verbal predicate. Thus, they 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 some other languages (e.g. Nathan, 2006) are capable of acting as concealed questions (CQs below). 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); such a shift is the essence of 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 same NP as used in (1a) can have the individual interpretation (2) as the object of a different predicate (e.g. Harris, Pylkännen, McElree & Frisson, 2008).

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

The difference 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 the NPs. In addition, not all nominals can act as CQs. Only relational NPs, like *the winner of the award* above, or functional NPs can appear as CQs (Caponigro & Heller, 2007). To sum up, the question-like interpretation is only available with the right kinds of NPs and predicates.

Anaphora serves as a diagnostic test to distinguish CQ NPs from individual-denoting NPs (Harris, et al., 2007; Romero, 2005): In English, the types of anaphora that refer to CQ interpretations and individual interpretations are different. A noun which denotes a person is referred back to by an agreeing pronoun (*he, she*); whereas 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 named 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, essentially a proposition (Nathan, 2006; Romero, 2006). Hence, sentence (3) may paraphrase (1a) better than (1b) does.

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 propositional complements as well as question complements. The theoretical debate is still 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 conclude 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 would be valuable in a priming study because they tap into those properties of priming that the other studies could not have revealed.

The experiments presented below investigate structural priming in CQs in order to understand whether priming is sensitive to the grammatical distinction between phrases and clauses.

**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 which 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”).

4. The observer reported ………………………………. 

Twelve target matrix predicates like the verb report were tested. In order to avoid making the task too long and demanding, we grouped these verbs into two sets of 6. The first set contained the verbs: explain, learn, find out, figure out, report, and disclose; and the second set contained the verbs: predict, estimate, determine, discover, announce, and guess. There were also 3 syntactically unrelated filler fragments between each experimental fragment. The items in both sets were randomized into four different orderings. As a result, each participant completed one of the six different versions each of which containing a total of 24 sentence fragments. At least one completion was required for each fragment and the participants were allowed to provide up to three completions per fragment, if they wished.

Procedure
The participants received an e-mail explaining the study. An instructional text file, the informed consent document and the 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” completions (e.g. “The student learned of the earthquake”). The count of these completion types provided their natural frequencies of occurrences with the 12 target verbs. Overall, most of the completions were embedded declaratives with the complementizer that (41.07%). In addition to this, there were also some 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 infrequent (11.90%). The rest of the completions were of different types that we coded together 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

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Experiment 2

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 fill in an immediately following incomplete target sentence fragment. We are interested in understanding whether participants’ productions are influenced by the form of the preceding (prime) sentence that they have just read. The prime sentences either contain a CQ NP (4a) or an overt embedded interrogative (4c). The target fragments only contain a subject NP and a verb that can take CQ NPs and clauses as its argument and the blanks for the participant to fill (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 the participants to see the same verb 4 times during the task, which would make it too long and cognitively demanding, 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, was the other way around (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 them look similar to the prime-target pairs and thus ensure that the participants do not recognize the present pattern, we designed half of the fillers as complete sentences and the other half as 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 one of these three fillers, i.e. the one immediately preceding the upcoming prime-target pair was always a complete filler, as we didn’t want the completion of an incomplete filler to have an influence on the experimental pair. There were five different prime-target pairs between each occurrence of the prime-target pairs that contain the same matrix verb with either an NP or a question argument (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), 3 fillers per prime-target pairs (36 items).

Procedure
The 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 comes to mind. They were also asked to follow the given order and not avoid the sentences that were already complete.

Before starting the main task, the participants were requested to fill in 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, the participants handed in the completed forms to the experimenter.

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” completions, as before.

The two versions with different matrix verb orderings were included in the analysis as the between subjects factor “SET”. The mixed ANOVA results indicate a significant main effect of Prime 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 overall (see Figure 2). In this regard, this finding is compatible 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 could be sensitive to the phrase-clause distinction.

Experiment 3

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

Design and Materials
In Experiment 2, the participants were asked to read and complete the sentences in the given order and read not only the incomplete fragments but also the completed sentences. However, it was not possible to ensure that they did not skip the complete sentences without reading and that they did not follow the order or go back to change their completions. In order to overcome such shortcomings of the offline paper-based task, we ran the same experiment with a different methodology. This time, the same exact stimuli, prepared with the same design and randomization criteria were presented to new participants in an internet-based online task through Amazon’s Mechanical Turk.

Procedure
The participants, who were registered workers of the 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 the little box that said “Next” to call for the following item. If the item was an incomplete fragment, they completed it by typing in the words and again clicked “Next”. The sentences were presented, one by one, in black

1 Amazon’s Mechanical Turk is a web site for the exchange of tasks and work requiring human intelligence. It can be accessed at: https://www.mturk.com/mturk/welcome.
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” completions. The two versions with different matrix verb orderings were again included in the analysis as the between subjects factor “SET”. The mixed ANOVA results indicate a significant main effect of Prime Type: F(1,18)=17.002, p=.001, η²=.486. Irrespective of the condition, the count of NP completions is greater than that of Question completions overall (see Figure 2). This finding is compatible with Experiment 1 and Experiment 2. However, unlike in Experiment 2, the interaction between Prime Type and Completion Type is not significant in this experiment. It could be the case that the structural priming effect found in Experiment 2 is not strong enough to persist and override the low frequency of embedded questions in the current methodology. The effect might be only visible when the nature of the task allows it. It seems that completing the fragments in handwriting rather than typing them in by a computer keyboard, boosts priming.

Results and Discussion
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.

Results and Discussion
The coding of the completions was identical to those in 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, η²=.192. Participants produced more NP-Completions after NP-primes than after That-Primes; and more That-Completions after That-Primes than after NP-Primes. This points out 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 result is comparable to the result of Experiment 2 and different from that 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 can also hypothesize that if Experiment 4 is re-run with the more traditional paper-based sentence completion task, we would get significant priming. This is an open question to be further investigated.

General Discussion
CQs, in which the same truth-conditional meaning as 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 in Experiment 3. Experiment 3 was an online task, and it only revealed the prominence of NPs over embedded questions and no significant priming. This difference between the two studies can have several explanations. First, the internet-based task was much more speeded, and that, in and of itself, may have given more prominence to frequency effects. When subjects are in a hurry, they tap into the most readily available strategy, which in this case is the use of NPs. Next, the change of methodology may have other effects as well. The internet-based task, which ensures that participants read all sentences one after the other, does not seem as sensitive to the priming effects as the traditional pencil-and-paper task. In the latter, the previous prime sentence may still be in the visual field of the reader, although not in the foveal position. Handwriting might also be more engaging and embodied 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 might 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 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 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 for the hypothesis that structural priming is sensitive to 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. 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 offline task and the same or a greater effect is observed, then it would be safe to reach more definitive conclusions.

These results have indirect indications for the processing and interpretation of CQs, as well. 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 go undistinguished 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 passed by. This might suggest that although both declaratives and questions carry a meaning similar to a CQ NP; at one level of representation, the interrogative is closer to the CQ NP than the declarative.

Another noteworthy finding is that whenever we compared 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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