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**Attention and syntax in sentence production:
A critical review**

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Abstract:

People often speak about visually perceived events that unfold in real time. In doing so speakers regularly translate the details of the visual world they describe onto the grammatical properties of the sentences about it. For example, the speaker needs to map her constantly changing attentional state onto the syntactic plan of the produced sentences. The present paper briefly discusses what attention is, explores methods for the co-activation of attentional and syntactic operations during the production of visually-mediated sentences in languages with different syntactic properties, and reviews the evidence for a regular link between the speaker's choice of sentential structure and the distribution of the speaker's attention to the event's referents. Also, it discusses evidence for interactive properties of attentional and other types of priming on the speaker's syntactic choice. Based on reviewed literature, we conclude that attention plays a crucial role in directing lexical and grammatical choices in human discourse. At the same time, the organization of the language's grammar reciprocates this influence by constraining the extent to which the distribution of attention can affect the real-time syntactic choices. Finally, we discuss how attentional priming engages in complex interactions with other priming effects: it interacts with lexical priming but not with syntactic priming, supporting an encapsulated view of sentence formulation.

Keywords:

attention, syntax, word order, sentence production

Résumé:

On parle souvent des événements alors qu'on est en train de les percevoir visuellement. Les locuteurs doivent alors projeter les détails du monde visuel qu'ils sont en train de décrire sur les propriétés grammaticales des phrases qui le décrivent. . Ainsi, le locuteur doit répercuter les changements constants de son état attentionnel sur la structure syntaxique des phrases qu'il produit. Le présent article discute brièvement de ce qu'est l'attention, puis présente les méthodes pour observer la co-activation des opérations attentionnelles et syntaxiques lors de la production de phrases résultant d'explorations visuelles, dans des langues ayant des propriétés syntaxiques différentes. Nous passons ensuite en revue les arguments en faveur d'un lien entre le choix du locuteur quant à la structure de la phrase et le partage de son attention sur les référents de l'événement. Nous discutons également des données mettant en évidence les propriétés interactives de l'amorçage attentionnel et d'autres types d'amorçage sur les choix syntaxiques du locuteur. Sur la base de la littérature, nous concluons que l'attention joue un rôle fondamental dans les choix lexicaux et grammaticaux du locuteur, tandis que la grammaire de chaque langue détermine, à son tour, dans quelle mesure la distribution de l'attention peut affecter les choix syntaxiques en temps réel. Enfin, nous exposons comment l'amorçage attentionnel interagit avec d'autres effets d'amorçage : il interagit avec l'amorçage lexical mais pas avec l'amorçage syntaxique, ce qui constitue un argument en faveur d'une vision modulaire de la production de phrase.

Mots-clés :

attention, syntaxe, ordre des mots, production de phrases

1. Introduction

- 1 When we talk about the world around us we need to organize our sentences in such a way that they properly convey constantly changing features of the entities and the events these sentences describe. In other words, we need to constantly *map* the relations between the elements in the visual world onto the relations between the elements in the linguistic world of our speech. Obviously, the visual system of the human brain provides the perceptual information for further conceptual and linguistic analysis and, finally, overt articulation. But the visual information is not processed indiscriminately; a specific brain circuit – *the attentional system* – operates as a filter helping to sort information for processing as more or less noticeable, important, or relevant. As a result, elements of visual information arrive for linguistic processing associated with a relative degree of salience. It is only natural to assume that these salience parameters need to be represented in human language in a regular way and that the languages develop and provide devices that are specifically responsible for this representation. Although this idea is not new to psycholinguistic research, it is only recently that the interplay between visual and linguistic processing has become the subject of rigorous experimentation (e.g., Henderson & Ferreira, 2004; Trueswell & Tannenhaus, 2005).
- 2 Our paper discusses the relationship between the speaker's attentional focus and one aspect of grammatical behavior – the real-time choice of syntactic structure and the corresponding word order. The general idea that we will discuss in the remaining of the paper is that attention influences syntax via preferential assignment of grammatical roles and/or via preferential ordering of the sentence constituents. First, we provide a very brief outline of what attention is. Second, we discuss the nature and the corresponding evidence of the two theoretical accounts that relate attention to syntactic choice: *the grammatical role account* (e.g., Tomlin, 1995) and *the positional account* (e.g., Myachykov, 2007; Myachykov, Posner, & Tomlin, 2007). In brief, the former account suggests that the focused referent is mapped as the most prominent grammatical constituent in a sentence (e.g., Subject); the latter maintains that the attentionally focused referent tends to occupy the sentential starting point regardless of its grammatical status. Third, we briefly analyze how attentional priming effects interact with other priming effects, such as syntactic and lexical priming, in biasing the speaker's syntactic choice. Finally, we provide conclusions and outline directions for future research.

2. What is attention?

- 3 What people see in the environment is largely determined by what they happen or choose to attend to. Typically, the surrounding world contains excessive perceptual information available for processing; attention facilitates selection of the information most relevant to making behavioral decisions (e.g., Chun & Wolfe, 2001). This property of the attentional system has been known to researchers for decades, and many of them underlined that such properties as selection, regulation, and control make attention prominent among other cognitive operations. For example, Titchener (1908) called attention “the heart of the psychological enterprise.” At the same time, operationally defining attention is not an easy task. Over century ago, William James suggested that

“Everyone knows what attention is. It is the taking possession of the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought”. (James, 1890, p.402).

- 4 Note that James also underlined *selection* as one of defining features of attention. More recently, Corbetta (1998) proposed a related definition.

“Attention defines the mental ability to select stimuli, responses, memories, or thoughts that are behaviorally relevant, among the many others that are behaviorally irrelevant” (Corbetta, 1998, p. 831).

- 5 Selection among stimuli is obviously not a single (and not the only) property of the attentional system. Posner and colleagues (e.g., Fan, *et al.*, 2002; Posner & Raichle, 1994; Posner & Rothbart, 2007) defined distinct operations and, correspondingly, distinct anatomical attentional networks in the human brain: those responsible for *alerting*, *orienting*, and *executive control* of attention. Alerting is achieving and maintaining an alert state; orienting helps selection of information from sensory input; and executive control of attention provides resolution of a conflict among competing responses (Fan *et al.*, 2002). The latter operation often subserves *shifting attentional focus* (Posner & Petersen, 1990) between competing stimuli, which consists of (1) disengaging attention from the current area or stimulus, (2) moving attention toward a new area or a stimulus, and (3) engaging the new area or stimulus with the newly established focus of attention.
- 6 The control of attention in visual experimental tasks is often achieved by means of a *cueing* paradigm (Posner, 1980). A cue in this case is something that makes a stimulus more salient among other stimuli; it can be an independent marker that “points” to the cued stimulus (e.g., an arrow) or it can be a feature of the stimulus itself (e.g., a stimulus’ larger size can be referred to as an attentional cue). A cue can be *exogenous* or *endogenous*, *explicit* or *implicit*, and it can result in *overt* or *covert* deployment of attention (Posner & Raichle, 1994). Exogenous cues are the world-situated, therefore, external to the perceiver’s mind, features that draw the perceiver’s attention to a particular location. Endogenous cues originate from within the perceiver’s mind and are guided by his internally generated plans in carrying out cognitive tasks. An explicit cue is a clearly noticeable and therefore consciously processed marker that attracts attention to a location or an entity. An example of such a cue is an arrow pointing toward a certain location on the screen presented long enough (e.g., 500 msec.) for a participant to notice and (likely but not inevitably) direct her gaze to it. An implicit cue directs attention in a more subtle manner. Such a cue is usually presented very briefly, for duration much smaller than would be necessary for conscious processing (e.g., 50 msec.). The presentation of an implicit cue is typically not noticed by a participant, but its brief display is sufficient for attracting attention and directing the gaze toward the cued location.
- 7 As we just noted, visual “searchlight” and attentional “searchlight” can be separated so that eye-movements do not necessarily accompany attentional shifts (Fischer, 1998, for a review). This property underlies the difference between overt and covert deployment of attention. An overt attentional shift occurs when the eyes move to align the visual focus with the attended object. A covert shift directs the focus of attention outside of the visual focus making the two foci dissociable (Posner, 1980; Posner, Nissen, & Ogden, 1978). Such dissociation between the attentional and the visual foci is notoriously difficult to elicit, and it can hardly be tested outside an experimental setting. Whether attention in fact moves through the intermediate space and how free covert attention is from the eye movement system are still disputed matters.

3. Attention and language research

- 8 Even by way of a very brief introduction, attention appears to be quite a complex system of interrelated cognitive operations. Are all of these properties important for our understanding of the visually-mediated linguistic behaviour? A simple answer is yes: Attention indeed plays a crucial role in both directing speakers’ linguistic choices during sentence production (see below), as well as directing addressees’ perception of visual events portrayed in sentences about them (Myachykov & Posner, 2005, for a recent review), and, at least in principle, it may be that operations originating from distinct attentional networks have their counterparts in linguistic behaviour or even overall organization of the language faculty. However, the existing data is quite sparse and the experimental tasks typically involve quite

basic approaches to manipulating attention. This often leads to certain adaptations of the cognitive theory of attention to language research. One of such adaptations was suggested by Russ Tomlin under a notion of *attention detection* (Tomlin, 1995, 1997). Attention detection effectively collapses operations from Posner's three-partite set by distinguishing only between focused and non-focused attention. According to Tomlin, an *attentionally detected* entity is the one currently in the speaker's attentional focus. Although slightly underspecified psychologically, this notion proved adequate for most psycholinguistic research that uses visual cueing tasks, in which speakers' or listeners' attention is deployed overtly and the visual focus always corresponds to the attentional focus. Although finer-grained attentional manipulations may be necessary to understand how covert attention is related to linguistic processing (e.g., Myachykov, 2007; Scheepers, 2008) or to analyze contributions of distinct attentional networks to the organization of linguistic behavior, experiments discussed in this paper all used overt deployment of attention and a binary distinction between focused and non-focused referents in the described scenes.

4. Attention and sentence production

- 9 Before any discussion of the role of attentional priming in sentence production takes place one needs to briefly lay out (1) how sentence production works and (2) what priming is in its most general form.
- 10 According to the standard view (e.g., Bock & Levelt, 1994) sentence production spans over four independent stages of sentence preparation: message, lemma, assembly, and articulation. Producing a sentence begins with the creation of a *message* – a conceptual representation of the event to be described linguistically. Then, the speaker translates the extracted message into an emerging sentence. This translation comprises stages of grammatical encoding of a sentence. Supposedly, grammatical encoding spans across two sub-stages: (1) lemma retrieval, during which concepts receive their lexical names accompanied by their grammatical properties and (2) grammatical assembly, at which the retrieved names assume positioning in the upcoming sentence. Finally, the speaker overtly produces the sentence at the stage of articulation. The production system in this and similar models is believed to be sequential and modular; it is sequential because processing at each preceding level has to be completed before processing at the next level can commence, and it is modular because processing at each level is believed to be encapsulated: for example, the speaker does not access lemmas at the message level or extract referential information at the assembly level. Also due to the sequential nature, some processing stages are natural “neighbours” (e.g., message and lemma) while others are separated (e.g., message and assembly).
- 11 Access to the relevant information at each stage of sentence production is associated with *accessibility* statuses of the corresponding units. For example, at message level referents may receive a higher *accessibility* status due to their more conspicuous perceptual or conceptual properties (e.g., Bock & Warren, 1985, *inter alia*). This may bias the speaker to process them earlier than the other referents when transferring the message details to the lemma level affecting lexical accessibility of the words associated with the referent and grammatical properties associated with these words. If such preferential processing continues all the way to overt articulation, it is likely that the most accessible (e.g., visually most salient) referent will be articulated before other referents taking part in the event and that it will be assigned as the most prominent grammatical constituent, for example, the Subject. This view helps understand how changes in accessibility at different production stages motivate syntactic choices made by the speaker. In experimental settings processing accessibility is often manipulated with the help of a priming paradigm (e.g., Bock, 1986). Irrespective of what becomes primed, priming implies the existence of a choice between alternatives (say, grammatical voice alternatives of transitive sentence frame), and it is achieved via exposing the participant to one of them ahead of the task where she has to select one alternative in favor of the other.

4.1. Referential priming and sentence production

- 12 Already in the early days of psycholinguistics, assessment of linguistic behavior led many researchers to suggest that attentional performance somehow correlates with linguistic performance at a variety of levels. Many of such early studies used variants of a *referential priming* paradigm. In a typical referential priming experiment a participant may be offered a preview of a referent before the display of a visual event, in which the previewed referent interacts with another, non-previewed referent. The instruction may be to describe or verify a sentence about, this target event. The previewed referent becomes effectively *primed* for preferential processing: In a production study the speaker may decide, for example, to resolve the primed referent as the starting point of a sentence about the target event, which in English will typically lead to the establishment of the primed referent as the sentential Subject. In one of the earliest of such studies, Prentice (1967) tried to explore the link between passivization and attentional focus by using a set of cartoon pictures portraying simple transitive interactions between two characters (e.g., *fireman kicking cat*). Some of the characters were human beings, some were animals, and others were inanimate objects (e.g., *flower pot*). These pictures were paired with cue slides depicting one of the event's characters: the agent or the patient. Participants first viewed the cue picture and then the whole event, to which they provided spoken descriptions. The results of this simple experiment demonstrated that speakers were more likely to place the primed referent first in their descriptions of target events. In addition, animacy was found to be a strong predictor of Subject assignment as participants were more likely to make animate referents sentential Subjects alternating between active and passive voice.
- 13 Turner & Rommetveit (1968) conducted similar research with children. They presented participants with the sentences and later asked them to recall these sentences. The materials were all active/passive voice sentences divided into four groups: (1) non-reversible actives, (2) reversible actives, (3) non-reversible passives, and (4) reversible passives. One sentence of each type was randomly paired with a picture of one of the following primes: The agent, the patient, the whole described event, or a blank screen. The time the prime was presented varied as the experimenter presented the prime pictures manually; however, it was always long enough for a participant to identify the primed referent or event. The pictures were shown to the participants both at the time of the sentence storage and recall. Analysis of the recalled sentences for correct vs. incorrect responses and for syntactic transformations demonstrated that (1) active voice sentences were better remembered than the passive voice ones, (2) the active voice sentences were more likely to be recalled correctly if the primed referent was the agent, while the passive voice sentences were better remembered if the primed referent was the patient.
- 14 In both authors' view, these results demonstrated that priming a referent leads to preferential assignment of attentional focus during sentence production or recall improving the chances of this referent of becoming the Subject. There is, however, a problem with this explanation, and this problem was already known to Prentice (1968). Speaking about the observed tendency to alternate syntax as a function of the prime, she noted:

“Whether the change occurs first at a verbal level, in tendency to name, or at perceptual level, in interpretation of the event, is the question at hand. Does the subject sometimes name the cue element before he “knows” which slide he will describe? Alternatively, does the subject perceive an event differentially as a function of cue?”
- 15 Nevertheless, Prentice favored the idea that the prime affected the choice of syntax directly via the assignment of grammatical roles. This interpretation is later echoed in Tomlin's work (1995), which also supported the idea of a direct link from perception to the assignment of grammatical roles in a sentence. However, together with directing attentional focus to the primed referent a preview provides the speaker with the conceptual, and the lexical information about the referent (but see, for example, Bloem & La Heij, 2003 for an

argument about optionality of lexical access in referential priming tasks). Obviously, in order to properly understand independent contributions of attention to the selection of syntax one needs to ensure that the attentional manipulation does not simultaneously lead to an increase in conceptual and/or lexical accessibility. It needs to be noted here that the *conceptual* effects on syntactic selection (such as animacy, definiteness, imageability, etc.) have been explored extensively in past decades (for animacy see, for example, Altman & Kemper, 2006; Bock, Loebell, & Morey, 1992; Ferreira, 1994; McDonald, Bock, & Kelly, 1993; Prat-Sala & Branigan, 2000; Sridhar, 1988). Because we are primarily interested in attentional effects independent of other priming effects, the remaining of this paper reviews studies in which at least one attentional manipulation did not make any reference to conceptual, semantic, or lexical information.

4.2. Attentional priming and sentence production

- 16 The early findings we discussed above led to the emergence of theoretical accounts suggesting that attentional processing of the cognized world may somehow be reflected in the organization of both production and comprehension of sentences. For example, Osgood & Bock (1977) and MacWhinney (1977) suggested that the referents' salience status (e.g., *vividness* in the former report) acting as an exogenous determinant of the distribution of speaker's attention should promote the referent in focus to the most prominent position in a spoken sentence. The latter report presented a theoretical platform known as the *Starting Point* hypothesis. Although it is not specifically geared toward sentence production, the Starting Point framework also predicts that one of the main factors determining the assignment of the grammatical roles in a sentence is the speaker's perspective or attentional focus. The attended object in these and similar accounts is either promoted as a higher accessibility item within the conceptual and then the linguistic representation (cascaded view) or it is repeatedly reactivated (serial processing view). For example, if the attention of a native speaker of English is directed to the Agent of a transitive event like the one portrayed in Figure 1, he may be more likely to describe such event with a sentence like "A policeman is punching a boxer". If, on the other hand, the attentional focus is on the Patient, a sentence like "A boxer is being punched by a policeman" seems more likely. In other words, focusing attention on the referent may lead to an earlier commitment to a sentential starting point and its Subject influencing the distribution of other syntactic roles in a spoken sentence.

Figure 1

- 17 This idea was taken as a working hypothesis in a study by Tomlin (1995), which has become one of the most prominent attempts to unravel the relationship between attention and the assignment of syntactic roles in sentence production. Tomlin's experimental program stems from a functional linguistic tradition, and it came as an opposition to a view commonly shared in linguistics, which is well illustrated by the following extract:

“The (sentence) constituents move to certain positions because of their discourse function interpretation” (King, 1995, 63).

- 18 The latter view is based on the idea that the assignment of the syntactic positions in a clause is based on the functional opposition between clause-level *theme* and *rheme*, *topic* and *comment*, and/or the referents' semantic roles, like *agent* and *patient*. Traditionally, (e.g., Daneš, 1970; Halliday, 1985) the notion of theme is associated with the element “one is talking about, the topic,” while the rheme is “what one says about it, the comment” (Daneš, 1970). It is widely assumed that the subject of a sentence frequently acts as the syntactic counterpart of the theme or topic of the utterance although other structures have been known to highlight the theme through means different than the assignment of the sentential roles (e.g., the change of ordering in clefts and dislocations). Functional interaction between discourse entities is usually realized as the hierarchy of semantic roles. For example, the term *agent* is traditionally used to identify an acting instigator of the action while *patient* is referred to as an experiencer of the agent's action (Fillmore, 1968). It was suggested the semantic agent is the most likely candidate to take the position of syntactic subject of a sentence. Some psycholinguistic studies (e.g., Kako, 2005) demonstrated that speakers tend to perceive sentential subjects as “agent-like”, while objects are rated as more “patient-like” (see also Gleitman, *et al.*, 1996).
- 19 In response to these theoretical views, Tomlin conducted a study, in which he used a computer animation program called “The Fish Film”. Participants viewed and described an unfolding engagement of two fish, which resulted in one fish eating the other (see Figure 2).

Figure 2

- 20 In each trial, an explicit visual cue in form of an arrow directed participants' attention toward one of the two fish. The instruction was to direct the gaze to the cued fish only and describe the interaction between the two fish in any preferred way. Apart from being *explicit*, such cue is also *mixed*, as it exhibits both endogenous (participants are told to treat the arrow as an attentional cue) and exogenous properties (the cue draws their attention to

the target by virtue of pointing to it) (Posner, 1980). Descriptions of the target event (the eating of one fish by the other) were analyzed for the probability of producing active and passive voice structures as a function of the cue location: on the agent or on the patient. The results revealed that English speakers consistently produced active voice sentences (e.g., *The blue fish ate the red fish*) when the cue was on the agent and they produced passive voice sentences (e.g., *The red fish was eaten by the blue fish*) when the cue was on the patient. This was true in virtually 100% of the corresponding experimental conditions. Based on this result, Tomlin drew a strong conclusion that the grammatical subject in English is consistently assigned to the referent currently in the speaker's attentional focus.

- 21 The effect reported by Tomlin was quite powerful, but the nature of the cueing procedure was widely criticized for being "too brutal" (Bock, *et al.*, 2004) or "blatant" (Gleitman, *et al.*, 2007) such that it likely revealed the experimenter's goals to the participants. Indeed, the cue used by Tomlin was quite strong: it was explicit, it was presented together with the stimulus, and it carried both exogenous and endogenous features. Finally, the use of the same event across 32 experimental trials with no filler materials intercepting the target trials was another criticism. From methodological point of view, such criticisms are, at least partially, justified. First, although the experimental instructions did not say anything about how to treat the cue in relation to the choice of event description, it considerably constrained the speaker's attentional focus to the cued referent making it not only perceptually but also conceptually more accessible. Second, the Fish Film protocol instructed participants to describe the events continuously and in real time making reference to *all* the interactions between the fish, including those preceding the target event. This inevitably increased the discourse status of both fish, more so for the fish that was cued marking it with the given discourse status (cf. Bock, 1982). Finally, the repetitive nature of the target event and the lack of filler materials made effects of syntactic priming (Bock, 1986) a possible concern.
- 22 Attentional priming studies that followed used more advanced and better controlled cueing procedures. For example, Forrest (1996) explored the visually cued production of locative sentences in English. This time speakers' attentional focus was attracted not to the cued referent itself but to its location prior to the target event presentation. Also, a mask was used between each target trial in order to minimize irrelevant visual and linguistic priming effects. The experimental materials were simple line drawings of locative events, for example a picture of *a star left of a heart*. Prior to target display presentation, an explicit visual cue appeared in the location of either the star or the heart. As a result, speakers tended to produce sentences like *A star is left of a heart* when the star's location was cued, and *A heart is right of a star* when the heart's location was cued.
- 23 Another study using English (Gleitman, *et al.*, 2007) tested the production of a wide array of syntactic structures including sentences with verbs of perspective (*give/receive*), conjoined noun phrases (*The boy and the girl/The girl and the boy*), transitive sentences (*The boy hits the girl/The girl is hit by the boy*), and sentences with symmetrical predicates (*The boy meets the girl/The girl meets the boy*). Instead of explicit cueing of attention, the researchers used an *implicit* cueing protocol: the cue was presented in the area of one of the subsequently presented referents only for 75 msec. This presentation duration is not sufficient for the participant to "notice" the cue; at the same time, it is sufficient to attract attention to the cued location. Once the picture was on the screen, participants extemporaneously described the presented event without any further manipulations of attention. Although the resulting syntactic alternations were not nearly as strong as those reported by Tomlin (around 10% in effect size), the cued referent was indeed more likely to become the starting point or the subject of the target sentence in all the structures tested.
- 24 Notably, while the authors acknowledged that it is possible that, as proposed by Tomlin, the attended referent is mapped directly as the sentential Subject (*grammatical role view*), there may be a simpler explanation: namely that the referent in focus becomes the first mentioned constituent (the starting point) of a sentence but not necessarily its Subject. This reflects a *positional* view of syntactic selection, according to which the focusing attention results in the focused referent being processed ahead of the rest of the information. As a result its

referential information becomes extracted and transferred to the lemma level earlier and the primed referent becomes lexicalized earlier than the its counterparts. Finally, because more available lexical entries are likely to be mentioned first; the primed referent becomes the first-mentioned constituent in a sentence; this, in the end, influences the assignment of the remaining of the sentential frame driving the resulting syntactic alternation. Gleitman, *et al.* (2007) further challenged the grammatical role hypothesis by highlighting that in the production of conjoined NP phrases attentionally driven alternation occurs within a Subject so the assignment of the ordering of the constituents has to be positional. At the same time, the data from the sentences with symmetrical predicates hint at the possibility of a hybrid system which may need to accommodate both grammatical and positional mappings. When describing a symmetrical event (say, kissing between a man and a woman), the speaker may choose among four different options: “*The man and woman kissed*”, “*The woman and the man kissed*”, “*The man kissed the woman*” and “*The woman kissed the man*”. Hence, the final assignment of the symmetrical predicates necessitates both positional and grammatical choices. The fact that the participants in Gleitman, *et al* (2007) consistently assigned the attentionally primed referent as the sentential starting point and the Subject during the production of such sentences supports such a hybrid view of attentionally driven syntactic selection.

4.3. Attentional priming of syntactic choice in other languages

- 25 The report by Gleitman *et al.* (2007) provided important insight into the nature of attentional effects on syntactic choices. However, this and other studies reported thus far used the same target language – English. In English, the Subject’s position coincides with the first mentioned element of a sentence or its *starting point*. This makes it difficult to distinguish between the grammatical role account and the positional account of syntactic selection. Other languages are more flexible in terms of ordering of constituents, which makes it possible to assign Subject as the second, the third, or the last constituent in a sentence. The use of such languages makes it possible to independently test predictions from the two theoretical accounts. Two recent studies used Russian (Myachykov & Tomlin, 2008) and Finnish (Myachykov, Scheepers, & Garrod, in preparation) in order to investigate how languages other than English accommodate attentional priming effects on the syntactic choice during sentence production.
- 26 The choice of the target language in both studies was motivated by the fact that Russian and Finnish are similar to English in that (1) they are also SVO languages and that (2) they allow voice-based assignment of transitive word order. In contrast with English, however, Russian and Finnish use explicit case marking on the nouns, allows for flexible ordering of sentence constituents so that all possible permutations of Subject, Verb, and Object become grammatical. So, a speaker of Russian or Finnish performing on an attentional priming task has both voice-based and scrambling-based production choices available. The question then becomes which of these two production systems is preferred: while voice-based assignment (subject first) confounds grammatical and positional assignments of constituent roles; scrambling (attended referent first) helps to test between them because the subject does not have to be the sentential starting point.
- 27 Myachykov & Tomlin (2008) used the original version of the Fish Film task (Tomlin, 1995). According to the grammatical role view, Russians, like their English counterparts should alternate between active and passive voice as a function of the cue direction (agent/patient). According to the positional view, they should scramble word order, which in the patient-cued condition should result in Subject being produced after Object. The results clearly supported the latter view: Russian speakers scrambled word order as the function of the attentional cue (agent/patient) producing correspondingly Subject-initial (SVO, SOV) or Object-initial (OVS, OSV) sentences. Importantly, they used passive voice in less than 2% of the sentences produced. This result offers support to the positional assignment view, at least for morphologically rich languages like Russian.

- 28 The authors also make a notable observation that using the same task as Tomlin they obtained a much smaller attentional priming effect (20% in effect size as compared to almost 100% in Tomlin (1995)). This may suggest that languages accommodate attentional effects differently so that attentionally driven choice of syntax in Russian is less likely than in English. Whether this is the case is an open issue. However, there is an intriguing possibility that that syntactic choice in different languages reflects contributions of heterogeneous parameters or even their sets putting different constraints onto accommodation of attentional effects in syntactic choice.
- 29 Another study by Myachykov and colleagues analyzed attentional priming effects onto syntactic choice in another case-marking language Finnish (Myachykov, Scheepers, & Garrod, in preparation). This time *implicit* attentional priming (cf. Gleitman, *et al.*, 2007) was used and the design was virtually the same as in Gletiman, *et al* (2007): Participants described pictures of transitive events after their attention was directed to the location of either its agent or its patient by an implicit (70 msec) visual cue. Like in Myachykov & Tomlin (2008), a direct comparison was made between the performance of English speakers and their Finnish counterparts on the same task. The English data from English participants replicated earlier findings in that the attentionally cued referent tended to become the starting point and the subject of a transitive sentence (Gleitman, *et al.*, 2007). Finnish speakers, on the other hand, did not alternate word order at all; instead, they produced active voice SVO sentences regardless of the cue location. Put together, the results of both Myachykov & Tomlin (2008) and Myachykov, Scheepers, & Garrod (in preparation) argue against universality of attentionally driven syntactic choice and demonstrate that the organization of the language grammar may affect accommodation of attentional effects. The relative weakness of attentional effects on syntactic choice in Russian and Finnish is explained by the authors as resulting from the necessity to perform an operation absent in English – the selection of explicit case markers on the nouns. In English, the cued referent's name can be retrieved and maintained even if the speaker decides to change the initially committed syntactic structure; its semantic role (agent or patient) does not have to be morphologically marked. In Finnish or Russian, commitment to a semantic role (e.g., Agent) involves a joint commitment to a case marker (Nominative case) and it effectively constraints the remaining options for syntactic selection. These early commitments lead to a larger degree of preplanning necessary at the earliest stages of sentence preparation and may put additional cognitive load on the production system limiting the extent to which word order assignments may continuously unfold accommodating the attentional statuses of the referents.
- 30 An alternative explanation would assume the already-mentioned hybrid view: namely that the choice of Subject may be a result of many contributing processes. If the speaker needs to consider multiple sources of information when deciding which referent to name first and/or to make the Subject, then the reduced effect of attentional priming in Russian and Finnish may reflect the fact that word order in those languages is more tightly coupled with other parameters of the discourse situation, such as discourse functions of the referents rather than with the speaker's attentional state (see, for example, Kaiser & Trueswell, 2004 for a similar argument for Finnish).

4.4. Interactive properties of attentional cueing

- 31 So far, we established that attention paid to the referent affects syntactic selection either by making it the Subject of the upcoming sentence or by mapping it as the first-mentioned sentential constituent. However, little is known about how attentional priming may interact with other priming parameters known to influence the speaker's choice of syntax, for example, lexical (e.g., Bock & Irwin, 1980) and/or syntactic priming (e.g., Bock, 1986). The use of *lexical priming* (e.g., preview of a referent's name) may lead to a tendency to make the primed referent as the sentential starting point and/or its subject (e.g., Bates & Devescovi, 1989; Bock & Irwin, 1980; Ferreira & Yoshita, 2003; Flores D'Arcais, 1975; Osgood & Bock, 1977; Prat-Sala & Branigan, 2000). Importantly, a similar effect may be

also achieved not only by the lexical priming of nouns but also by priming of verbs related to the event portrayed in the target trial. For example, in a study by Melinger & Dobel (2005) German speaking participants described ditransitive events (e.g., *A boy giving a girl a toy*) that allow both a prepositional object (*A boy gives a toy to a girl*) and a double object (*A boy gives a girl a toy*) descriptions. Prior to the target event presentation, the participant previewed either a ditransitive verb that permitted only a prepositional object frame (e.g., *adressieren*) or only a double object frame (e.g., *entziehen*). The syntactic frame associated with the isolated prime verb (prepositional or double object) influenced speakers' syntactic choices in the target (see also Salamoura & Williams, 2006). Finally, *syntactic priming* refers to a tendency to repeat the whole syntactic configurations from the structures the speaker has previously encountered or produced (Branigan, 2007; Ferreira & Bock, 2006; Pickering & Ferreira, 2008, for recent reviews). Some accounts of syntactic priming claim that the tendency to repeat syntax from sentence to sentence has a strong lexical component (e.g., Pickering & Branigan, 1998; Scheepers, submitted); other accounts claim that syntax is recycled without necessary reference to either conceptual or lexical information (e.g. Bock & Loebell, 1990; Bock, Loebell, & Morey, 1992; Desmet & Declercq, 2006; Scheepers, 2003).

- 32 Independent of these theoretical differences, interactive properties of the distinct priming effects established at different production stages are largely unknown. This lack of knowledge motivated the set of studies reported in Myachykov, Scheepers, & Garrod (submitted). In four experiments, Myachykov and colleagues investigated syntactic choice in English transitive sentence production by combining different priming manipulations. In each study participants described visually presented transitive events after receiving combinations of the following priming manipulations. Lexical (verb overlap) and syntactic primes preceded attentional prime and they were presented within the same sentence read by the participant before the target event was displayed. Attentional prime was an explicit visual cue to the location of one of the referents presented for 500 msec immediately before the target display presentation. In Experiment 1 all three priming manipulations were used, in Experiment 2 only attentional priming was used, Experiment 3 crossed attentional with lexical priming, and Experiment 4 – attentional and syntactic priming. One important finding from these studies was that distinct priming effects interacted only if they were established within *neighboring* production stages: message and lemma, or lemma and assembly, but not message and assembly. Hence, attentional priming interacted with lexical priming, lexical priming interacted with syntactic priming, but attentional priming did not interact with syntactic priming. This finding supports the “encapsulated” view of sentence production, according to which information from one production stage is fed forward to the next production stage and, therefore, processes at the stages that are not neighbors do not affect each other (e.g., Jackendoff, 2002; Levelt, 1989). Another important finding was that although attentional priming was reliable throughout its effect was substantially diminished by priming of lexical information. At the same time, presence of lexical priming boosted the syntactic priming effect. This difference in interaction patterns suggests important constraints on how priming effects established at message level become accommodated at later production stages: attentional priming affects syntactic selection best when its effect is not “obstructed” by informational processes at the later production stages.

5. Conclusions

- 33 The research reviewed in this paper provides evidence for a regular link between visual attention and the syntactic organization of human discourse. The relationship between attention and syntax, however, is not simple. On one hand, speakers' performance on attentional priming production tasks suggests that the distribution of attention to the referents in the described event may influence positioning of the corresponding constituents in a sentence. On the other, the exact mapping from attention to syntax is uncertain. A grammatical account predicts that grammatical roles are assigned directly based on the information extracted at the message level and independent of the sequential order of

constituents in a sentence. As such, it predicts that once the system has detected the most salient element in the event it may check for its referential role and assign its grammatical role immediately based on the direct mapping from attention to syntax. In this case, the system has to be in possession of a complete message before it can perform any operations of grammatical encoding. The extracted message in this view enters later processing stages with “tags” of predetermined grammatical commitments, which makes attentionally driven assignment of grammatical roles possible regardless of whether the referent will eventually appear at the beginning, at the middle, or even at the end of a sentence.

- 34 An alternative positional account relies on cascaded production sequence, in which once the referent is focused, it becomes the first referent to be conceptualized, the first referent to be named, and the first constituent inserted in a sentence. This very opportunistic view of production also implies that the system does not have to wait until the message is fully conceptualized before it can process the primed referent further at, say, lemma level. One inevitable consequence is that the focused referent has to be the starting point of a sentence; in English sentence production – its Subject. Because attentional focus and the sentential starting point in a positional view are coupled, the attentionally driven assignment of constituents that are not starting points becomes impossible.
- 35 In support of the first view, a number of studies demonstrate how speakers of English regularly alternate between syntactic alternatives as a function of the attentional focus on one of the referents always making the primed referent the sentential Subject. The persistence of such results led to the emergence of theories proposing that attentionally detected referent in English is mapped directly onto the Subject position (Tomlin, 1995). Other studies (Gleitman, *et al.*, 2007; Myachykov & Tomlin, 2008; Myachykov, *et al.*, in preparation) supported the second view. For example, English speakers were demonstrated to rely upon a combination of positional and grammatical mappings when producing certain constructions (symmetrical predicates). Speakers of Russian and Finnish were shown to prefer scrambling instead of grammatical role assignment when producing transitive sentences performing in an attentional priming task. In addition, speakers of both Finnish and Russian demonstrated a much weaker capacity for accommodating attention detection in their choice of syntax than their English counterparts as revealed by generally small attentional priming effects.
- 36 We have continued testing the two theoretical accounts by experimenting with different languages. One of such follow-up avenues uses English structures, in which the commitment to the focused referent needs to be carried beyond the assignment of the initial constituent. One of such structures is the English dative construction that allows for the choice between the prepositional-object or PO construction (e.g., *A boy gave a toy to a girl*) and the double-object or DO construction (e.g., *A boy gave a girl a toy*). The choice between these two alternatives relies on post-Subject ordering of the Object and the Theme. Positional and grammatical accounts of syntactic selection make different predictions about plausibility of attentionally driven commitments beyond the first-mentioned constituent. According to the grammatical role view, it may be possible to induce PO/DO alternation by attentionally priming the theme or the object of the event while according to a positional account, such mapping should be impossible as the primed referent needs to be inserted after the first-mentioned constituent. Also, experimenting with Subject-final languages (e.g., Malagasy) may provide more evidence for either grammatical or positional assignment of attentionally driven syntactic choice. One study (Rasolofo, 2008) provides evidence that favors the grammatical account. In this study Malagasy speakers performed on the Fish Film task (Tomlin, 1995). One important finding from this study was that the participants consistently assigned Subject – the last element in a sentence – to the cued referent (agent or patient). In any case, further experimentation is necessary to continue to explore attentionally driven syntactic choice across languages.
- 37 Another important finding is the demonstration of the fact that the distribution of the speaker’s attention can be reflected in her syntactic choice only to a degree that the language’s grammar permits. The lack of explicit case marking on the nouns in English

permits direct mapping of the noun phrase pre-selected for preferential processing onto the position of the initial sentential constituent. This lack of case marking allows for delayed commitment to the final syntactic continuation (e.g., the choice between the active and the passive voice). In languages like Russian and Finnish, this is impossible because more often than not the commitment to a case-marked form of NP comes with the commitment to the accompanying semantic role and, therefore, to a limited choice of syntactic continuations. We continue this line of research in experiments using Russian and German, in which we contrast between case-marked and case-ambiguous noun forms. If case marking indeed reflects an additional cognitive operation complicating direct mapping between attention and syntax then there should be interaction between attentional priming and absence/presence of case marking on the noun.

- 38 Finally, Myachykov, *et al.*, (submitted) explored interactions between attentional priming and other priming effects providing two crucial findings. First, English speakers' performance in a multiple-priming environment demonstrated that processing at each production stage is relatively encapsulated. The authors assumed sequentiality of sentence production from message to lemma to assembly proposed in Levelt (1989). They distributed the priming manipulations accordingly: attentional priming at message level, lexical priming at lemma level, and syntactic priming at the level of assembly. Importantly, priming effects established at message level (e.g., attentional cueing) were independent of priming effects established at the level of grammatical assembly (e.g., syntactic priming). At the same time, priming of attention interacted with the lexical priming – the effect established at the stage of lemma selection immediately following the stage of message extraction. This pattern suggests that the product of message-level processing is accommodated at the level of lemma selection; the product of lemma selection receives syntactic positioning at the level of grammatical assembly.
- 39 One remaining question is whether multiple priming effects established within the same stage also interact? For example, does visual salience interact with animacy, since both relate to the message level? Similarly, does the simultaneous lexical priming of verbs and nouns lead to an interaction? Other questions follow from the *neighborhood* principle outlined above. For example, if the stage of *phonological encoding* were included in the priming environment, our theoretical view would predict that the phonological priming effect should interact with syntactic priming but not, say, with perceptual priming. One earlier report (Clelland & Pickering, 2003) examined whether phonological similarities between nouns in prime and target sentences (e.g., *ship* and *sheep*) affect the magnitude of the syntactic priming effect but failed to register the existence of such a “phonological boost”. However, more recent research suggests that a better phonological match between nouns, such as in homonymic (Santesteban, Pickering, & McLean, 2008) or rhyming (Branigan, ongoing) pairs, indeed leads to the establishment of a stronger syntactic priming effect. Another interesting future direction relates to the decay functions for the individual priming effects. There is evidence that the syntactic priming effects are characterized with considerable persistence (Bock & Griffin, 2000) and that they tend to outlast the lexical boost effect (Hartsuiker, *et al.*, 2008). At the same time, little is known about (1) how persistent perceptual and/or conceptual priming effects are? and (2) how the decay of the message-related priming is affected by other priming effects (e.g., lexical and/or syntactic) established in parallel?

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