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EFFECTS OF AUDITORY AND VISUAL CUEING OF ATTENTION ON SYNTACTIC CHOICE IN SENTENCE PRODUCTION

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Abstract

One of the topics in current psycholinguistic research is the study of the factors affecting syntactic choice in sentence production. Previous research suggests that syntactic choice results from an interplay between linguistic and non-linguistic factors, and a speaker's attention to the elements of a described event represents one such factor. It is a well-established fact that our attention simultaneously receives input from various attentional modalities (e.g. auditory, motor, olfactory, etc.). Afterwards, attention filters the input by a number of factors (e.g. saliency) and allocates resources to the most prominent and important input at a given moment. This poses the question of whether other attentional modalities affect syntactic choice in a similar manner to visual modality. In this study we aimed to understand whether auditory and visual attention can affect syntactic choice. English native speakers described drawings of simple transitive events while their attention was directed to the location of the agent or the patient of a depicted event by means of either an auditory (monaural beep) or a visual (red circle) explicit lateral cue. We have measured the amount of passive structures produced. Our results were not significant, however there was a visible trend in visual cueing condition. In this paper we discuss possible reasons for such outcomes.

Keywords: syntactic choice, grammar, attention, priming.

Introduction

Life without attention would be an unstoppable flow of information, which could hardly ever be shaped into understandable patterns. Attention works as a filter, which sorts and regulates this flow for what is necessary and what can be skipped. This filtering is done by the focus of attention. The focus of attention can be spatially directed and manipulated (Posner, 1980). Directing of attention focus can be achieved in various ways. One way is via different sorts of signals (cues) coming from various perceptual modalities. Obviously a flash of light can attract the focus of attention as well as a car horn. Imagine these cues happening simultaneously –

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flashing on the right of your visual field and the horn beeping on the left. Definitely both the flash and the sound of a horn will be perceived and both stimuli will reach perception at once. But what will happen to the focus of attention after this manipulation? Will the visual stimuli attract the attention more than auditory ones, or vice versa, or whether they will somehow interfere separating the focus of attention? We will look at this issue through the prism of psycholinguistic research. Based on previous findings about manipulation of visual and auditory attention the research will look at the way different attentional modalities interact. The outcome of this interaction will be assessed through changes in language production patterns.

Language is used for a variety of functions. As we live in a visualised world, one of the most important functions of language is sharing visually perceived events. Thus people mostly talk about what they see. Language production is automatic and fluent; however, creation of a simple sentence is preceded by a chain of choices concerning the grammatical, lexical and phonetic structure of the sentence. According to Myachykov, Thompson, Garrod, & Scheepers (2011) psycholinguistic theories propose that these choices are systematic, because they follow the rules of regular interface between language and cognition. This is the interface between mechanisms of attention and perception and mechanisms of language production. It is important to describe how the process of sentence production works. This will be followed by evaluation of results in the background literature regarding the role of attention in sentence production.

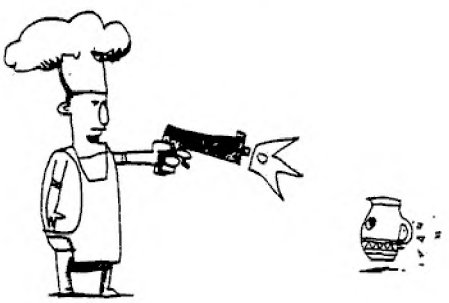
Describing visual events with language is a simple task. Although this process is automatic, it involves different linguistic and non-linguistic mechanisms. The description of this process is essential in understanding how these processes interact and how manipulating different stages can affect language production. The first step is the message. The message is an abstract representation of a perceived event (Levelt, 1989, as quoted in Myachykov, Thompson, Garrod, & Scheepers, 2012a). Message is generated on the basis of the information received about an event. This information is delivered through various perceptual modalities (visual, auditory). The important components of information are filtered out by the mechanism of attention. Attention filters the incoming information about the event creating a message. Consecutively this message will be transformed into a sentence. The second step is translation of the message into linguistic form (Myachykov et al., 2012a). The transformation involves choosing relevant words and assigning lexical and grammatical structure (Ibid.). Here the focus of attention plays a crucial role, as it guides the translation process through the event by choosing relevant information (Ibid.). The choice is highly dependent on the properties of the referent, which make it more salient in comparison to other possibilities (Ibid.). There are two types of cues that can increase the referential salience: exogenous and endogenous (Ibid.). Endogenous cues derive from a speaker's own knowledge, while exogenous cues are properties of the referent: size, color, etc. (Ibid.). The referent which has outstanding properties may then occupy a central role in the message (Ibid.). When the process of translation into a linguistic form starts, this referent would have already been emphasized and will be assigned the subject role in a sentence (Ibid.).

For example, look at the event in Figure 1. Although it is possible to assign the subject role to the jar (*The jar is shot by the chef*), it is highly improbable for several reasons. First of all, in this event there is only one animated referent – the chef. Animated referents tend to capture attention and have more preference to occupy the grammatical role of a subject in a sentence compared to inanimate referents (Myachykov et al., 2011). Secondly, the chef is larger, has a gun and performs an action – these make him more salient compared to the jar. Both these exogenous cues will lead to attention being occupied by the chef. During language production the chef will receive the subject position in a sentence by being more salient compared to the jar.

There have been various setups to test the effects of visual information on language production. In this study the focus will be on a visual cueing paradigm. The visual cueing paradigm (Posner, 1980) has long been an intriguing matter of research in the area of psycholinguistics (see Myachykov et al., 2011 for review). The procedure for testing the visual cueing paradigm is simple and elegant and it has been retested multiple times. Usually the attention of the participant is manipulated by means of a visual cue to either of the referents in the scene. The outcome choice of a referent and a consecutive grammatical structure in the produced sentence is an independent variable. Previous research, which applied that methodology, found that visual cues affect the grammatical structure during speech production (Ibid.). Among the first to test the visual cueing paradigm using this methodology was Tomlin (1995 as quoted in Myachykov et al., 2011). Tomlin (1995 as quoted in Myachykov et al., 2011) hypothesised that the grammatical structure outcomes would be affected by the direction of attention. Attention has been manipulated via a visual cue. The Fish film experiment (Tomlin, 1995 as quoted in Myachykov et al., 2011) presented participants with a short animated cartoon of one fish eating the other. Prior to the event participants were presented with a visual cue. Tomlin found that when directing attention towards the agent fish active voice sentences totally dominated among other possible structures, whereas when the cue was on the patient fish participants tended to use passive voice structures over active ones. These results entailed Tomlin (1995 as quoted in

Figure 1

Transitive event "Chef shoots the jar"



Myachykov et al., 2011) to conclude that the subject role is assigned according to where the attentional focus is situated during the presentation of the stimuli. However, this study has been criticised for its methodology (Bock et al., 2004, as quoted in Myachykov et al., 2012a; Gleitman, January, Nappa, & Trueswell, 2007). A consecutive study by Gleitman et al. (2007) avoided some issues presented in Tomlin (1995 as quoted in Myachykov et al., 2012a) developing a better methodology. They found similar results, however, the effect of visual cues was smaller. They concluded that the apprehension of a scene and language production drives some overlapping processes, which increase the efficiency of the whole language system (Gleitman et al., 2007). Myachykov et al. (2012a) investigated how different types of visual cues affected grammatical structures in sentence production. They compared informative and uninformative cues to the referents' location. The attentional manipulation worked well in predicting the grammatical structure of a sentence, however, the type of a cue did not affect the outcome. Myachykov et al. (Ibid.) concluded that there must be a direct automatic mapping mechanism from attentional focus to the subject's position in a sentence. Similarly, a study by Myachykov, Garrod, & Scheepers (2012b) further supported the findings of previous research on the interaction between visual attention and language production. Thus it is possible to manipulate attention with visual cues and the effect of this manipulation can be clearly assessed through produced language. Manipulating attention with auditory cues will be discussed next.

Kostov and Janyan (2012) successfully directed covert attention with auditory stimuli. In their study participants had to respond bimanually whether an affordable object was presented upright or upside-down. Attention was manipulated via a moving sound or a countdown from the centre either to the left or to the right. Affordances were either congruent or incongruent with the direction of a cue. The reaction time was an independent measure of the experiment. Interestingly the results supported the attentional shift hypothesis – the attentional bias was inhibited in the condition when the affordance was incongruent with the attention direction. In this condition participants were significantly slower in responding. An important conclusion from these results is that attention is driven spatially by auditory cues and stays in that direction for some time. In a particular situation the focus of attention is driven by a single modality (in this case auditory) at a time and all other modalities follow the direction of a dominant modality. Thus it is possible to conclude that, when presented simultaneously, one modality will suppress the other.

Most previous research tested the effects of various linguistic and non-linguistic cues either separately or conjointly on language production (Myachykov et al., 2011), however, all research was focused on visually perceived types of cues: the referent preview (Myachykov et al., 2012a), the verb preview (Myachykov et al., 2012b), the location cue (Tomlin, 1995; Gleitman et al., 2007; Myachykov et al., 2012a, 2012b), etc. But a real life visually driven sentence production might also be affected by cues from other attention modalities, that in turn speaks about interactivity in the production system (Myachykov et al., 2012a). Previous research studied the interface between attention modalities (Spence & Driver, 2004; Fritz,

Elhilali, David, & Shamma, 2007; Shinn-Cunningham, 2008), however, they did not look at the way this interaction affects language production. Consequently in this research several issues will be addressed. First of all, do different attention modalities interact? This issue has been addressed through the testing visual cueing paradigm when auditory cueing is included. Both cues were proven to direct attention (Posner, 1980; Myachykov et al., 2011; Kostov & Janyan, 2012), but no research looked at the interaction between them. The methodology will be similar to Myachykov et al. (2012a) as it is one of the most recent studies in the field, which eliminated most previous methodological issues and successfully proved the effect of visual cues on sentence production. To test the interaction between modalities, cues of different types have been simultaneously presented. The conditions have differed in spatial position (left or right), which were connected with the consecutive place of one of the referents. The results of this interaction will be the amount of passive voice produced in event description sentences. Predictably the most passive voice production will be when both cues will direct attention to the patient of an event, the least – in condition when both cues are towards the agent. This will cause the discussion of cueing paradigm in sentence production. The issue of interaction between modalities will be seen from incongruent conditions. The pattern of results in incongruent cues condition is unpredictable. According to a cross-modal attention hypothesis (Spence & Driver, 2004), either one of the modalities will dominate and lead the focus of attention.

Methodology

Design

The main goal of the experiment was to test how different attention modalities interact and this interaction affects the grammatical structure of a sentence. A number of previous studies (Tomlin, 1995, 1997; Gleitman et al., 2007; Myachykov et al., 2011, 2012b, Myachikov, Ellis, Cangelosi, & Fischer, 2013) developed a well-designed method to test the interaction of language and attention paradigms. Similar methods, though manipulated in order to answer research questions, have been adopted here. Two factors (independent variables) have been manipulated at two levels — visual cue (location on the agent/patient) and auditory cue (location agent/patient). The interaction between cues was measured via the amount of passive voice sentences produced. This amount was a dependent variable. The interaction has been tested using the fully-crossed Latin square design with independent measures. It means that each stimuli picture had to be paired with all four variants of a cue's locations, however, each participant would have only once seen each picture in each condition. It has been achieved with four separate presentations.

Subjects

24 participants (17 Female, M age: 23.1) have been recruited from a research pool of undergraduate students from Northumbria University. All participants

indicated that they were native English speakers with normal or corrected to normal vision and no language or attentional disorders.

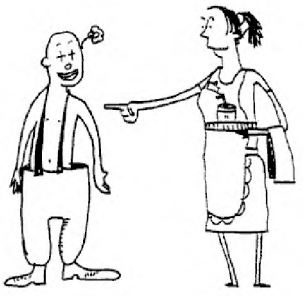
Materials

The experiment consisted of a 247 slide presentation. The first 25 slides were instruction and training session slides. The instruction included: information about the experiment, slides introducing characters and their names, and training trials. All characters and four training trials with examples of possible responses were included. Target pictures and fillers have been drawn from previous psycholinguistic studies (Myachykov et al., 2012a, 2012b). There were 24 experimental trials and 50 filler trials. Each experimental trial consisted of a fixation slide followed by a cue slide and a target picture slide (See Figure 2 for an example of a target picture). The participants' attention was manipulated via a presentation of visual and auditory cues. The cues have been presented simultaneously prior to a target picture. Visual attention has been driven by a red dot of 1 cm in diameter presented for 1 second. To shift the auditory attention a single 0.5 sec. beep was given to either left or right ear of a participant. Cues were either presented in congruence (on the left or right side) with each other or against each other. Thus it made four different conditions of cues and each target picture was to be shown in all four conditions in order to compare the effects of cues.

A review by Myachykov, Posner and Tomlin (2007) discussed how perceptual priming manipulates the structure of transitive events more effectively than intransitive ones. As that manipulation was crucial in the experiment target pictures depicted six simple transitive events between two referents (hit, shoot, chase, touch, push, kick). There were 15 characters (Artist, Chef, Clown, Cowboy, Monk, Nun Painter, Pirate, Policeman, Swimmer, Professor, Waitress, Burglar, Boxer, and Soldier). Each event was presented four times by different characters and was directed either left to right or right to left. In order for the target pictures to be in four conditions, four separate presentations have been designed. Each participant viewed only one presentation, which made it six participants in each condition.

Figure 2

Example stimulus of transitive event "Waitress touches clown"



Randomisation has been used throughout target pictures and all targets have been controlled for left and right orientation (12 events each). Filler pictures (four at the beginning of each list and two prior to each target trial) were similar to the target pictures. The difference was in that only one cue has been presented and there was a picture of either one or two characters performing transitive or intransitive events or not performing an action at all. At filler trials participants had to do the same task as at target trials (to describe a picture in one sentence). Fillers have been added to prevent participants applying strategies and to blur the exact purpose of the experiment.

Apparatus

The experiment was created in Microsoft PowerPoint (2007/2011). An ASUS laptop with 17' Inch display with a refresh rate of 60Hz has been used to run the presentation. All participants' responses were recorded. An iPhone with preinstalled application 'Voice Record' was used for the recording. All records have been transferred to the laptop for safe storage and analysis using Windows Media Player. Left and right auditory cues were created by silencing one of the sound channels in Cubase 5.1.1 sound editor and making two separate sound files. To deliver sound cues a pair of in-ear Philips headphones has been used.

Procedure

This research has been approved by the Department of Psychology UG Ethics Committee. Participants have been positioned 60 cm away from monitor and asked to put on the headphones. Prior to the start of the experiment the sound level was manipulated to prevent discomfort. At this point the audio recording started. Participants had verbally instructed to read out loud all the instructions, names of characters and example prompts. Importantly, participants were instructed to focus their attention on both cues. After reading instructions participants were introduced to characters. Characters were shown with their names written below. This was done to familiarise participants with referent's names because of to the ambiguity of the drawings. Participants were instructed to try to remember names of characters as they were to be used in session. Secondly, there was a training session. Participants were instructed to focus on the 'plus' in the 'focus' slide, then press the spacebar, then on a 'cue' slide they were told to drive their attention to both visual and auditory cues, without pressing or saying anything, finally the participants received a target picture, which they had to describe. A description should have involved an action on the picture and names of all referents presented. The training session involved 4 trials: 2 filler trials and 2 experimental trials. First trial has been followed by example sentences. After finishing with training participants were asked about any questions and if none appeared they proceeded to the experimental session. The experimental session consisted of 24 experimental trials and 50 filler trials. During the session notes on grammatical choice have been done. At the conclusion participants were debriefed and asked if they had any questions.

All grammatical choices were then analysed in order to answer the research question.

Results

The produced verbal sentences have been coded as either being active voice, passive voice and patient first. A sentence was coded in Active condition if it had a transitive verb and if the subject role was assigned to an agent (Figure 2 *The waitress touches the clown*). To be coded as passive voice, the transitive verb had to be in passive construction and the subject role be assigned to a patient (Figure 1 *The clown is touched by the waitress*). To be coded as patient first, the only criterion was the subject role assigned to a patient (Figure 2 *Clown and waitress are holding hands*). However, on most occasions the assignment of the subject role to a patient was paired with a passive voice. In cases when the utterance produced did not fit any criteria it was left blank. Table 1 shows descriptive statistics of the percentage of passive voice produced across conditions and Figure 3 visualizes cue interactions.

From the pattern of means it can be judged that only visual cue affected the amount of passive voice — 7% and 6% more passive in Visual Patient condition. Also it can be said that Auditory cue did not affect the amount of passive voice — null difference between VA/AA and VA/AP and 1% difference between VP/AA and VP/AP. Interestingly the predicted VP/AP condition produced less passive then VP/AA condition — 19% and 20% respectively. Further analysis was conducted to measure the significance of the effects.

IBM SPSS 21 was used to analyse data. Each participant produced four scores for four conditions in each questionnaire. These scores were the amount of passive voice produced as percentages for particular conditions. They were transferred into SPSS for the analysis. To understand whether the position of the cues affected the grammatical structure and whether there was an interaction between the type of cues, the 2×2 Repeated measures ANOVA has been used. The effects of cues on the amount of passive voice are summarised in Table 2. It was expected that visual cue would show significant effect on the amount of passive voice produced. However, the results showed no effect of visual cues: $F(1, 23)= 1.53, p >.23$. It is important to mention though that this effect is still stronger than the effect of auditory cues: $F(1, 23)=.17, p >.68$. These results do not support previous findings regarding the

Table 1

Mean and SD of passive voice across conditions

Condition (N = 24)	Mean	SD
Visual Agent/Auditory Agent	13%	15
Visual Agent/Auditory Patient	13%	16
Visual Patient/Auditory Agent	20%	22
Visual Patient/Auditory Patient	19%	19

Figure 3

Visualised interaction of visual and auditory cues

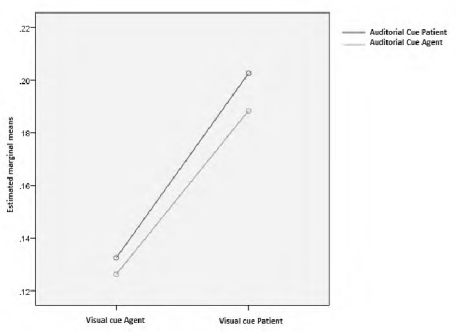


Table 2

ANOVA on the effect of Cue location on the amount of passive voice structures produced

Cue type	*df*	*F*-value	*p*-value
Visual cue	1.23	1.53	.23
Auditory cue	1.23	0.17	.68

effects of visual cue on grammatical structure. Similarly there was no effect of auditory cues on the amount of passive voice produced.

Discussion

The aim of this experiment was to test how directing the attention of the speaker by the simultaneous presentation of uninformative visual and auditory location cues to a particular referent effects the grammatical structure of a produced descriptive sentence. Secondly, the interactions between visual and auditory modalities have been assessed on the basis of these results. Based on previous research on attention and interaction of attention and language production we studied the way the focus of the speaker's attention is affected by the presentation of cues from different attentional modalities and whether the grammatical structure is affected by the modality type of a cue presented.

Both visual and auditory cues failed to significantly change the grammatical choice. No significant difference in the amount of passive voice produced has been shown between the conditions. This finding declines the hypothesis of the effects of visual cueing on grammatical structures of sentences. However, although this interaction is not significant, there is still a mentionable difference between the conditions. In Figure 3 it is clearly seen that in conditions where a visual cue was on the position of the patient there were more passive voice produced. There are several possible explanations for this pattern of results.

Attentional bias could have vanished with the target stimuli present. A cue slide has been presented for 1000 ms (it is possible that this time was enough for bias caused by cues to disappear). Furthermore, the difference in the timescale between cues might have also affected perception. In Kostov and Janyan (2012), for example, an auditory cue directed attention gradually from the centre to a side and for 5 seconds. In this experiment the length of the cue (0.5 sec) might simply have not been enough to challenge a 1-second visual cue.

It seems from the means that the visual cues were more effective in directing attention than the auditory cues. The cross-modal attention hypothesis is then supported. Means of incongruent conditions (VA/AP and VP/AA) are slightly different: more passive is in condition VP/AA. Thus it appears that when auditory cues challenge visual cues in driving attention - visual dominates. Moreover, it appears that attention has either skipped or inhibited the effect caused by auditory cues. This, in turn, might lead to a conclusion that in terms of directing attention visual cues are more effective than auditory cues. This interaction further supports the evidence of Reisberg's study (1978) which found that adults tend to listen in the direction they are looking.

One of the main limitations is that the gap between cues and stimuli pictures was obvious. Attention could have changed the direction during that gap. This can be eliminated by combining cues and target pictures on one slide. For example a visual attention can be manipulated via the colour of a referent or by being presented next to a referent or over a referent. Also the length of both cues has to be the same. As it was said above one of the reasons for the auditory cue being inhibited might have been the fact that visual cue has been presented for longer. Different types of cue presentation should also be tested. In Kostov and Janyan (2012) auditory attention has been guided by a countdown (in voice or in tone) from middle to the side for 5 seconds. Similar manipulation can be tested for visual and auditory cues. A visual cue can change its position from the middle of a visual field to a position of the referent, whilst the same will happen to an auditory cue. Thus, that type of presentation will clearly define what type of cue will dominate.

Another possible limitation is the stimuli themselves. Although target pictures have been taken from a previous study (Myachykov et al., 2012a, 2012b), which found significant results with these stimuli, there are some issues with them. These cartoon-like pictures presented characters each with some outstanding properties. These properties have not had controls. For example, in the event 'pirate chases boxer' (Fig. 3) the pirate has a sword. This is a weapon and thus the participant's attention could have been locked on it. This is supported by the fact that out of all participants in all conditions the pirate has been always assigned a subject role. Furthermore, it was mentioned by some participants that they thought that they described an interaction between 'negative' and 'positive' characters (pirate, burglar vs. nun, doctor etc.). It is possible that participants had a bias towards characters with 'good' attitudes. Consecutive studies should also control for that bias by using only one character type (e.g. a positive type) or counterbalancing them. In addition to the properties of the characters, participants have distinguished that some actions performed by the characters were aggressive. Out of six transitive events used in the study four were aggressive (hit, kick, push and shoot). This needs to be counterbalanced.

Last but not the least limitation is allowing participants unregulated time to produce a sentence. Although participants have been instructed to produce sentences as soon as they saw the stimuli, they were not limited in the amount of time to watch the pictures. This is another reason why the manipulation of attention might not have worked well. It is obvious that several seconds is enough for an

event to be grasped. Limiting the exposure of the stimuli for 1–3 seconds will enable a more confident discussion of the effects of the cues. Avoiding these methodological flaws could have provided robust results of modular interaction and effects of this interaction on language production.

Some new directions for future research have developed. Visual stimuli obviously dominated auditory ones, however, this was checked for uninformative types of cues. But will visual modules dominate auditory ones if cues were informative? For example, the word representing the name or the preview of one of the referents appears on the screen, whilst the name of the other referent is delivered via auditory channel. The final sentence will show which type of the stimuli dominates during informative cueing. These findings will further link the cross-modal attention (Spence & Driver , 2004) and the language production mechanism (Myachykov et al., 2011) through developing understanding about perceptual links between auditory and visual modalities. Further studies should avoid the limitations already discussed regarding this research.

This research has concluded that the interaction of different attentional modalities is linked to language production. Uninformative cues were shown to fail in directing attention. However, when judged on the type of a cue, obviously visual uninformative cues were more successful in directing attention as the amount of produced passive voice showed. New questions have arisen concerning modular interactions and the effects of these interactions on grammatical structures will require further research. Specifically the information delivered by the cue may probably change the pattern of received results.

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Эффекты визуального и аудиторного маркирования внимания на синтаксический выбор при порождении предложений

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Резюме

Одной из тем в современной психолингвистике является изучение факторов, влияющих на выбор синтаксиса при порождении предложений. Предыдущие исследования показывают, что синтаксический выбор обусловлен взаимодействием лингвистических и нелингвистических факторов. Одним из этих факторов является внимание говорящего, направленное на элементы описываемого события. Одновременно, наше внимание получает сигналы от ряда модальностей (например, слуховой, моторной, обонятельной и т.д.). Впоследствии внимание фильтрует получаемую информацию, основываясь на ряде факторов (например, на выделенности сигнала), и направляет ресурсы на обработку наиболее важного сигнала в данный момент. Исходя из этого, возникает вопрос о влиянии других модальностей системы внимания на синтаксический выбор. Основной объем предыдущих исследований был проведен с использованием визуальной модальности. Поэтому в этом исследовании мы стремились понять, влияет ли слуховое и визуальное внимание на выбор грамматической структуры порождаемого предложения. Англоговорящие испытуемые описывали изображения простых транзитивных событий, в то время как их внимание праймировалось на местоположение агенца или пациенца события с помощью звукового (монофонического сигнала) или визуального (красного круга) эксплицитного сигнала. Зависимой переменной, как и в предыдущих исследованиях, мы выбрали количество порождаемых пассивных структур. Наши результаты не показали значимых результатов, однако наблюдалась заметная тенденция выбора пассивных структур при маркировании пациенса зрительным маркером.

Ключевые слова: синтаксический выбор, грамматика, внимание, прайминг.

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