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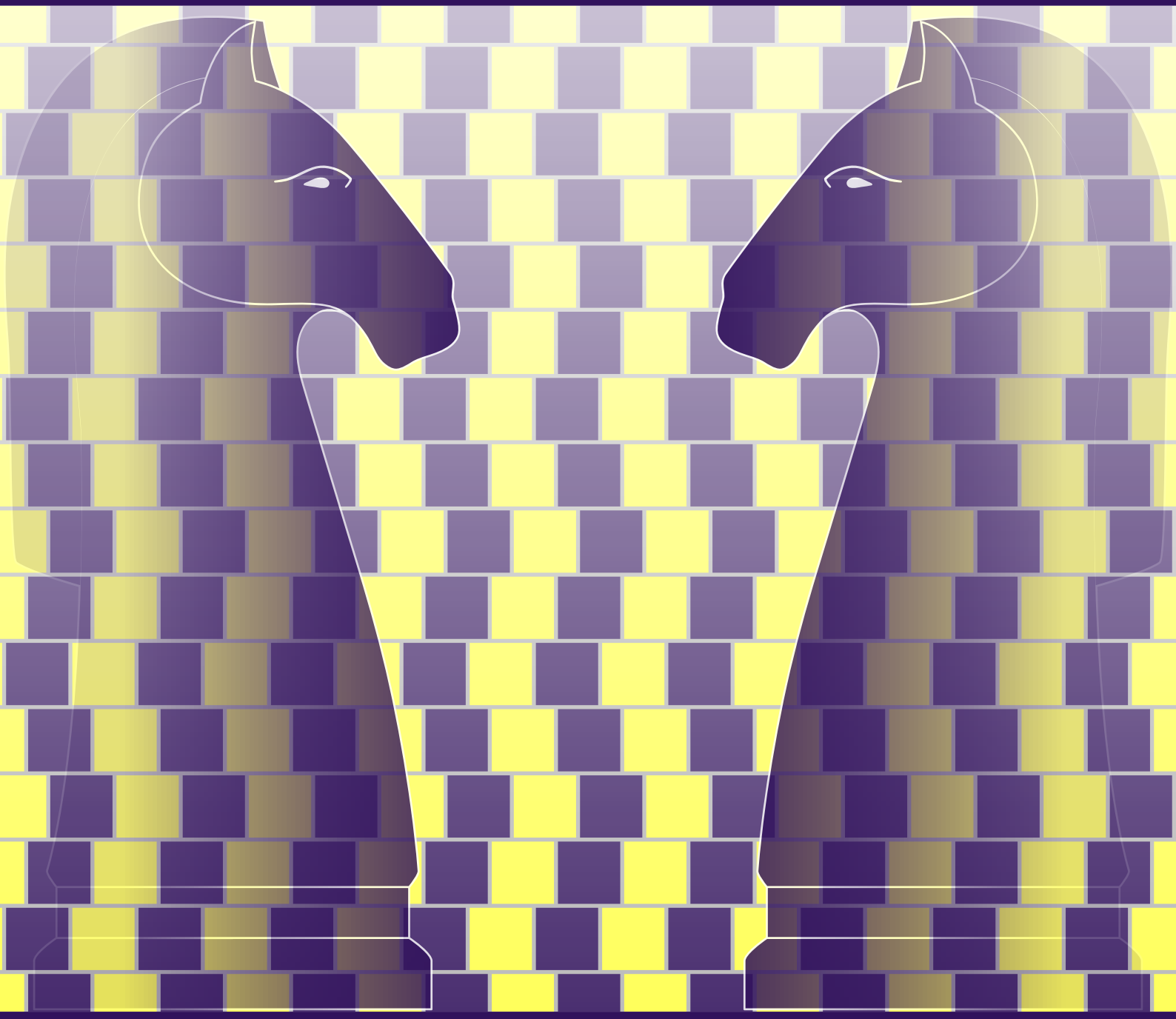

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Contents

Оглавление

От редакции

Представляем вниманию читателей первый выпуск нового рецензируемого электронного журнала — Российского журнала когнитивной науки. Под когнитивной наукой мы понимаем междисциплинарную область исследований познания, которое в широком смысле может быть описано как приобретение, хранение, преобразование и использование знания живыми и искусственными системами.

Когнитивная наука ведет свою официальную историю с 1950-х годов и к настоящему моменту в Западной Европе, США и Канаде является уже развитой отраслью знания. В России же институционализация когнитивных исследований познания, проводившихся в таких областях, как экспериментальная психология, нейропсихология, нейрофизиология, лингвистика и искусственный интеллект, которые исходно не рассматривались российскими исследователями как части единого целого. Один из основателей американской когнитивной науки Джордж Миллер писал в своих воспоминаниях, что «двигался навстречу когнитивной науке в течение двадцати лет, прежде чем узнал, как она называется» (Miller, 1979, p. 9)[1]. Российские ученые повторили его историю, поскольку многие, лишь оказавшись на семинаре или конференции по когнитивной науке с удивлением обнаруживали, что их исследования прямо относятся к этой области.

В 2000-е годы самоорганизация российских исследователей-когнитивистов происходила быстрее, чем в свое время в США. Московский семинар по когнитивной науке начал свою работу в 2002 году. Первая Российская конференция по когнитивной науке состоялась в Казани в 2004 году и получила продолжение в виде серии Международных конференций по когнитивной науке, проходящих в России каждые два года. В том же году была образована Межрегиональная ассоциация когнитивных исследований. В 2008 году открылась магистратура по когнитивной психологии и когнитивной науке в Российском государственном гуманитарном университете, а в 2010 году состоялся ее первый выпуск.

В 2010-е годы появились новые серии семинаров и конференций. С 2011 года проходят конференции стендовых докладов «Когнитивная наука в Москве: новые исследования», в которых активно принимают участие не только московские исследователи, но и коллеги из других городов и из-за рубежа. Коллегами из Москвы и Санкт-Петербурга совместно проводятся ежегодные семинары «Великая иллюзия сознания». Стали активнее взаимодействовать исследовательские группы когнитивистов не только из Москвы и Санкт-Петербурга, но и из Казани, Томска, Ярославля, Самары, Новосибирска.

Именно преодоление изоляции и налаживание контактов — с учеными, работающими в других областях знания, живущими в других городах и других странах — стало одной из самых сложных задач, стоящих перед российскими учеными, занимающимися междисциплинарными исследованиями познания. Отечественные когнитивисты часто встречаются с неприятием своих работ исключительно в связи с их междисциплинарным характером, поскольку это «не психология», «не физиология», «не лингвистика». Вынужденная изоляция советской науки от международного научного сообщества за многие годы также сформировала предпосылки к географической и культурной самоизоляции. Однако ставшее традиционным ограничение профессиональной коммуникации сейчас уже во многих случаях является добровольным, а барьер, который заставляет отечественных ученых предпочитать при публикации своих результатов российские журналы международным, носит в значительной степени субъективный характер.

Новый журнал призван стимулировать обмен информацией, с одной стороны, между представителями разных научных дисциплин, которых объединяет интерес к исследованиям познания, а с другой — предоставить российским исследователям возможность публиковать свои результаты и идеи не только на русском, но и на английском языке, который в настоящее время является общепринятым языком международного общения.

Нам особенно приятно, что в первый выпуск нового журнала вошли не только статьи российских исследователей, но и статья сотрудников Центрально- и Восточноевропейского центра когнитивной науки (София, Болгария), который для очень многих из нас стал окном не только в Европу, но и в мир когнитивной науки.

Время вносит свои коррективы в форматы научной коммуникации, и новый журнал будет выходить уже исключительно в электронном виде (символично, что и десять лет назад первой очной российской конференции по когнитивной науке предшествовала Интернет-конференция). Мы надеемся, что свободный доступ к статьям также сыграет свою положительную роль в распространении информации о достижениях российской (и не только) когнитивной науки среди отечественных и зарубежных ученых.

Желаем вам интересного чтения и надеемся, что многие из читателей со временем станут также и авторами нашего журнала.

Екатерина Печенкова, главный редактор
«Российского журнала когнитивной науки»

[1] Miller, G. A. (1979). A very personal history. Massachusetts Institute of Technology, Center for Cognitive Science.

Editorial

We are pleased to introduce the first issue of the new peer-reviewed electronic journal *The Russian Journal of Cognitive Science*. Cognitive science refers to an interdisciplinary field focused on studies of cognition; the latter may be broadly described as the acquisition, maintenance, transformation and usage of knowledge by living and artificial systems.

The history of the cognitive science movement may be traced back to the 1950s. By now it is a well developed branch of knowledge in Western Europe, the United States and Canada. In Russia, however, the institutionalization of cognitive studies is relatively recent, about a half century behind those western countries. At the same time, the groundwork for the study of cognitive science in Russia was laid by decades of research on cognition in cognitive psychology, neuropsychology, neurophysiology, linguistics and artificial intelligence, although these disciplines initially were not considered as parts of the single whole. George Miller, one of the founders of the American cognitive science movement, wrote in his memoirs: "I have been working toward a cognitive science for about twenty years beginning before I knew what to call it" (Miller, 1979)[1]. Many Russian scientists followed a similar path, and only when they first attended a special seminar or a conference on cognitive science, did they realize that their work contributes to this field.

In the first decade of the new millennium, the self-organization of the Russian cognitive scientists developed faster than that of our American predecessors at their time. The Moscow Cognitive Science Seminar started in 2002. The first Russian Conference on Cognitive Science took place in Kazan in 2004 and was continued by a series of the International Conferences on Cognitive Science held in Russia biannually since then. Also in 2004, the Russia-based Interregional Association for Cognitive Studies (IACS) was organized. In 2008 the first Master-level program in cognitive psychology and cognitive sciences debuted at the Russian State University for Humanities, and the first graduation from this program took place in 2010.

The present decade have seen a growth in the number of regular workshops and conferences. The poster-only conference "Cognitive Science in Moscow: New Research" began in 2011; it brings together not only Moscow researchers, but scientists from other cities and countries as well. Our colleagues from Moscow and Saint-Petersburg organize the annual workshop "The Grand Illusion of Consciousness". Beyond Moscow and Saint-Petersburg, research groups from Kazan, Tomsk, Yaroslavl, Samara, and Novosibirsk are becoming involved in more intense research interactions.

Russian researchers have confronted a difficult task in overcoming isolation and establishing communication with scientists from other disciplines, other cities and other countries. Russian cognitive scientists often face intolerance of their work solely because it is interdisciplinary and therefore "not psychology", "not physiology", "not linguistics". Enforced isolation of the Soviet sciences from the international academic community for many years formed a strong background for geographical and cultural self-isolation. Constraints on professional communication became traditional and are often willingly continued; the barrier that makes Russian scientists prefer local journals to international ones is nowadays largely subjective.

The mission of the new journal is to encourage the communication between the academics from different disciplines who share an interest in cognitive studies, and to provide an outlet for Russian researchers to publish their results and ideas not only in Russian, but also in English, which is now broadly accepted as a language of international communication.

We are especially pleased by the fact that in the first issue of the new journal the articles by Russian researchers are complemented with a paper by colleagues from the Central and East European Center for Cognitive Science (Sofia, Bulgaria) which for many of us has become a window not only to Europe, but to the field of cognitive science as well.

The format of scientific communication has changed over time, and the new journal will be published only online. Indeed, it is remarkable that ten years ago the first Russian on-site Conference on Cognitive Science was preceded by the first online Russian Internet Conference on Cognitive Science. We believe that open access to the articles will also play a positive role in the dissemination of the advances and discoveries in cognitive science within Russian and in the international academic community.

We wish you an interesting reading and hope that many of our readers will eventually become our authors.

Ekaterina Pechenkova
Editor-in-Chief

[1] Miller, G. A. (1979). A very personal history. Massachusetts Institute of Technology, Center for Cognitive Science. P. 9.

The role of potential referential conflict in the choice of a referring expression

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Abstract. The present survey focuses on the phenomenon of referential ambiguity, or referential conflict, i.e., the discourse situation in which two or more referents are activated high enough to be chosen the antecedent of a reduced referring expression. While permanent ambiguity occurs occasionally and is quite uncommon, potential ambiguity is pervasive in language and, thus, should be thoroughly studied. In addition to proposing the typology of referential conflicts, this study seeks to give an explanation of the effects related to the potential referential conflicts that are described in the literature. It proposes a model of the referential conflict that accounts for the choice of the referential strategy made by the speaker depending on whether she or he precludes referential conflicts or not. Finally, from examining the past work on the topic as well as analyzing the results of the current experiment on Russian material, a general model of referential choice is presented which should place the mechanism responsible for the preclusion of referential conflict as a separate module rather than reckoning referential ambiguity among the factors which lower the activation of a referent, as it has been proposed by some researchers.

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Keywords: discourse, ambiguity, reference, referential choice, potential referential conflict, preclusion of referential conflict

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Introduction. Reference and ambiguity: The tension between explicitness and efficiency

One of the central aspects of language use is the process of *reference* — speakers or writers refer to a particular entity that they have in mind, i.e., the *referent*. When they subsequently refer back to the same referent to provide new information about it, this phenomenon of repeated mention of a referent is known as *anaphora*. In order for communication to be successful, the listener or the reader must recognize what the speaker or the writer is referring to. Meanwhile, human beings have limited resources of time, and a general desire to make their communication as economical as possible. One way to make communication more efficient is to use a shorter and a simpler linguistic element, i.e., a *referring expression*, such as a pronoun or an anaphoric zero. In this case, however, a reduced referring expression can refer to more than one referent, establishing *coreference* — deciding that two different referring expressions refer to the same referent.

If it is unclear to a listener or reader what a reduced referring expression is refers to, then the expression is referentially ambiguous. Generally, ambiguity is a pervasive phenomenon in language which occurs at all levels of linguistic analysis — in phonetics, morphology, syntax and discourse. Some linguists argue that the key structures of language have not evolved for purposes of communication precisely because of ambiguity. "The natural approach has always been: Is [language] well designed for use, understood typically as use for communication? I think that's the wrong question. ... If you want to make sure that we never misunderstand one another, for that purpose language

is not well designed, because you have such properties as ambiguity. If we want to have the property that the things that we usually would like to say come out short and simple, well, it probably doesn't have that property." (Chomsky, 2002: 107).

As pointed out by Piantadosi and colleagues (2012), however, contrary to the Chomskyan view, "Ambiguity is in fact a desirable property of communication systems, precisely because it allows for a communication system which is short and simple" (Piantadosi, Tily, & Gibson 2012: 281). The authors proposed two beneficial properties of ambiguity: "First, where context is informative about meaning, unambiguous language is partly redundant with the context and therefore inefficient; and second, ambiguity allows the re-use of words and sounds which are more easily produced or understood" (Piantadosi et al., 2012: 281). Ambiguity is therefore a functional property of language, and the investigation of this phenomenon contributes to the knowledge about how people use language in communication.

This survey focuses on referential ambiguity, or *referential conflict*[1], namely, the issue of how speakers choose a particular referring expression amongst alternatives in a situation of potential referential conflict. The structure of the paper is as follows. Section 1 focuses on the choice of a particular referring expression for a referent, or the *referential choice*[2] that is made by the speaker on the basis of a number of various factors. Section 2 addresses the typology of referential conflicts. In Section 3, I consider the case of the potential referential conflict when there are two highly activated referents of the same or different conceptual genders. The Section 4 summarizes and discusses the major findings and proposes the model that underlies the speaker's choice of referring expressions in a situation of referential conflict.

1. Referential choice: Factors and models

When a speaker mentions a referent, she or he chooses from a multitude of different kinds of referring expressions — various full noun phrases (NPs), pronouns, and anaphoric zeroes. Which factors determine the preference for a particular referring expression over the alternatives? Is there a model which best describes the referential choice? This section considers early accounts of referential choice (Subsection 1.1) as well as the cognitive multi-factorial model of referential choice proposed in Kibrik (2011) (see Subsection 1.2).

1.1. Past accounts of referential choice

It is widely believed that a speaker does not choose referring expressions randomly. Almost all researchers explain the choice of a particular referring expression by its appeal to the cognitive status of the referent in the speaker's and the addressee's minds. There seems to be a general assumption that when the referent is highly active or available in the discourse participants' minds, less explicit referring expressions such as pronouns or anaphoric zeroes tend to be used, whereas when the referent is less active or available, more explicit referring expressions such as proper names and definite NPs are preferred. At the same time the full palette of ideas and cognitive notions is employed to identify the processes and mechanisms of the choice of referring expressions. Some of the terms that are used to describe the referential choice are: focusing, memory, activation, consciousness, salience, prominence, accessibility, and topicality.

There are traditionally two different views on the phenomenon of referential choice, adopted in theoretical linguistics and psycholinguistics respectively. The former concentrates on identifying different factors that determine the referential choice and their relation to different types of referring expressions. The latter focuses on how these factors are used during language production and comprehension. Note that the majority of psycholinguists deal with interpretations of referring expressions by the addressee, i.e., *reference resolution*. See linguistic and psycholinguistic surveys in Garnham (2001).

Among the landmark studies in functional linguistics relevant to the present study are the Topic Continuity Hypothesis by Givón (1983), the Accessibility Hierarchy by Ariel (1988, 1990), and the Givenness Hierarchy by Gundel et al. (1993) which elaborated on Chafe's (1976) discussion of givenness. Researchers recognize different linguistic properties affecting the referential choice, including: (1) referential distance between the antecedent and the anaphor; (2) potential interference, i.e., how many potential antecedents of the referring expression are present in the discourse; (3) persistence, i.e., how long the referent remains in the discourse; (4) saliency of the antecedent, which is determined by whether it is a topic or not; (5) unity, i.e., whether the antecedent is within the same episode or not (Givón, 1983; Ariel, 1988 and 1990); and (6) rhetorical structure of the discourse (Fox, 1987).

Some psycholinguistic research has shown that speakers use more reduced referential forms when the referent is the subject in sentence-initial position (subjecthood) rather than a second-mentioned object (e. g., Arnold, 2001). The results are consistent with theoretical accounts which claim that the referent's accessibility is affected by the antecedent's grammatical role (Centering Theory by Grosz, Weinstein, & Joshi, 1995) or the antecedent's sentence position (Gernsbacher & Hargreaves, 1988). The research based on Finnish data suggests that both the antecedent's grammatical role and its sentence position influence the accessibility of the referent (Järvikivi, van Gompel, Hyönä, & Bertram). Another factor is parallelism. First proposed by Sheldon (1974), this hypothesis refers to the increased accessibility of antecedents in the same grammatical position — subject, object, or other — as in the preceding clause (see Arnold, 2008 for a review). Implicit causality is a phenomenon associated with certain verbs that are biased either towards the subject or towards the object. Several researchers argued that this is because certain semantic roles are more likely to be seen as the cause of the event denoted by the verb. Some psycholinguists identify ambiguity as another factor affecting the activation

[1] The term 'referential conflict' was introduced in Kibrik, 1987.

[2] In the paper the term 'referential choice' is used that was first mentioned in the Pear Stories (Chafe, 1980); it is not common, but see Arnold & Griffin, 2007 or Kibrik, 2011.

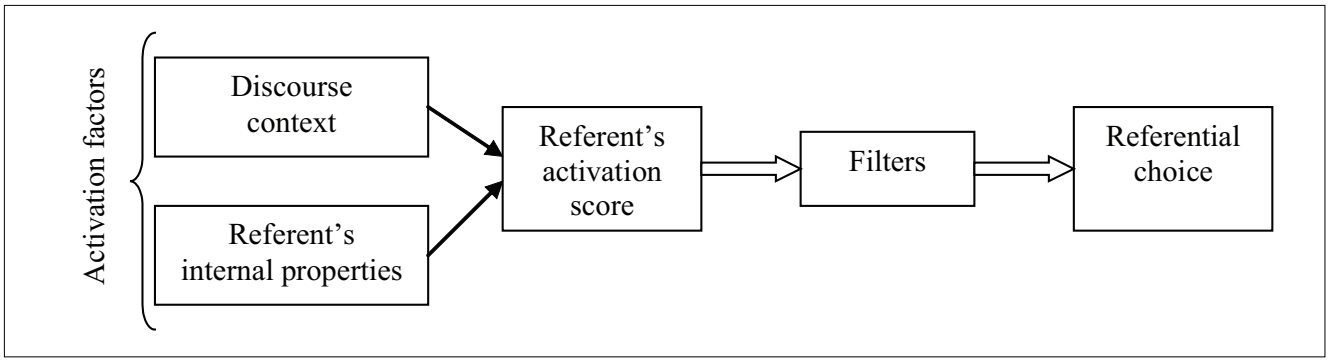

Figure 1. The Cognitive multi-factorial model of referential choice (reproduced from Kibrik 2011: 394, with the permission of the author)

in the speaker's mind (e.g., McDonald & MacWhinney, 1990), but the present study put the phenomenon within another component of the Model of Referential Conflict.

Past accounts of referential choice — linguistic and psycholinguistic — have generally focused on the roles of one or a few factors in establishing reference. In contrast with previous work, the purpose of the cognitive account by Kibrik (2011) is to pull together many different factors into one general framework, namely, the Cognitive Multi-factorial Model of referential choice.

1.2. Cognitive multi-factorial model of referential choice by Kibrik (2011)

Many theories of reference and referential choice suggest that cognitive concepts of attention and memory are the critical constraints in speakers' calculations about which referential forms to use (Chafe, 1994; Gundel et al., 1993; Givón, 1993; Rosa & Arnold, 2011). According to Kibrik, the notions of reference and referential choice are not synonymous: Reference is a process referring to a speaker's decision to mention a certain referent at a certain moment in discourse, while referential choice denotes the process of choosing a certain referring expression amongst others. In Kibrik's (2011) model, the attention to a referent determines its reference while the activation in the speaker's working memory determines referential choice.

According to this model the referential choice is made by the speaker on the basis of different factors that are hereby called activation factors, falling into two categories: discourse context and referent's internal properties, see Fig. 1. The first category of activation factors includes rhetorical, linear, and paragraph distances to the antecedent, syntactic and semantic roles of the antecedent, the antecedent's referential form, the referential, syntactic and semantic roles of the current mention, sloppy identity of referents, supercontiguity, temporal or spatial shift, predictability, and introductory antecedent. The second category includes animacy and protagonisthood.

In Kibrik (2011) an approach is adopted that allows the description of the integration of activation factors, hereby called the activation score, in each moment of the discourse stream. Each factor of activation is ascribed a certain value; in sum, the activation score can range from 0 to 1. The scale has some thresholds; for example, if an activation score is below a certain threshold, a full NP is used; otherwise, a reduced form is possible. Note that some values allow for a free choice between the two alternatives.

Finally, a separate component of the model — 'Filters' — consists of the world boundary filter that blocks a reduced form of a referent activated in an alternative 'world', and the referential conflict filter that allows to revise a reduced referring expression if it can create the ambiguity effect for the addressee.

In Section 4, a new model of the referential choice is proposed, which is a modification of the model described here.

2. Typology of referential conflicts

From the addressee's perspective, a more general definition of referential conflict says that a referential conflict arises whenever the addressee is unable to select a unique referent for a referring expression out of multiple alternatives. From the speaker's perspective, according to the Cognitive Multi-factorial Model, a referential conflict can take place whenever two or more referents are activated, and activation scores of all of them allow using a reduced form.[1] This section examines different types of referential conflicts from the addressee's (Subsection 2.1) and the speaker's (Subsection 2.2) perspectives.

2.1. Referential conflict from the addressee's perspective

Two distinctions are used in discussing this topic. The first distinction is between precluded and actual referential conflicts. A precluded referential conflict occurs when in the presence of all above-mentioned prerequisites (high activation scores for two or more referents) there are some linguistic devices that help the addressee to tease apart two or more alternatives; see examples below:

(1) My sister$_i$ was very fond of her new schoolmaster$_j$. **She$_i$**/**He$_j$** always arrived in the classroom ten minutes early.[2]

(2) At a quarter to nine the laboratory assistant Petrov$_i$, all out of breath from running, rushed into the room, but it turned out that the department chair$_j$ still wasn't there. Of course, the **secretarial/executive** position obliged him$_i$/

[1] Referential conflict is more probable with reduced referring expression, but it can related to the full NPs as well.

[2] In all examples the following conventions are used. An anaphoric referring expression and its antecedent have the same index; the first-mentioned referent is underlined, the second-mentioned referent is double-underlined; referential aids are boldface; ambiguous fragments are italicized.

him$_j$ to come on time. In addition, an appointment was scheduled for half past eight, and the visitor was already waiting in the hall.

(3) For over a year Katya$_i$ has been extremely worried for her niece$_j$. Except for **the niece/Katya**, she$_i$/she$_j$ had no other close relatives.

(4) My sister$_i$ was very fond of her new schoolmistress$_j$, **so/because** she$_i$/she$_j$ always arrived in the classroom ten minutes early.

These linguistic devices that help the addressee to preclude referential conflicts are hereby called deconflicters (Kibrik, 2011: 287ff.)[1]. Kibrik distinguishes two classes of deconflicters: conventional and ad hoc. Conventional deconflicters refer to lexico-grammatical categories, such as gender (Ex. 1), number, etc. Ad hoc deconflicters are based on semantic compatibility with the context and the encyclopedic information (Ex. 2) and the engagement factor[2] (Ex. 3). For the same notion Givón (1983) used the term 'potential interference', and Foley and Van Valin (1984) used the terms 'inference system' or 'pragmatic system'. It is possible to discriminate the third class — implicit causality (Ex. 4) — that differs from the two others because the phenomenon of implicit causality relates to attention (and therefore to reference), but not to activation in working memory (and therefore to referential choice). Moreover, experiments by Fukumura and van Gompel (2010) showed no evidence that semantic biases affect the choice of anaphor: participants produced more reduced referring expressions when referring to the first-mentioned subjects than to the second-mentioned objects. So, the factor 'implicit causality' is not among activation factors. This factor is excluded from the list of referential aids influencing preclusion of referential conflict as well (see below). However, implicit causality likely helps the addressee to preclude referential conflicts. Implicit causality thus is a factor related to which deconflicters and referential aids are distinguished.

The second distinction is the one within actual referential conflict, namely, between temporarily and permanently ambiguous referential situations. The first situation — a temporary referential conflict — is actually quite common in everyday language use. Consider some examples:

(5) The schoolmistress$_i$ told my sister$_j$ that she$_i$/she$_j$ *certainly could* **conduct/take** an exam next Thursday.

(6) My sister$_i$ was very fond of her new schoolmistress$_j$. She$_i$/She$_j$ *always arrived in the classroom ten minutes early to* Ø$_i$/Ø$_j$ **be able to sit in the front row/chat with her students**.

(7) The cat$_i$ smelled the dog$_j$ only when it$_i$/it$_j$ *ran out in the road. Then, having stopped in the middle of the road,* it$_i$/it$_j$ *suddenly* **meowed/barked**.

(8) My sister$_i$ was very fond of her new schoolmistress$_j$. She$_i$/She$_j$ *always arrived in the classroom ten minutes early* to Ø$_i$/Ø$_j$ *better prepare for the class.*

But today **my sister/the schoolmistress** was forced to be late.

In all these examples, the addressee is unable to determine the antecedent[3] during some discourse fragment: within a clause (Ex. 5), a sentence (Ex. 6), a paragraph (Ex. 7), and a whole discourse fragment (Ex. 8). The temporary referential conflict is resolved with the help of the deconflicters as well. The most common deconflicters in such cases are ad hoc ones.

The second situation within actual referential conflict — a permanent referential conflict — is not as common as the previous one. For example:

(9) The cat$_i$ smelled the dog$_j$ only when it$_i$/it$_j$ *ran out in the road.*

(10) My sister$_i$ was very fond of her new schoolmistress$_j$. She$_i$/She$_j$ *always arrived in the classroom ten minutes early* to Ø$_i$/Ø$_j$ *better prepare for the class.*

(11) At a quarter to nine the laboratory assistant Petrov$_i$, all out of breath from running, rushed into the room, but it turned out that the department chair$_j$ still wasn't there. Of course, the position obliged him$_i$/him$_j$ *to come on time. In addition, an appointment was scheduled for half past eight, and the visitor was already waiting in the hall.*

In these examples the addressee is unable to determine the antecedent of the reduced referring expression from start to finish. There is no resolution to the referential conflict.

2.2. Referential conflict from the speaker's perspective

There is one explicit distinction, between a discourse situation where only one referent with a high activation score exists and a situation where two or more referents are highly activated. In the first situation, the probability of the referential conflict is close to zero. This type of situation is excluded from further consideration.

This study concentrates on the second situation, namely a potential referential conflict, which is created due to the concurrent activation of two or more referents. One might argue that this situation is represented as a sort of continuum between two poles: at one pole of this continuum are cases in which there is a high (close to 100%), probability of referential conflict. At the other pole are those cases which have a low probability of referential conflict, regardless of the concurrent activation of two or more referents. What factors influence the probability of the referential conflict? Does the speaker always take the addressee factor into account, or are there various speakers' strategies? These questions are addressed in the next section.

3. Potential referential conflict: Ambiguity avoidance or semantic competition?

The section is structured as follows. Subsection 3.1 describes the so-called 'gender effect' on referential conflict resolution while Subsection 3.2 considers 'two-character effect' introduced in Arnold and Griffin (2007). Next, a review of the literature is presented which provides evidence for two

[1] Studying reference production, Kibrik (2011) uses terms 'deconflicters' and 'referential aids' as synonyms. Here, I use the term 'deconflicters' describing reference resolution, and 'referential aids' describing reference production.

[2] The term 'engagement factor' was introduced in Kibrik, 1987.

[3] The term 'antecedent' refers to the linguistic form with which the referent was last mentioned.

alternative hypotheses — the ambiguity avoidance hypothesis and the semantic competition hypothesis — that are proposed for accounting for a situation of potential referential conflict (Subsection 3.3). Finally, Subsection 3.4 addresses the experiment in Russian.

3.1. Gender effect

Usually, the gender effect on referential conflict resolution is described as evidence for ambiguity avoidance. The gender effect account predicts that a speaker uses fewer reduced referring expressions (mostly, third-person pronouns) when there is more than one highly activated referent that matches the gender of the referring expression (Fletcher, 1984; Karmiloff-Smith, 1985; Arnold et al., 2000; Arnold & Griffin, 2007; Fukumura et al., 2010). Two studies are of particular relevance, first relating to pronoun resolution, and the second — to reference production.

In the two eyetracking experiments of Arnold et al. (2000) participants were presented with pictures of two familiar Disney cartoon characters of either the same (Ex. 12) or a different (Ex. 13) gender. They listened to texts describing the pictures, in which a pronoun referred to either the first character that was more accessible, or the second.

(12) Donald$_i$ is bringing some mail to Mickey$_j$ while a violent storm is beginning. He$_i$/He$_j$ *is carrying an umbrella, and it looks like they're both going to need it.*

(13) Donald$_i$ is bringing some mail to Minnie$_j$ while a violent storm is beginning. He$_i$/She$_j$ *is* carrying an umbrella, and it looks like they're both going to need it.

The results of the experiment demonstrated a gender effect and the fact that gender (as well as accessibility) affects the initial processes (approximately 200 ms after the pronoun offset) of pronoun resolution.

In Arnold and Griffin's (2007) experiments, participants were also shown pictures with two familiar Disney cartoon characters of either the same or a different gender. The participant's task was to listen to a sentence describing the first picture, repeat it, and then continue the story by making up a sentence that would describe the second picture. (See Ex. 14 for the same-gender context and Ex. 15 for the different-gender context.)

(14) Mickey$_i$ went for a walk with Donald$_j$ in the hills one day.

(15) Mickey$_i$ went for a walk with Daisy$_j$ in the hills one day.

Arnold and Griffin (2007) provided evidence that participants produced fewer pronouns in the same-gender than in the different-gender condition; i.e., the presence of another character of the same gender reduced pronoun use.

Usually, the gender effect is described as evidence for ambiguity avoidance. Another possibility is that this effect is driven by increased semantic competition between referents in the same-gender condition, which reduces the referent's activation in the speaker's memory. This dilemma is discussed below.

3.2. Two-character effect

Arnold and Griffin (2007) showed that the presence of a second character influences the referential choice between a pronoun and a proper name. This is true, however, even if the characters differ in gender, so that a proper name does not disambiguate any more than a pronoun. Arnold and Griffin's (2007) study demonstrated that speakers were less likely to use a pronoun in the two-character context (29% pronouns) than in the single-character context (67% pronouns).

(16) Mickey$_i$ went for a walk with Daisy$_j$ in the hills one day.

(17) Mickey$_i$ went for a walk in the hills one day.

Whereas the gender effect could be the result of an ambiguity avoidance strategy, the two-character effect cannot. Arnold and Griffin (2007) argued that the reasons for the two-character effect lie in the speakers' cognitive load when they generate referring expressions.

3.3. Ambiguity avoidance or semantic competition?

The experiments described in the previous sections demonstrated two effects on speakers' decisions to use full or reduced referential expressions. Speakers produced reduced referential expressions more often when there was no other character present in the discourse context than when there was another character of a different (two-character effect) or the same (gender effect) gender.

There are two alternative hypotheses that are proposed to account for the two phenomena. The first hypothesis — ambiguity avoidance — is the most common explanation for the gender effect: speakers use fewer reduced referential expressions when the linguistic context includes a competitor that has the same gender as the referent to facilitate identification of the referent for the addressee. This 'addressee-oriented' view (see Arnold, 2008 for a review) of referential choice is in accordance with evidence about the role of common ground and audience design in language use (Clark, 1996; Brown-Schmidt, 2009 and in press).

The addressee-oriented view, however, does not fit with the two-character effect, according to Arnold and Griffin (2007). The authors argue that this effect is not affected by the addressee's factor; on the contrary, it is of an egocentric nature. Consider the speaker-oriented view in more detail. Arnold and Griffin (2007) explained the two-character effect in terms of competition between two characters that were present in discourse context. They argued that "the reduction in pronoun use for situations with more than one character is likely to result from competition between entities in the speaker's mental model, which results in a lower level of activation for each entity" (Arnold & Griffin, 2007: 528). Further support for the semantic competition hypothesis came from Arnold and Griffin's (2007) findings that reduced forms declined when utterances were disfluent, reflecting the stage of planning.

Is it possible that the gender effect described above is also due not to ambiguity avoidance, but to semantic competition? In English, pronouns are ambiguous in the same-gender condition, but not in the different-gender condition. That is, the gender effect is specific to gender-marking languages. Fukumura (2010) tested this effect in Finnish, where pronouns are not gender marked.

The Finnish pronoun *hän* does not encode gender distinction; i.e., it is ambiguous in the same-gender condition (Ex. 18), as well as in the different-gender condition (Ex. 19):

(18) Kuningas$_i$ vieraili linnassa lentäjän$_j$ kanssa.
'The king visited the castle with the pilot.'

(19) Kuningas$_i$ vieraili linnassa lentoemännän$_j$ kanssa.
'The king visited the castle with the stewardess.'

According to the ambiguity avoidance hypothesis, the referential choice is not affected by the competitor's gender in Finnish. The semantic competition hypothesis, however, predicts that the competitor's gender affects referential choice in Finnish, because semantic similarity between referents of the same gender influences the referent's activation score. The results showed that Finnish speakers produced significantly fewer pronouns when the competitor had the same gender (*lentäjän* 'pilot') than a different gender (*lentoemännän* 'stewardess'), supporting the semantic competition hypothesis.

Fukumura and Hyönä (2011) tested Finnish native speakers in an English version of the same experiment. If this effect, referred to as gender congruence, is not due to ambiguity avoidance, it should remain the same with English stimuli. However, it is significantly larger in English than in Finnish, suggesting that gender congruence affects both semantic competition and ambiguity avoidance.

3.4. Experiment in Russian

This section describes the experiment on the Russian material which replicates Exp. 2 of Arnold and Griffin (2007).

Method. ***Participants.*** Twenty-four students participated in the study. All of them were naïve with respect to the purpose of the experiment, they were native speakers of Russian and had normal or corrected-to-normal vision.

Materials and procedure. Participants were presented with a set of visual stimuli. Each stimulus item consisted of two pictures which together formed a short story involving one or two referents. All pictures used in the experiment represented the characters from popular Soviet cartoons which are familiar to most Russian speakers and thus could be easily identified and named by the participants.

The condition of interest was the number of characters displayed in the pictures. Each of the 15 stimulus items appeared in three versions, so that: (1) only one character was displayed in each of the two pictures (1/1 context); (2) two characters of different genders were displayed in both pictures (2/2 context); (3) two characters of different genders were present in the first picture, but only one of them remained in the second picture (2/1 context). See Fig. 2. Three stimulus lists were constructed by rotating the 15 stimulus items through the three conditions in a Latin Square design. Additionally, two practice items were placed at the beginning of each list.

In each trial, the participant was first shown both pictures, placed one under another on the computer screen, for two seconds. Then the second picture disappeared and the participant heard the pre-recorded voice that described the first picture in one sentence. The first character was always mentioned in the subject position, and the second character was mentioned in the comitative prepositional phrase (PP) (see Ex. 20).

(20) Freken Bok$_i$ s Karlsonom$_j$ byli na kuxne.
'Freken Bok with Karlsson was in the kitchen.'

The participant was asked to repeat the sentence that he or she had just heard word-for-word. Right after that, the experimenter pressed a key and the second picture reappeared on the screen. The participant's task was to continue the story by making up a sentence that would describe the second picture. In order to stimulate participants to produce coherent and simple discourses, they were asked to imagine that they were telling a story to a five-year-old child.

Results and discussion. The character that was present in both pictures was made somewhat visually more prominent so the participants were encouraged to mention it first and to make it the grammatical subject of the second sentence. As can be seen from the table below, canonical sentences prevailed among the responses. Non-canonical sentences (those having both characters as a subject) as well as those containing errors were excluded.

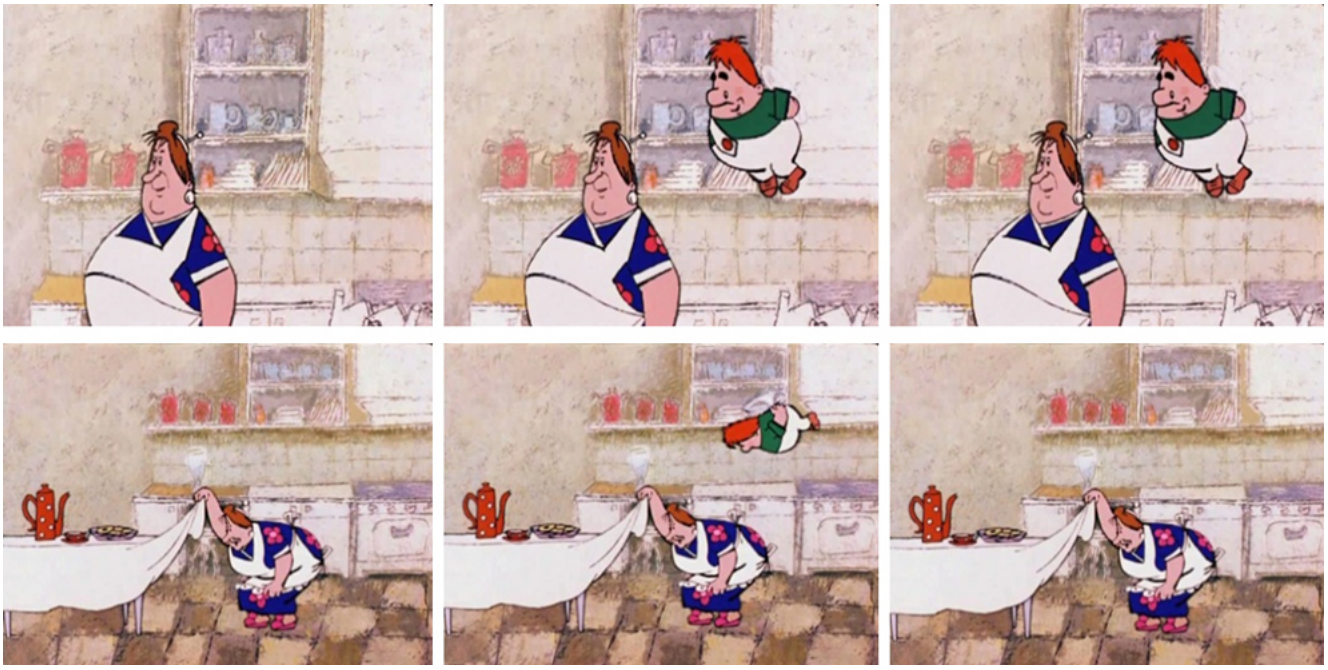

Figure 2. An example of a stimulus item. From left to right: 1/1, 2/2 and 2/1 contexts

The number of characters displayed in the first/second picture	Canonical sentences, %	Type of the referring expression, %		
		Anaphoric zero	Pronoun	Full NP
1/1	90	34	37	29
2/2	72	1	2	97
2/1	78	0	1	99

Table 1. Percentage of the chosen referring expressions

In the present study the phenomenon of interest is the choice of the referring expressions in one- and two-character contexts. The percentage of anaphoric zeroes, pronouns and full NPs was measured. Table 1 shows that while in 1/1 contexts the distribution of referential choices is almost equal, in 2/1 and 2/2 contexts participants overwhelmingly chose full NPs, despite the fact that the use of a pronoun would not cause any referential conflict and thus be sufficient.

The statistical reliability of the obtained results was evaluated using the R software environment. Specifically, the functions binom.test and prop.test were run in order to calculate p-values. The statistical testing showed that the three types of referring expressions were identically distributed in 1/1 contexts ($p = .42$), while in two-character contexts the difference between the amount of full and reduced referring expressions was statistically significant ($p = .01$) proving that the preference for full NPs was not accidental. In addition, the similarity in the distribution of referring expressions in 2/1 and 2/2 contexts (p-values ranging from .24 to .73) supports the idea that the referential choices made by participants were based on the activation of referents rather than being conditioned by the type of the presented visual stimulus.

Recall that Exptriment 2 of Arnold and Griffin (2007) demonstrated the use of full NPs 33 % *of the time* in the single-character context, compared to 71 % in the two-character contexts. In this experiment full NPs were used 29 % of the time in the single-character context, but almost 100% of the time in the two-character context. This suggests that the PPs used in the Russian experiment, 'Freken Bok with Karlsson were in the kitchen', significantly differed from stimuli used in Arnold and Griffin (2007), *Mickey went for a walk with Daisy*. In the Russian experiment, all PPs are continuous, so participants perceived them as a whole referent. In order to explain this effect I introduce a novel activation factor, called 'multiple antecedent'. It is possible that this factor decreases the activation score nearly twice so the current activation of 'Freken Bok' becomes too low to use a reduced referring expression, thus suggesting that there is no situation of potential referential conflict at all.

4. Discussion. Potential referential conflict from the speaker's perspective

The above-mentioned studies revealed two novel effects: the gender effect and the two-character effect; two novel hypotheses: the ambiguity avoidance hypothesis and the semantic competition hypothesis; two views on referential choice: the speaker-oriented view and the addressee-oriented view, and a number of novel questions. In particular, these findings raised four important and controversial questions. The first question addresses a possible locus for the gender effect and the two-character effect; the second evaluates the role of the addressee in referential choice; the third relates to the speaker's referential strategies; the last focuses on linguistic devices used to preclude referential conflict. This section examines the major findings of the related research reported in the literature.

Let us begin with the question about a possible locus for the gender effect and the two-character effect. There are two possibilities. One possibility was stated by Arnold and Griffin: "When two characters are present in the discourse, they share the attentional resources available, and each receives less activation in the speaker's internal representation" (Arnold & Griffin, 2007: 528). That is, the locus for these effects is the activation system in the speaker's working memory. Contrary to this hypothesis, Kibrik (2011) suggested that the locus was separate from the activation system. He proposed a distinct component of referential choice, namely, the referential conflict filter (see Fig. 1 above). He argued that "the speaker's caring about precluding referential conflicts is a part of his/her efforts in establishing the common ground (Clark & Brennan, 1991; Clark & Bangerter, 2004; Hanna et al., 2003) with the addressee", and that "by using this filter, a speaker may revise a projected reduced referential device if it creates a threat of ambiguity for the addressee" (Kibrik, 2011: 67ff.). Kibrik drew an analogy between the separate component of referential conflict in his model and the idea that the common ground is used as a second-stage filter in reference processing (Keysar et al., 2000).

The second question relates to the addressee's role. Whereas early studies of the addressee's factor supported the addressee-oriented view on the referential processes (see, e.g., Clark & Wilkes-Gibbs, 1986; Brennan & Clark, 1996; Clark & Krych, 2004), more recently the focus has shifted to the speaker-oriented view. The reason for this shift primarily came from Ferreira et al.'s 2005 study. They distinguish between nonlinguistic ambiguity (conceptual ambiguity, in terms of Arnold, 2008) and linguistic ambiguity. Nonlinguistic ambiguity arises, for example, in the context of two flying mammals, one larger and one smaller. Linguistic ambiguity arises because of segmentation ambiguity (*a back* vs. *aback*), syntactic ambiguity, and homophony (e.g., the word *bat* means a flying mammal or an instrument for hitting baseballs).

Ferreira et al.'s (2005) central claim is that the similarity that relates to nonlinguistic ambiguity is represented at the level of meaning, whereas the similarity that relates to linguistic ambiguity is represented at the level of linguistic form. They presented three experiments that have demonstrated that speakers consistently avoid saying *the bat* when two bats of different sizes are visible: they say, for example, *the small bat* instead. But speakers very

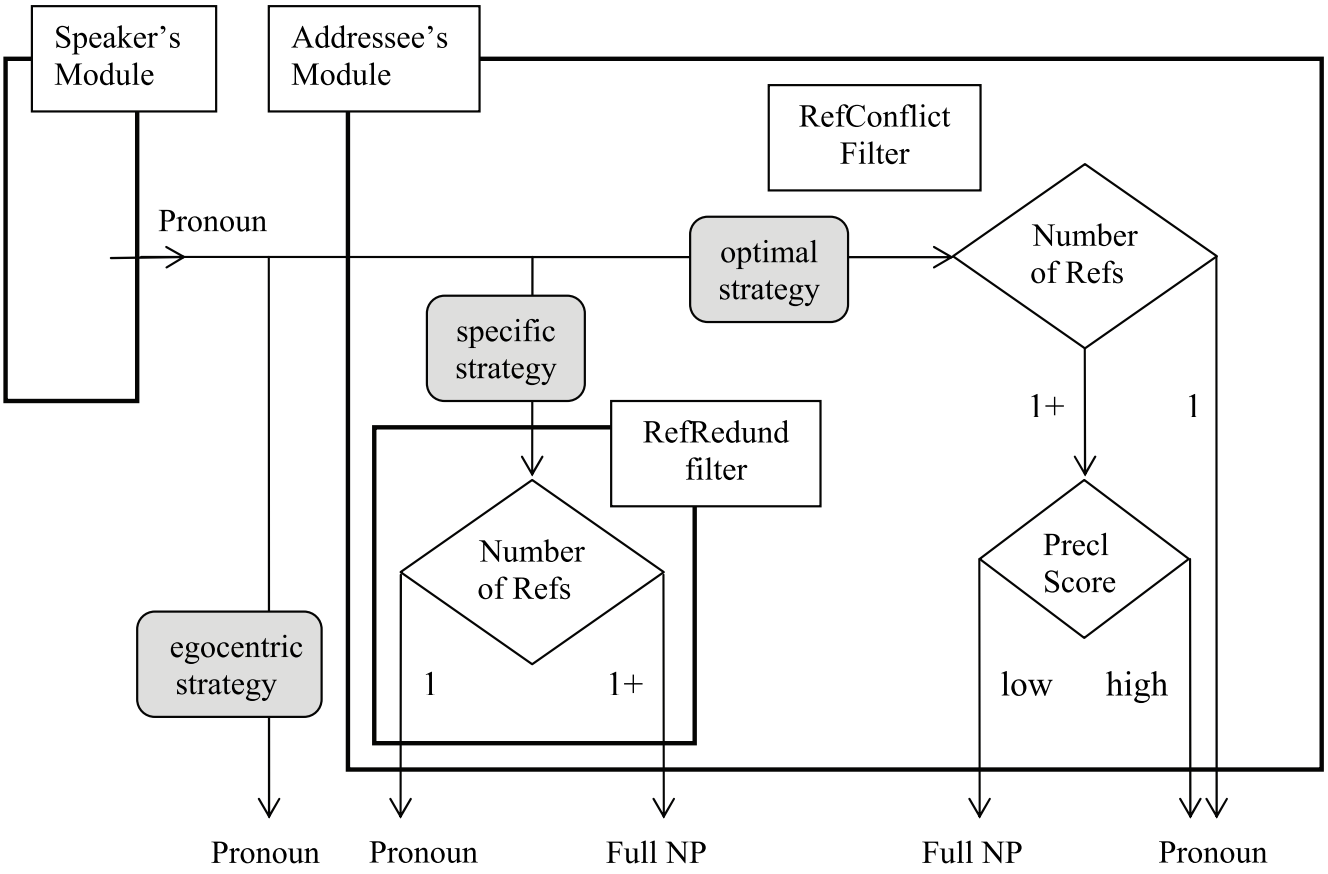

Figure 3. Referential strategies in situation of potential referential conflict

often say simply *the bat* when pictures of both a baseball bat and a flying mammal are visible. Ferreira et al.'s (2005) suggested that people are much less likely to avoid linguistic ambiguities, because this type of similarity does not become available until after the production process has begun. Before producing an ambiguous expression, they proposed, speakers have available only a comprehension-based ambiguity-detection strategy. This strategy, however, is not especially effective, because it involves monitoring one's inner speech, which has been argued to pose a high processing demand (see Levelt, 1989).

A production-based ambiguity-detection strategy is more effective than one based on comprehension, but it detects ambiguous expressions after they are produced. However, such an after-the-fact ambiguity avoidance strategy helps speakers to clarify already articulated ambiguous expressions (antitopics in terms of Lambrecht, 2004). Ferreira et al. (2005) concluded that "at least as far as online production is concerned, linguistic-ambiguity may not powerfully influence speakers' utterances, at least not until after they have been articulated" (Ferreira et al., 2005: 280).

The third question concentrates on the speaker's referential strategies. Arnold (2008) suggested that a referential choice in discourse deals with both speaker- and addressee-oriented processes. She proposed that speakers suppose that addressees have a similar current mental model as themselves, so they could simply calculate the referent's activation score referring to their own mental model. At the same time, Arnold (2008) noted that speakers sometimes provide information that is redundant from the addressee's perspective. Describing speaker-internal and addressee-oriented processes engaged in referential choice, Kibrik (2011) proposed three speakers' strategies: egocentric, optimal, and overprotective. Using an egocentric strategy, speakers overestimate the addressees' ability to identify processes in their own minds. Using an overprotective strategy, they allow linguistic redundancy. The optimal strategy allows speakers to efficiently model their addressees' minds.

Finally, the fourth question focuses on linguistic devices of the preclusion of referential conflict. In his cross-linguistic study, Kibrik (2011) described a wide range of linguistic resources that help to preclude referential conflict. He considered the classification of the so-called referential aids that include ad hoc and conventional referential aids. The latter type is divided into two classes: stable (e.g., gender, number, animacy or honorificity) and current (e.g., logophoricity). Showing the importance of referential aids for the purpose of referential conflict preclusion, Kibrik suggested, however, that they evolve in language for others reasons and are used here in their subsidiary functions.

The final subsections of this study are devoted to a further exploration of all above-mentioned questions. There are several important issues regarding the implications of the presented results and opinions, including a model of referential conflict from the speaker's perspective (Subsection 4.1), preclusion factors (Subsection 4.2), and referential strategies (Subsection 4.3).

4.1. A model of referential conflict from the speaker's perspective

The detailed investigation begins at the moment when a speaker projects a reduced referring expression (a pronoun in our case) of a highly activated referent. That is, he or she

exits the first module of the two-module model of referential choice (see Fig. 3). In this moment, a speaker is at his/her first fork: he or she can choose the egocentric strategy, avoiding the addressee's module. If a speaker prefers consider the addressee, he or she runs into the addressee's module and finds himself/herself at the second fork. This time, he or she can choose between the specific and the optimal strategies. The specific strategy is, on the one hand, egocentric or speaker-internal oriented (according to Arnold & Griffin, 2007), because it does not evaluate the addressee's mind. On the other hand, it is in a certain sense overprotective (Kibrik, 2011: 56ff.), because a speaker prefers to use a more explicit referring expression to avoid a mistake. When a speaker decides to use the specific strategy, he or she must first check the number of highly activated referents. If there is only one highly activated referent, a speaker does not make any change. If there are two or more highly activated referents, he or she changes a projected referential form from a pronoun to a full NP. I call this component of the model the referential redundancy filter (see Fig. 3). I hypothesize that checking the number of highly activated referents is not a resource-demanding process; on the contrary, highly activated discourse referents would be automatically numbered in the speaker's working memory.

Using the third (optimal) strategy speakers model their addressee' minds. When a speaker decides to use this strategy as in the case of specific strategy, he or she must first check the number of highly activated referents. If there is only one highly activated referent, a speaker does not make any change. If there are two or more highly activated referents, he or she must calculate the current preclusion score. If this score is high, a speaker does not make any change. If this score is low, he or she must change a projected referential form from a pronoun to a full NP.

The current preclusion score depends on several factors, which are described in the next subsection. It is hereby proposed that so-called optimal strategy is the best strategy, but it is too resource-demanding for speakers to engage in all the time. So, there are two others strategies that are available to speakers. Predictions about the distribution of the mentioned strategies are discussed later.

4.2. Preclusion factors

The final choice between reduced forms and full NPs is influenced by the current degree of preclusion, i.e., the preclusion score. The different variables are taken into consideration when precluding referential conflict; the current evidence suggests that both linguistic and nonlinguistic context can affect the preclusion score. Some factors increase the probability of using reduced referring expressions, while some factors decrease it. Let us consider these factors in turn.

First, each language has its own list of potential conventional referential aids. For example, there are two Senegalese languages, Pulaar and Sereer; both of them have a noun class system. Kibrik (2011) showed, however, that only the former uses noun classes to preclude referential conflict, because the third person pronouns in Sereer are not distinguished for noun class (Kibrik, 2011: 347ff.). Some conventional referential aids, such as gender or number, are cross-linguistically quite common; in contrast, some others, such as honorificity or logophoricity, are quite rare. In any case, the use of a certain conventional referential aid is not obligatory: a speaker has a choice to use it or not.

Second, each language user routinely uses ad hoc referential aids. It may be argued that ad hoc referential aids are the most common linguistic devices for precluding referential conflict. However, there is one peculiarity in using this type of referential aids — they sometimes allow temporary referential conflict, as shown in Ex. 5–8 above. It can be argued, however, that speakers do not take care of avoiding temporary referential conflict, so these situations are common in everyday language use.

So, a speaker can employ a referential aid — conventional or ad hoc — that is, a linguistic device distinguishing the target referent from the competing one. Attention is now turned to the third group of factors influencing the preclusion score, namely, nonlinguistic context. After over a decade of research on the role of nonlinguistic factors, the literature is largely equivocal. For example, Arnold and Griffin (2007) demonstrated that visual context does not affect the choice of referring expression. In this author's experiment on the Russian material, this effect is replicated (see above): the proportion of pronoun responses was unaffected by the visual presence (condition 2/2) or absence (condition 2/1) of the competitor in the second picture.

However, Fukumura et al. (2010) found that visual presence of a competitor in both the same- and the different-gender conditions does affect the choice of referring expression. There are several differences in the method and materials between Arnold and Griffin's (2007) and Fukumura et al's. (2010) experiments: Fukumura et al. (2010) used the referential communication task where the speaker instructed the addressee to pick up the referent in the visual context, and the second character was mentioned in a passive *by*-phrase, as in Ex. (21) and (22):

(21) The pirate$_i$'s carpet had been cleaned by a prince$_j$.

(22) The pirate$_i$'s carpet had been cleaned by a princess$_j$.

Note that Fukumura et al.'s (2010) results also provided evidence that the effect of visual context was smaller when the competitor was not linguistically introduced.

Specifying the role of visual context, Fukuruma et al. (2011) found an 'effect of the competitor's similarity': speakers produced fewer pronouns when the competitor was in the same situation as the target referent (both on a horse) rather than in a different situation (only the target referent on a horse). This effect was larger when it was relevant to the to-be-described action (getting off a horse) than otherwise (taking off a hat). Moreover, Fukuruma et al. (2011) found the same effect in the different-gender context. All these findings support the semantic competition hypothesis (Arnold & Griffin 2007) based on the speaker-internal view of referential choice.

Vogels et al. (2011) presented the results from a story completion experiment in Dutch. They showed that the visual context affects referential choice only when the impact of linguistic factors is moderated, i.e., when referents are linguistically non-salient. The authors argued that in other situations the factor of visual context can be overruled by linguistic factors.

The next question pertains to how the above-mentioned factors influence the preclusion score. It is apparent that all these factors can have pervasive effects on probabilities of the referential conflict. Four groups of preclusion factors are singled out:

(i) Conventional referential aids used in discourse context increase the preclusion score.

(ii) Ad hoc referential aids used in discourse context increase the preclusion score, but sometimes they create temporary referential conflicts.

(iii) Conceptual overlap between the target referent and the competitor in discourse context decreases the preclusion score.

(iv) Conceptual overlap between the target referent and the competitor in visual context decreases the preclusion score.

The hypothesis here is that in everyday communication, the current preclusion score depends on more than one factor, demonstrated in Ex. 23. Each factor contributes to the aggregate preclusion score, but not much is known about how these factors interact. So, this paper restricts consideration to the intuitive notions of high and low degrees of the preclusion score. It is noted, however, that the question of speaker sensitivity to avoiding referential conflict is not answered with 'yes' or 'no'. Instead, the current degree of the preclusion score varies across speakers and emerges through a complicated balancing of multiple factors.

(23) My sister$_i$ was very fond of her new schoolmaster$_j$. **She$_i$/He$_j$** always arrived in the classroom ten minutes early to Ø$_i$/Ø$_j$ **be able to sit in the front row/chat with his students**.

Intuition suggests that the conceptual factors (all but the first groups) play a more significant role in how people preclude referential conflicts than grammatical ones. The key difference between the conceptual and the grammatical factors, then, is similar to the difference between the linguistic and nonlinguistic contexts outlined by Ferreira et al. (2005): a comprehension-based ambiguity detection strategy is not especially effective, because it involves monitoring one's inner speech.

4.3. Referential strategies

In this section I describe the three strategies used by speakers in situations of potential referential conflict. These alternative strategies can be distinguished by comparing relations between the main components of the referential choice model described above.

One possible way to avoid referential ambiguity is to evaluate whether the to-be-produced reduced referring expression rules out reference to the competitor; this is the optimal strategy. As one can see in Table 2, it uses addressee-oriented and resource-demanding mechanisms that are too resource-intensive for speakers to routinely engage in. So, there must be alternative strategies that are available for speakers to use. The specific strategy also uses the addressee-oriented mechanism of avoiding referential redundancy, but it is likely automatic and fast (see also Table 3). The egocentric strategy uses none of the mentioned mechanisms, so the speaker makes a choice with a minimal effort.

The suggested hypothesis is that there are three different strategies. What factors affect the choice of a particular strategy? An important factor influencing the speaker's choice relates to audience design. Horton and Keysar (1996) found that when speakers had no time pressure, they avoided ambiguous referring expressions more often when the addressee was present. However, they found no such evidence for situations when speakers were under time pressure. The authors suggested that speakers take into account the addressee's needs during later stages of production process. Kantola and van Gompel (2011) demonstrated that activation factors were not affected by the presence or absence of the addressee, but the effect of visual context did interact with addressee presence. It may be speculated that the speaker takes into account the addressee using a more "user-friendly" strategy when an addressee is present in the discourse situation. Of course, confirming this prediction is an agenda for future studies.

Strategy	Resource-demanding mechanism	Addressee-oriented mechanism
egocentric	–	–
specific	–	+
optimal	+	+

Table 2. Referential strategies and associated mechanisms

Strategy	Speaker's module	Addressee's module	
		Referential conflict filter	Referential redundancy filter
egocentric	+	–	–
specific	+	–	+
optimal	+	+	–

Table 3. Referential strategies and modules

Conclusion. Agendas for future research

The aim of this paper was not to provide a comprehensive model of the preclusion of the referential conflict. Rather the goal was only to propose the typology of referential conflicts and to emphasize the two-stage nature of the referential choice; that is the independence of the processes responsible for the preclusion of the referential conflict from activation factors. Processes that take place in the first module of the model — the speaker's module — are automatic and apparently not effortful, because speakers do not take into account the perspective of their addressees. This module works only when a choice must be made between several referential options.

The second module — the addressee's module — works only when speakers need to evaluate and change their projected reduced referring expressions if there is potential ambiguity for the addressee. If the activation score is too low, this module does not work. This experiment with Russian data supports the view that the first module is more accurate and categorical while the second module allows a number of possibilities.

Suppose that the referential choice is a one-stage process. In this case, speakers must evaluate all activation factors together — both resource-demanding and not. This would suggest that this process is necessarily resource-demanding.

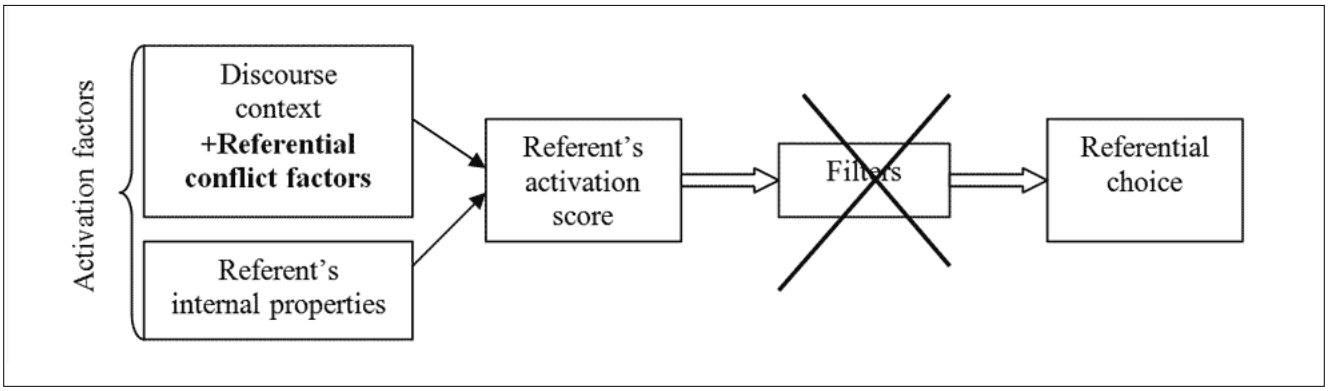

Figure 4. The Cognitive multi-factorial model of referential choice as a one-stage model

In any case, the question of whether the referential choice is a two-stage process or not is a topic for further research. Consider Kibrik's model of referential choice remade into a one-stage model, as shown in Fig. 4.

Suppose that we conduct a study on reference production in which participants describe pictures. We design an experiment with two variables: context and time pressure manipulation. In general, in situations of potential referential conflict speakers prefer full NPs, but in situations with only one highly activated character they prefer pronouns.

The prediction is that if speakers use the one-stage model, their results under time pressure will not differ from the results without time constraints, see Table 4. If speakers use the two-stage model, however, under time pressure in the condition 'two-character context' they will use pronouns instead of full NPs because the time pressure should force them to skip the process of precluding the referential conflict, as shown in Table 5.

Referential context	Time pressure	
	yes	no
single-character context	pronoun	pronoun
two-character context	full NP	full NP

Table 4. Predictions for the one-stage model

Referential context	Time pressure	
	yes	no
single-character context	pronoun	pronoun
two-character context	pronoun	full NP

Table 5. Predictions for the two-stage model

* * *

Let us conclude with three final comments. First, ambiguity is not routinely noted when people communicate in their everyday speech. In contrast, psycholinguists who study language use notice ambiguity everywhere, cf. the famous quote by Chafe: "Ambiguities may be more salient to the exocultural linguist than to the endocultural narrator or audience, for whom familiarity and context are likely to remove most problems of keeping third-person referents straight" (Chafe, 1990: 315).

Second, indeed, language is rarely ambiguous within context, as noted by Miller (1951) who considered the polysemy of the word *take*: "Why do people tolerate such ambiguity? The answer is that they do not. There is nothing ambiguous about 'take' as it is used in everyday speech. The ambiguity appears only when we, quite arbitrarily, call isolated words the unit of meaning" (Miller, 1951 as quoted in Piantadosi et al., 2012: 289).

Third, the consideration of context is not cost-free. However, the cost is moderate, and addressees are able to quickly use discourse context to disambiguate the speakers' utterances (see Kaiser & Trueswell, 2004). So, it is hereby suggested that the temporary referential conflict is a regular phenomenon while the permanent referential conflict should be considered as an occasional aberration.

References

Ariel, M. (1988). Referring and accessibility. *Journal of Linguistics, 24*, 65–87. doi: 10.1017/S0022226700011567

Ariel, M. (1990). *Accessing noun-phrase antecedents*. London: Routledge.

Arnold, J. E. (2001). The effect of thematic roles on pronoun use and frequency of reference continuation. *Discourse Processes, 31*, 137–162. doi: 10.1207/S15326950DP3102_02

Arnold, J. E. (2008). Reference production: Production-internal and addressee-oriented processes. *Language and Cognitive Processes, 23*(4), 495–527. doi: 10.1080/01690960801920099

Arnold, J. E., Eisenband, J. G., Brown-Schmidt, S., & Trueswell, J. C. (2000). The rapid use of gender information: evidence of the time course of pronoun resolution from eye tracking. *Cognition, 76*, B13–B26. doi: 10.1016/S0010-0277(00)00073-1

Arnold, J. E., & Griffin, Z. M. (2007). The effect of additional characters on choice of referring expression: Everyone counts. *Journal of Memory and Language, 56*(4), 521–536. doi: 10.1016/j.jml.2006.09.007

Brennan, S. E., & Clark, H. H. (1996). Conceptual pacts and lexical choice in conversation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*(6), 1482–1493. doi: 10.1037/0278-7393.22.6.1482

Brown-Schmidt, S. (2009). Partner-specific interpretation of maintained referential precedents during interactive dialog. *Journal of Memory and Language*, *61,* 171–190. doi: 10.1016/j.jml.2009.04.003

Brown-Schmidt, S. (2012). Beyond common and privileged: Gradient representations of common ground in real-time language use. *Language and Cognitive Processes*, *27*(1), 62-89. doi: 10.1080/01690965.2010.543363

Chafe, W. L. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and point of view. In C. N. Li (Ed.), *Subject and topic* (pp. 25–56). New York: Academic Press.

Chafe, W. L. (1990). Introduction to a special issue on third-person reference in discourse. *International Journal of American Linguistics, 56*(3), 313–316. doi: 10.1086/466160

Chafe, W. L. (1994). *Discourse, consciousness, and time: The flow and displacement of conscious experience in speaking and writing*. Chicago: University of Chicago Press.

Chomsky, N. (2002). An interview on minimalism. In N. Chomsky, A. Belletti, & L. Rizzi (Eds.), *On Nature and Language* (pp. 92–161). Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511613876.005

Clark, H. H. (1996). *Using Language*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511620539

Clark, H. H., & Bangerter, A. (2004). Changing ideas about reference. In: I. A. Noveck & D. Sperber (Eds.), *Experimental Pragmatics* (pp. 25–49). New York: Palgrave Macmillan.

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. M. Levine, and S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127–149). Washington, D.C.: APA Books. doi: 10.1037/10096-006

Clark, H. H., & Krych, M. A. (2004). Speaking while monitoring addressees for understanding. *Journal of Memory and Language*, *50*, 62–81. doi: 10.1016/j.jml.2003.08.004

Clark, H. H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition, 22*, 1–30. doi: 10.1016/0010-0277(86)90010-7

Ferreira, V., Slevc, L., & Rogers, E. (2005). How do speakers avoid ambiguous linguistic expressions? *Cognition, 96*(3), 263–284. doi: 10.1016/j.cognition.2004.09.002

Fletcher, C. R. (1984). Markedness and topic continuity in discourse processing. *Journal of Verbal Learning and Verbal Behavior, 23*, 487–493. doi: 10.1016/S0022-5371(84)90309-8

Foley, W., & Van Valin, Jr. R. D. (1984). *Functional syntax and universal grammar.* Cambridge: Cambridge University Press.

Fox, B. A. (1987). *Discourse structure and anaphora: Written and conversational English*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511627767

Fukumura, K. (2010). *Choosing referring expressions*. PhD dissertation. University of Dundee.

Fukumura, K., & van Gompel, R. P. G. (2010). Choosing anaphoric expressions: Do people take into account likelihood of reference? *Journal of Memory and Language, 62,* 52–66. doi: 10.1016/j.jml.2009.09.001

Fukumura, K., & van Gompel, R. P. G. (2011). The effects of animacy in the choice of referring expressions. *Language and Cognitive Processes, 26,* 1472–1504. doi: 10.1080/01690965.2010.506444

Fukumura, K., van Gompel, R. P. G., Harley, T., & Pickering, M. J. (2011). How does similarity-based interference affect the choice of referring expression? *Journal of Memory and Language, 65*, 331–344. doi: 10.1016/j.jml.2011.06.001

Fukumura, K., van Gompel, R. P. G., & Pickering, M. J. (2010). The use of visual context during the production of referring expressions. *Quarterly Journal of Experimental Psychology, 63,* 1700–1715. doi: 10.1080/17470210903490969

Fukumura, K., & Hyönä, J. (2011). *Two of the same gender compete: evidence from reference production.* Talk presented at he 24th Annual Conference on Human Sentence Processing, Stanford.

Garnham, A. (2001). Mental Models and the Interpretation of Anaphora. Hove: Psychology Press.

Gernsbacher, M. A., & Hargreaves, D. J. (1988). Accessing sentence participants: The advantage of first mention. *Journal of Memory and Language, 27,* 699–717. doi: 10.1016/0749-596X(88)90016-2

Givón, T. (Ed.), (1983). *Topic continuity in discourse: A quantitative cross-language study.* Amsterdam: John Benjamins Publishing. doi: 10.1075/tsl.3

Givón, T. (1993). Coherence in text, coherence in mind. *Pragmatics and Cognition 1*(2), 171–227. doi: 10.1075/pc.1.2.01giv

Grosz, B. J., Weinstein, S., & Joshi, A.K. (1995). Centering: A framework for modeling the local coherence of discourse. *Computational Linguistics, 21,* 203–225.

Gundel, J. K., Hedberg, N. & Zacharaski, R. (1993). Cognitive status and the form of referring expressions. *Language, 69,* 274–307. doi: 10.2307/416535

Hanna, J. E., Tanenhaus, M. K., & Trueswell, J. S. (2003). The effects of common ground and perspective on domains of referential interpretation. *Journal of Memory and Language, 49,* 43–61. doi: 10.1016/S0749-596X(03)00022-6

Horton, W. S., & Keysar, B. (1996). When do speakers take into account common ground? *Cognition, 59,* 91–117. doi: 10.1016/0010-0277(96)81418-1

Järvikivi, J., van Gompel, R. P. G., Hyönä, J., & Bertram, R. (2005). Ambiguous pronoun resolution: Contrasting the first-mention and subject-preference accounts. *Psychological Science, 16,* 260–264. doi: 10.1111/j.0956-7976.2005.01525.x

Kaiser, E., & Trueswell, J. (2004). The role of discourse context in the processing of a flexible word-order language. *Cognition*, *94*(2), 113–147. doi: 10.1016/j.cognition.2004.01.002

Kantola L. & van Gompel, R. P. G. (2011). Does the addressee matter when choosing referring expressions? *Proceedings of PRE-Cogsci: Bridging the gap between computational, empirical and theoretical approaches to reference.* Boston.

Karmiloff-Smith, A. (1985). Language and cognitive processes from a developmental perspective. *Language and Cognitive Processes, 1,* 61–85. doi: 10.1080/01690968508402071

Keysar, B., Barr D. J., Balin, J. A., & Brauner, J. S. (2000). Taking perspective in conversation: The role of mutual knowledge in comprehension. *Psychological Science, 11,* 32–37. doi: 10.1111/1467-9280.00211

Kibrik, A. A. (1987). Mekhanizmy ustranenija referentsial'nogo konflikta [Mechanisms of referential conflict removal]. In: A. E. Kibrik & A. S. Narin'jani (Eds.), *Modelirovanie jazykovoj dejatel'nosti v intellektual'nykh sistemakh* (pp. 128–145). Moscow: Nauka.

Kibrik, A. A. (2011). *Reference in discourse.* Oxford: Oxford University Press. doi: 10.1093/acprof:oso/9780199215805.001.0001

Lambrecht, K. (1994). *Information structure and sentence form. Topic, focus, and the mental representation of discourse referents.* Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511620607

Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Cambridge: MIT Press.

MacDonald, M. C., & MacWhinney, B. (1990). Measuring inhibition and facilitation from pronouns. *Journal of Memory and Language, 29*, 469–492. doi: 10.1016/0749-596X(90)90067-A

Miller, G. (1951). *Language and communication*. McGraw-Hill. doi: 10.1037/11135-000

Piantadosi, S. T., Tily, H., & Gibson, E. (2012). The communicative function of ambiguity in language. *Cognition 122,* 28–291. doi: 10.1016/j.cognition.2011.10.004

Rosa, E. C., & Arnold, J. E. (2011). The role of attention in choice of referring expressions. In *Proceedings of PRE-Cogsci: Bridging the gap between computational, empirical and theoretical approaches to reference*. Boston, MA.

Sheldon, A. (1974). The role of parallel function in the acquisition of relative clauses in English. *Journal of Verbal Learning and Verbal Behavior, 13,* 272–281. doi: 10.1016/S0022-5371(74)80064-2

Vogels, J., Krahmer, E. J., & Maes, A. (2011). How visual saliency affects referent accessibility. In L. Carlson, C. Hoelscher, & T. F. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society* (pp. 3128–3133). Austin, TX: Cognitive Science Society.

Роль потенциального референциального конфликта в выборе референциального выражения

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Аннотация. Настоящий обзор посвящен феномену референциальной неоднозначности, или референциального конфликта, то есть такой дискурсивной ситуации, при которой два или более референтов активированы достаточно сильно, чтобы быть выбранными в качестве антецедентов редуцированных референциальных выражений. В то время как глобальная неоднозначность встречается в языке редко, потенциальная неоднозначность широко распространена и вследствие этого нуждается в тщательном изучении. В данном обзоре описывается типология референциальных конфликтов, а также делается попытка дать объяснение эффектам, связанным с потенциальным референциальным конфликтом, которые были раньше описаны в литературе. Предлагается модель референциального конфликта, которая определяет выбор референциальной стратегии говорящего в зависимости от того, смог ли он предотвратить референциальный конфликт. Наконец, на материале анализа как предыдущих исследований, так и собственного русскоязычного эксперимента автор представляет общую модель референциального выбора. В данной модели механизм предотвращения референциального конфликта описывается как отдельный модуль, что отличает эту модель от других подобных моделей, в которых референциальная неоднозначность включается в число факторов, понижающих уровень активации референта.

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Литература

Кибрик А.А. Механизмы устранения референциального конфликта // Моделирование языковой деятельности в интеллектуальных системах. 1987. С. 128–145.

Ariel M. Referring and accessibility // Journal of linguistics. 1988. Vol. 24. № 1. P. 65–87. doi: 10.1017/S0022226700011567

Ariel M. Accessing noun-phrase antecedents. London: Routledge, 1990.

Arnold J.E. The effect of thematic roles on pronoun use and frequency of reference continuation // Discourse Processes. 2001. Vol. 31. № 2. P. 137–162. doi: 10.1207/S15326950DP3102_02

Arnold J.E. Reference production: Production-internal and addressee-oriented processes // Language and cognitive processes. 2008. Vol. 23. № 4. P. 495–527. doi: 10.1080/01690960801920099

Arnold J.E., Eisenband J.G., Brown-Schmidt S., Trueswell, J.C. The rapid use of gender information: Evidence of the time course of pronoun resolution from eyetracking // Cognition. 2000. Vol. 76. № 1. P. B13–B26. doi: 10.1016/S0010-0277(00)00073-1

Arnold J.E., Griffin Z.M. The effect of additional characters on choice of referring expression: Everyone counts // Journal of Memory and Language. 2007. Vol. 56. № 4. P. 521–536. doi: 10.1016/j.jml.2006.09.007

Brennan S.E., Clark H.H. Conceptual pacts and lexical choice in conversation // Journal of Experimental Psychology: Learning, Memory, and Cognition. 1996. Vol. 22. № 6. P. 1482–1493. doi: 10.1037/0278-7393.22.6.1482

Brown-Schmidt S. Partner-specific interpretation of maintained referential precedents during interactive dialog // Journal of memory and language. 2009. Vol. 61. № 2. P. 171–190. doi: 10.1016/j.jml.2009.04.003

Brown-Schmidt S. Beyond common and privileged: Gradient representations of common ground in real-time language use // Language and Cognitive Processes. 2012. Vol. 27. № 1. P. 62–89. doi: 10.1080/01690965.2010.543363

Chafe W.L. Givenness, contrastiveness, definiteness, subjects, topics, and point of view in subject and topic // C.N. Li (Ed.). Subject and topic. New York: Academic Press, 1976. P. 25–56.

Chafe W.L. Introduction to a special issue on third-person reference in discourse // International Journal of American Linguistics. 1990. Vol. 56. № 3. P. 313–316. doi: 10.1086/466160

Chafe W. Discourse, consciousness, and time: The flow and displacement of conscious experience in speaking and writing. Chicago: University of Chicago Press, 1994.

Chomsky N. An interview on minimalism // N. Chomsky, A. Belletti, L. Rizzi (Eds.) On Nature and Language. 2002. P. 92–161. doi: 10.1017/CBO9780511613876.005

Clark H.H. Using language. Cambridge: Cambridge University Press, 1996. doi: 10.1017/CBO9780511620539

Clark H.H., Bangerter A. Changing ideas about reference // Experimental pragmatics. 2004. С. 25–49.

Clark H.H., Brennan S.E. Grounding in communication // L. B. Resnick, J.M. Levine, S.D. Teasley (Eds.) Perspectives on socially shared cognition. Washington, D.C.: APA Books, 1991. P. 127–149. doi: 10.1037/10096-006

Clark H.H., Krych M.A. Speaking while monitoring addressees for understanding // Journal of Memory and Language. 2004. Vol. 50. № 1. P. 62–81. doi: 10.1016/j.jml.2003.08.004

Clark H.H., Wilkes-Gibbs D. Referring as a collaborative process // Cognition. 1986. Vol. 22. № 1. P. 1–39. doi: 10.1016/0010-0277(86)90010-7

Ferreira V.S., Slevc L.R., Rogers E.S. How do speakers avoid ambiguous linguistic expressions? // Cognition. 2005. Vol. 96. № 3. P. 263–284. doi: 10.1016/j.cognition.2004.09.002

Fletcher C.R. Markedness and topic continuity in discourse processing // Journal of Verbal Learning and Verbal Behavior. 1984. Vol. 23. № 4. P. 487–493. doi: 10.1016/S0022-5371(84)90309-8

Foley W.A., Van Valin Jr R. D. Functional syntax and universal grammar. Cambridge: Cambridge university press, 1984.

Fox B.A. Discourse structure and anaphora: Written and conversational English. Cambridge: Cambridge University Press, 1987. doi: 10.1017/CBO9780511627767

Fukumura K. Choosing referring expressions. PhD dissertation. University of Dundee, 2010.

Fukumura K., van Gompel R.P.G. Choosing anaphoric expressions: Do people take into account likelihood of reference? // Journal of Memory and Language. 2010. Vol. 62. № 1. P. 52–66. doi: 10.1016/j.jml.2009.09.001

Fukumura K., van Gompel R.P.G. The effect of animacy on the choice of referring expression // Language and Cognitive Processes. 2011. Vol. 26. № 10. P. 1472–1504. doi: 10.1080/01690965.2010.506444

Fukumura K., van Gompel R.P.G., Harley T., Pickering M.J. How does similarity-based interference affect the choice of referring expression? // Journal of Memory and Language. 2011. Vol. 65. № 3. P. 331–344. doi: 10.1016/j.jml.2011.06.001

Fukumura K., van Gompel R.P.G., Pickering M.J. The use of visual context during the production of referring expressions // The Quarterly Journal of Experimental Psychology. 2010. Vol. 63. № 9. P. 1700–1715. doi: 10.1080/17470210903490969

Fukumura K., Hyönä J. Two of the same gender compete: evidence from reference production. Talk presented at the 24th Annual Conference on Human Sentence Processing, Stanford, 2011.

Garnham A. Mental models and the interpretation of anaphora. Hove: Psychology Press, 2001.

Gernsbacher M.A., Hargreaves D.J. Accessing sentence participants: The advantage of first mention // Journal of Memory and Language. 1988. Vol. 27. № 6. P. 699–717. doi: 10.1016/0749-596X(88)90016-2

Givón T. Topic continuity in discourse: A quantitative cross-language study. Amsterdam: John Benjamins Publishing, 1983. doi: 10.1075/tsl.3

Givón T. Coherence in text, coherence in mind // Pragmatics & Cognition. 1993. Vol. 1. № 2. P. 171–227. doi: 10.1075/pc.1.2.01giv

Grosz B.J., Weinstein S., Joshi A.K. Centering: A framework for modeling the local coherence of discourse // Computational linguistics. 1995. Vol. 21. № 2. P. 203–225.

Gundel J.K., Hedberg N., Zacharski R. Cognitive status and the form of referring expressions in discourse // Language. 1993. С. 274–307. doi: 10.2307/416535

Hanna J.E., Tanenhaus M.K., Trueswell J.C. The effects of common ground and perspective on domains of referential interpretation // Journal of Memory and Language. 2003. Vol. 49. № 1. P. 43–61. doi: 10.1016/S0749-596X(03)00022-6

Horton W.S., Keysar B. When do speakers take into account common ground? // Cognition. 1996. Vol. 59. № 1. P. 91–117. doi: 10.1016/0010-0277(96)81418-1

Järvikivi J., van Gompel R.P.G., Hyona J., Bertram R. Ambiguous pronoun resolution: Contrasting the first-mention and subject-preference accounts // Psychological Science. 2005. Vol. 16. № 4. P. 260–264. doi: 10.1111/j.0956-7976.2005.01525.x

Kaiser E., Trueswell J.C. The role of discourse context in the processing of a flexible word-order language // Cognition. 2004. Vol. 94. № 2. P. 113–147. doi: 10.1016/j.cognition.2004.01.002

Kantola L. & van Gompel, R.P.G. Does the addressee matter when choosing referring expressions? Proceedings of PRE-Cogsci: Bridging the gap between computational, empirical and theoretical approaches to reference. Boston, 2011.

Karmiloff-Smith A. Language and cognitive processes from a developmental perspective // Language and cognitive processes. 1985. Vol. 1. № 1. P. 61–85. doi: 10.1080/01690968508402071

Kaiser E., Trueswell J. The role of discourse context in the processing of a flexible word-order language // Cognition. 2004. Vol. 94. № 2. P. 113–147. doi: 10.1016/j.cognition.2004.01.002

Keysar B., Barr D.J., Balin J.A., Brauner J.S. Taking perspective in conversation: The role of mutual knowledge in comprehension // Psychological Science. 2000. Vol. 11. № 1. P. 32–38.

Kibrik A. A. Reference in discourse. Oxford: Oxford University Press, 2011. doi: 10.1111/1467-9280.00211

Lambrecht K. Information structure and sentence form: Topic, focus, and the mental representations of discourse referents. Cambridge: Cambridge University Press, 1996. doi: 10.1017/CBO9780511620607

Levelt W.J.M. Speaking: From intention to articulation. Cambridge: MIT Press, 1989.

MacDonald M.C., MacWhinney B. Measuring inhibition and facilitation from pronouns // Journal of Memory and Language. 1990. Vol. 29. № 4. С. 469–492. doi: 10.1016/0749-596X(90)90067-A

Miller G.A. Language and communication. McGraw-Hill, 1951. doi: 10.1037/11135-000

Piantadosi S.T., Tily H., Gibson E. The communicative function of ambiguity in language // Cognition. 2012. Vol. 122. № 3. P. 280–291. doi: 10.1016/j.cognition.2011.10.004

Rosa E.C., Arnold J.E. The role of attention in choice of referring expressions // Proceedings of PRE-Cogsci: Bridging the gap between computational, empirical and theoretical approaches to reference. Boston, MA, 2011.

Sheldon A. The role of parallel function in the acquisition of relative clauses in English // Journal of Verbal Learning and Verbal Behavior.1974. Vol. 13. № 3. P. 272–281. doi: 10.1016/S0022-5371(74)80064-2

Vogels J., Krahmer E. J., Maes A. How visual saliency affects referent accessibility. // L. Carlson, C. Hoelscher, T.F. Shipley (Eds.) Proceedings of the 33rd Annual Conference of the Cognitive Science Society. Austin, TX: Cognitive Science Society, 2011. P. 3128–3133.

Give Me Time to Picture That: Effects of Time and Imageability on Effector-Specific Motor Activation in Idiom Processing

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Abstract. A great amount of evidence has now been accumulated indicating that many aspects of cognition, including language are closely interconnected with or "grounded" in the sensory-motor modalities. In this respect, an interesting line of research that has not yet been studied in great detail is whether activation of the sensory-motor brain areas can be found when figurative language is processed. Two experiments were conducted to address the following questions: firstly, can evidence of effector-specific motor activation be found in the processing of idioms; secondly, how would such activation unfold in time? We hypothesized that highly imageable idioms are more strongly coded in different modalities and would therefore be processed faster and be more likely to show evidence of activation in the motor cortex. We also hypothesized that the time between the subsequent presentation of two stimuli would affect the response pattern, as complex simulation processes involving the motor modality in the processing of language would take time to unfold and for two conflicting activations to be integrated. Participants saw pairs of idioms presented one by one and had to indicate whether both idioms were familiar. In Experiment 1, participants responded manually by pressing a button. Experiment 2 required an oral response. For both experiments, highly imageable idioms were processed faster than those with low imageability, indicating a processing advantage related to imageability. More importantly, in Experiment 2 there was a three-way interaction: after a stimulus onset asynchrony (SOA) of 3000 ms there was facilitation in highly imageable idioms in the Same Effector condition compared to the Different Effector condition, suggesting that the motor simulation process might need time to unfold.

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Introduction

Traditionally, language has been viewed as an abstract, amodal, proposition-based, symbolically operated system with perception and action acting as simple input-output systems (Wilson, 2002). However, there is emerging evidence that sensory-motor representations play a role in the processing of literal language, from individual words to phrases and sentences (see Fischer & Zwaan, 2008, for a review). In particular, a wealth of brain imaging research shows that processing motion-related, effector-specific verbs (e.g., *lick, pick, kick*) or sentences activates motor and premotor cortices in a somatotopic[1] manner (Pulvermüller, Haerle, & Hummel, 2001; Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005; Buccino et al., 2005; Tettamanti et al., 2005). Behavioral studies, in turn, have found evidence of activation for a variety of spatial and motor characteristics in response to verbal material (e.g., Glenberg & Kaschak, 2002; Matlock, 2004; Bergen, Lau, Narayan, Stojanovic, & Wheeler 2010). These data are broadly consistent with the claim that cognition is based on action and perception, and is grounded in the human body (Barsalou, 2008). Thus, "embodiment" (that is, the sensory and motor characteristics of the actor's body) impacts cognitive processing.

One of the strongest claims of the embodiment theory relates to the processing of abstract language (Jirak, Menz, Buccino, Borghi, & Binkofski, 2010). An obvious extreme example of the abstract language is figurative language, which includes metaphors, idioms, irony and the like. Idioms are of special interest because the combination of meanings of the constituents is usually different from the figurative meaning of an idiom, and the relationship between literal and figurative meanings is considered to be arbitrary (Cacciari et al., 2011). Cacciari et al. (2011) conducted a transcranial magnetic stimulation (TMS) study which confirmed that verb reading engaged the motor system even if the verbs were embedded in fictive motion or metaphoric sentences. However, such activation was not observed for idiomatic sentences. On the other hand, Boulenger, Hauk, and Pulvermüller (2009) obtained fMRI evidence for effector-specific motor activation in the processing of idioms. In contrast, Raposo, Moss, Stamatakis, and Tyler (2009) failed to obtain evidence of motor activation for idioms in another fMRI study. The researchers pointed out that there might be a crucial difference in the explored time window. Boulenger, Roy, Paulignan, Deprez, Jeannerod, and Nazir (2006) also emphasized the importance of timing, suggesting that processes that run in parallel interfere with each other. They observed that if an action verb was presented during a reaching movement, interference occurred (in terms of reaction time), but the movement was facilitated if the word was presented before the movement onset.

Also exploring the temporal dynamics of activation, Borreggine and Kaschak (2006) reproduced the original action-sentence compatibility (ACE) study by Glenberg and Kaschak (2002) but varied the time at which a response cue was given, indicating when participants should initiate a movement. The ACE facilitation effect for direction-compatible actions and sentences was obtained only if the cue was given at the onset of the stimulus sentence, but presenting the cue at 1000 ms after that resulted in a reversal of the pattern, i.e. inhibition. The authors explained the results within the framework of the Theory of Event Coding (TEC) by Hommel, Musseler, Aschersleben, and Prinz (2001). According to this theory, action planning is divided into two stages. First, there is activation of all action-relevant features; at this stage, facilitation for processes activating the same motor features can be observed. During the following stage, the features are integrated and bound to a specific action, so inhibition might be observed due to competition for the same resources. This approach is useful and revealing since it differentiates between mere activation and the integration of features, which prompts the question of what other factors, apart from time, might be influencing the integration. Possible candidates would be the nature of the task and the characteristics of the stimuli themselves.

Our previous research (Gradinarova & Janyan, 2011a; Gradinarova & Janyan, 2011b) showed that both imageability (the ease and speed with which a mental image is evoked by a verbal stimulus) and the nature of the task (familiarity and meaning-verification tasks) affected the activation pattern in the processing of idiomatic expressions. Imageability seems to be an important dimension of the representation and processing of motion verbs and idioms. It is closely connected to mental imagery and, therefore, to our sensorimotor experience (Kosslyn, Ganis, & Thompson, 2001; Kosslyn, 2005; see also Lakoff, 1994, for the importance of imagery in discovering the meaning of tropes and idioms). In Gradinarova and Janyan (2011a, 2011b) a semantic interference paradigm was applied as described by Bergen et al. (2010). Action picture-verb pairs were presented. Participants were asked to indicate whether the picture and the verb stood for the same action or not. The target pairs were those in which both the picture and the verb referred to a specific action performed either with the same effector (e.g., foot in the pair *kick-run*) or a different effector (e.g., foot and hand in the pair *jump-write*). Analysis showed that participants were slower in saying "No" in the same-effector condition than in the different-effector condition. Bergen et al. (2010) accounted for this interference effect in terms of competing activation of the same motor circuits.

The same logic was used in Gradinarova and Janyan (2011a, 2011b) but verbs and idioms were used as stimuli instead. Pictures were not included because automatic motor activation in linguistic processing should also be elicited when only linguistic stimuli are presented, and such a presentation method would lead to greater simplicity of the experiment and exclude an additional modality to be studied. Secondly, finding images to depict phrases with idiomatic, non-literal meanings would be difficult and would unnecessarily strengthen the subjectivity factor as different participants might imagine a situation described by an idiom in different ways. To verify the strong embodiment claim, Gradinarova and Janyan (2011b) used idiom pairs as stimuli, with the first idiom always containing a verb referring to a hand-action and the second idiom containing either a hand-action verb or a verb referring to a different-effector action. Imageability was hypothesized to be a factor of importance. Following the logic of Paivio's

[1] The motor cortex is organized somatotopically, i. e. specific areas being responsible for specific body parts.

(1991) Dual Coding Theory, which states that language is represented in two separate but strongly interconnected systems – logogens (verbal) and imagens (non-verbal, sensory) – it was supposed that highly imageable idioms would be strongly represented in the sensory-motor system (see also Boulenger et al., 2009) and would have a processing advantage as well as being more likely to elicit stronger motor activation effects. Participants had two different tasks in two separate experiments: meaning verification (indicating whether two idioms have the same meaning) and familiarity verification (indicating whether both idioms were familiar to them). In both experiments, highly imageable idioms elicited significantly faster responses (supporting the hypothesized processing advantage) as well as a semantic interference effect. Low-imageability idioms were influenced by the task and gave an opposite, facilitation effect. That is, the same-effector idioms were processed faster than different-effector idioms in the familiarity verification task, but no significant effect was found in the meaning verification task. Importantly, experiments that reversed the idiom presentation order so that a response was always given to a phrase involving an action with the hand effector (Markova, 2011) failed to reproduce the effects. Unpublished data from recent research conducted by Gradinarova and Janyan (2011) suggests that highly imageable idiomatic phrases presented individually actually interfere with the hand movement required for the response (pressing a button).

As in our 2011b study, the experiments presented here implemented the semantic interference paradigm and varied imageability as a factor possibly influencing motor activation for idiomatic language. Additionally, the methodological corrections from Markova (2011) were incorporated. A familiarity verification task was implemented to test the previously obtained facilitation effects (in low-imageability idioms) versus inhibition effect (in high-imageability idioms) and whether these effects might have resulted from methodological faults. An SOA manipulation was included so as to test for temporal effects. A different task was also used in Experiment 2 in order to preclude any effect resulting from the manual response action interacting with the idiom processing. Our main focus was on highly imageable idioms. We hypothesized that: 1) highly imageable idioms would have a processing advantage; 2) stimuli with higher imageability would elicit stronger motor activation, i.e. there would be a difference in reaction times (RTs) for same-effector versus different-effector pairs of highly imageable idioms; 3) this difference might be influenced by the temporal dynamics of activation, though the exact pattern of the activation was hard to predict given the scarce amount of previous research.

Method: Experiment 1.

Participants: 25 native Bulgarian speakers (18 females) participated in the experiment (mean age=24.6, SD=4.6).

Stimuli and Design: A 2 (Effector Matching: Same vs. Different) × 2 (Imageability: High vs. Low) × 2 (SOA: 2000 ms vs. 3000 ms) factorial design was used. The stimuli were the same as in Experiment 2 in Gradinarova and Janyan (2011b) but the order of presentation within an idiom pair was reversed for methodological reasons (so that the response would always follow an idiom containing a HAND-action verb). Target stimuli consisted of 16 pairs of high-imageability and 16 pairs of low-imageability idioms, controlled for their familiarity, transparency and length (see Table 1). All idioms had a similar syntactic structure, consisting of a verb that referred to an action performed with a specific effector (HAND, FOOT, MOUTH) and a noun and/or prepositional phrase. The second idiom in a pair always contained a HAND-action verb. It was presented after a phrase with a verb referring either to another HAND-action or to an action with a different effector (see Figure 1). SOA was varied so that after a 1500 ms presentation of the first idiom, the interstimulus interval was either 500 ms or 1500 ms. 18 more pairs of Bulgarian idioms and 50 pairs containing idioms translated from another language were used as fillers.

	High Imageability		Low Imageability	
	Idiom 1	Idiom 2	Idiom 1	Idiom 2
Imag.	5.4(0.3)	5.7(0.5)	3.6(0.3)	3.6(0.4)
Famil.	6.2(0.4)	6.1(0.3)	6.0(0.7)	6.1(0.5)
Transp	5.0(0.6)	5.0(0.6)	4.9(0.8)	4.9(0.7)
N.words	3.0(1.0)	3.1(0.9)	3.1(1.1)	3.1(1.0)

Table 1. **Means and standard deviations (SDs; in parenthesis) for characteristics of target idiom pairs.** Note. Imageability, familiarity, and transparency represent a 7-point subjective rating (7 – the most imageable, familiar, and transparent) based on pretests conducted with native Bulgarian speakers; N.words refers to idiom length measured in number of words.

Procedure: Participants were asked to discriminate between familiar and unfamiliar idioms. Two idioms appeared one after another on the screen. Participants were instructed to give a "YES" response if BOTH of these expressions were familiar to them, and a "NO" response if ANY (either or both) of the idioms were unfamiliar to them. The task was implemented in order to engage the participants in carefully reading and trying to understand the stimuli. Motor activation was expected to occur automatically with the processing of the linguistic stimuli and to a different degree depending on the characteristics of these stimuli.[1] All fillers required a "NO" response and all "NO" responses to target (familiar) stimuli were considered erroneous (erroneous responses included errors, in which participants accidentally indicated that they did not know an idiom that was actually familiar to them, as well as cases in which the target stimuli were unfamiliar to the participants and were therefore not analyzed, since the focus of the present study is on familiar idioms. Only "YES" responses were analyzed. Four lists were devised in order to

[1] Unpublished research by Gradinarova and Janyan (2011) suggests that the effects elicited when implementing the familiarity judgment task cannot be explained merely by lexical retrieval processes. The processing of the HAND-action verb in the stimuli seemed to interact with the hand-action (pressing a button) required for the response, indicating involvement of motor activation in language processing.

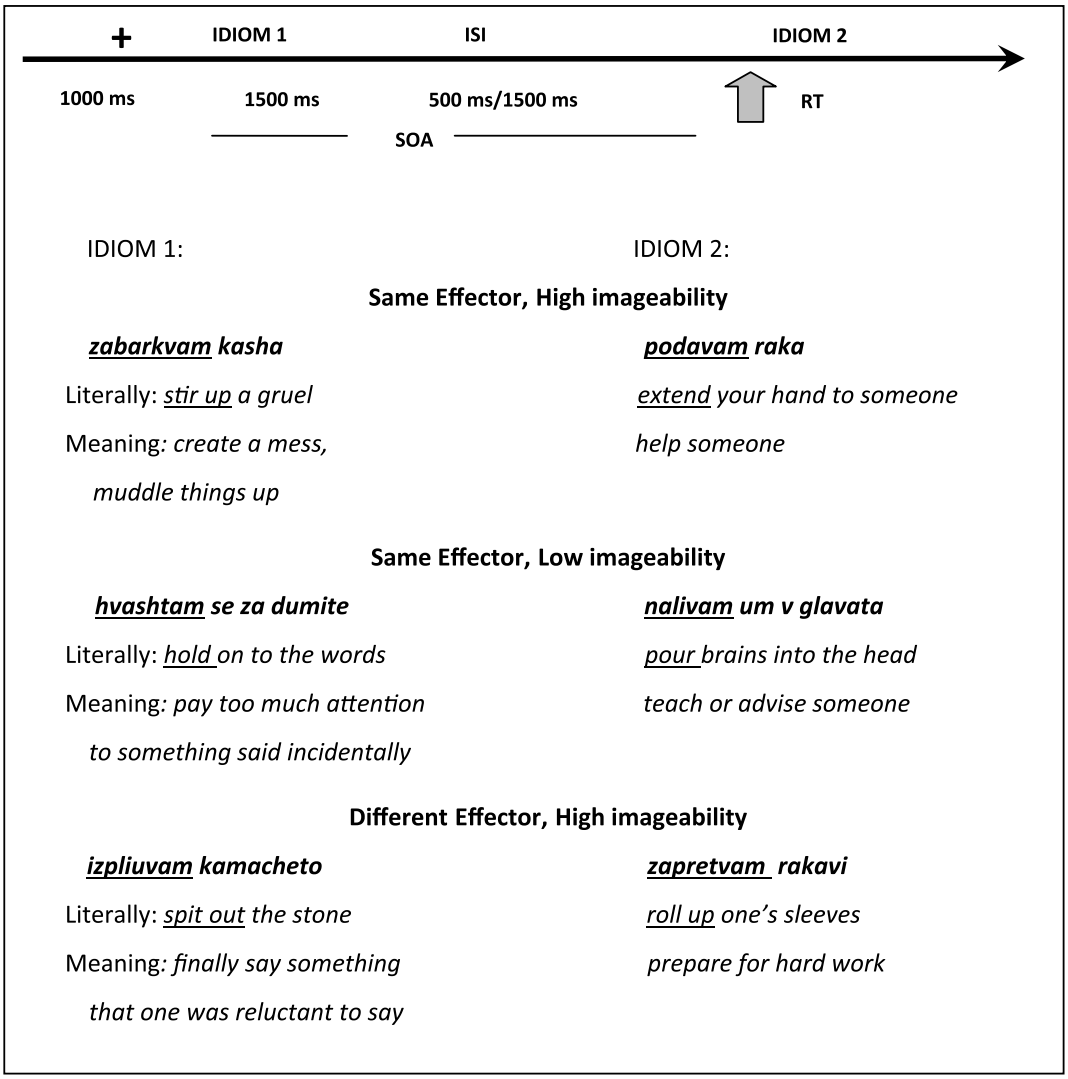

Figure 1. Procedure and example stimuli for Experiments 1 and 2.

counterbalance the Effector-Matching and SOA conditions across idioms. Each participant saw each target idiom only once, as the idioms were randomly assigned to one of the four lists. The stimuli presentation was pseudorandomized, so that the same condition did not appear in more than three consecutive trials.

Participants were given written and oral instructions, after which they went through a short practice session. Each trial started with a fixation cross ("+") for 1000 ms, followed by an idiom, which stayed on the screen for 1500 ms, followed by a blank screen for either 1500 ms or 500 ms (depending on the SOA condition), and then by another idiom, which stayed on the screen for 4000 ms or until a response was given. The inter-trial interval was 1500 ms. E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) was used to present the stimuli and record the response accuracy and RT.

Results: Experiment 1

Prior to the analysis[1], erroneous responses (7.1%) and response times lying more than ± 2.5 standard deviations from the mean per condition (2.1%) were excluded. A 2 (Effector Matching: Same vs. Different) x 2 (Imageability: High vs. Low) x 2 (SOA: 3000 ms vs. 2000 ms) repeated measures ANOVA was performed for subject and item means. Table 2 presents the means and standard deviations for each condition.

The analysis revealed a significant main effect of Imageability in subject and item means ($F_s(1,24)=16.59$, $p=.00$, $\eta_p^2=.41$; $F_i(1,26)=5.21$, $p=.03$, $\eta_p^2=.17$). Response times to high-imageability idioms were faster than for low-imageability idioms (see Table 2). This main effect confirms the results of Gradinarova and Janyan (2011a, 2011b), who reported faster response times for high-imageability idioms than for low-imageability idioms. In addition, a marginal effect of SOA in both subject and item means was revealed ($F_s(1,24)=3.62$, $p=.07$, $\eta_p^2=.13$; $F_i(1,26)=4.13$, $p=.05$, $\eta_p^2=.14$), suggesting that subjects were slower in the 3000 ms SOA condition than in the 2000 ms SOA condition. A marginal interaction between Effector Matching and SOA was also found ($F_s(1,24)=3.30$, $p=.08$, $\eta_p^2=.12$; $F_i(1,26)=4.03$, $p=.06$, $\eta_p^2=.13$). The Fischer LSD post-hoc test showed that at SOA 3000 ms, same-effector idioms were processed significantly slower than at SOA 2000 ms ($p=.01$).

[1] Although there was not an equal amount of subject data per list we report data of all 25 participants. Data of 24 participants were analyzed and the results were of no difference from the 25 subject data. Due to space restriction we report only one analysis.

SOA	Matching	High Imageability	Low Imageability
2000	Diff.	1357 (275)	1456 (330)
	Same	1268 (255)	1428 (291)
3000	Diff.	1375 (322)	1458 (251)
	Same	1444 (358)	1561 (334)

Table 2. Experiment 1. Mean response times (in ms) and SDs (in parenthesis) for each condition, subject means.

As a whole, Experiment 1 did not produce any convincing evidence for effector-specific motor activation in both types of idioms, although the marginal interaction between Effector Matching and SOA did suggested an inhibition effect at a later time window for phrases sharing the same effector. However, a possible interaction between the manual response movement and the processing of the idioms might have masked any effects. Therefore, Experiment 2 was designed to preclude any interaction of that kind, by changing the response mode from manual to oral.

Method: Experiment 2

Participants: 20 native Bulgarian speakers (11 females) participated in the experiment (mean age=8.1, SD=7.1).

Stimuli and Design: The stimuli and design were identical to Experiment 1.

Procedure: The same as in Experiment 1, the only difference being that responses were oral ("Yes"/"No"). A serial response button box recorded voice onset RT through a microphone.

Results: Experiment 2

Prior to the analysis, erroneous responses (7.7%) and response times lying more than ± 2.5 standard deviations from the mean per condition (2.3%) were excluded. A repeated measures ANOVA was performed for subject and item means (see Table 3 for means and SDs for each condition).

As with Experiment 1, the analysis revealed a significant main effect of Imageability in subject means but not in item means ($F_s(1,19)=20.66$, $p=.00$, $\eta_p^2=.52$; $F_i(1,30)=2.93$, $p=.1$). The main effect of SOA was also significant both in subject means and in item means ($F_s(1,19)=6.17$, $p=.03$, $\eta_p^2=.25$; $F_i(1,30)=17.76$, $p=.00$, $\eta_p^2=.37$). More importantly, two two-way interactions were obtained between Effector Matching and Imageability ($F_s(1,19)=7.83$, $p=.02$, $\eta_p^2=.29$; $F_i(1,30)=4.58$, $p=.04$, $\eta_p^2=.13$) and between SOA and Imageability in item means only ($F_s(1,19)=1.42$, $p=.2$; $F_i(1,30)=4.78$, $p=.04$, $\eta_p^2=.14$). Most crucially, there was a significant three-way interaction ($F_s(1,19)=8.18$, $p=.02$, $\eta_p^2=.30$; $F_i(1,30)=5.17$, $p=.03$, $\eta_p^2=.15$), plotted in Figure 2. Fischer's LSD post-hoc test revealed a significant difference between the Effector Matching conditions for high-imageability idioms in the 3000 ms SOA condition ($p<.05$) both in subject and in item means, suggesting a facilitation effect for highly imageable idioms sharing a same-effector verb for 3000 ms only.

Thus, the results from Experiment 2 suggested that: (i) participants were slower after a longer SOA; (ii) Imageability and Effector matching interacted, indicating that highly imageable idioms might trigger a stronger motor simulation; (iii) SOA interacted with the other factors, supporting the hypothesis that the temporal unfolding of activation is important, and more specifically, that at a later stage and for highly imageable idioms, features activated by the first expression in a pair facilitate the processing of the second idiom. Low imageability idioms remained indifferent to the experimental manipulations. Since our focus was on highly imageable idioms as bearing more potential for revealing motor activation we exclude the null results of low imageability idiom from further discussion.

SOA	Matching	High Imageability	Low Imageability
2000	Diff.	1261 (256)	1436 (373)
	Same	1254 (257)	1382 (309)
3000	Diff.	1436 (316)	1406 (292)
	Same	1308 (293)	1486 (319)

Table 3. Experiment 2. Mean response times (in ms) and SDs (in parenthesis) for each condition, subject means.

Conclusion

The comparatively new concept of embodied cognition provides a theoretical framework for the interaction of high- and low-level processes. It links personal experience, sensorimotor processes and cognitive processes such as language comprehension. The theory claims that language processing recruits the same sensorimotor areas needed for action execution or interaction with objects to which the words refer One of the strongest claims of embodiment cognition refers to the embodiment of abstract language. Experimental data on the link between motor representation and abstract, idiomatic language are scarce and inconclusive.

The current experiments aimed to explore a possible motor activation in the processing of idioms by using the semantic interference paradigm (Bergen et al., 2010). Another aim of the study was to trace the time needed for capturing the motor activation. Both experiments used the same paradigm and the same target stimuli. Two idioms were presented to the participants that contained verbs for actions performed with a particular effector (hand, foot, mouth). The first idiom either shared the same effector as the second one (hand) or did not. Based on previous rating studies the stimuli were evenly divided into pairs of idioms with either high or low imageability. Two SOAs were used: 2000 ms or 3000 ms. We hypothesized that there would be a significant difference between the RTs if idioms activated the same motor circuit in comparison with the motor circuits responsible for different effectors. Based

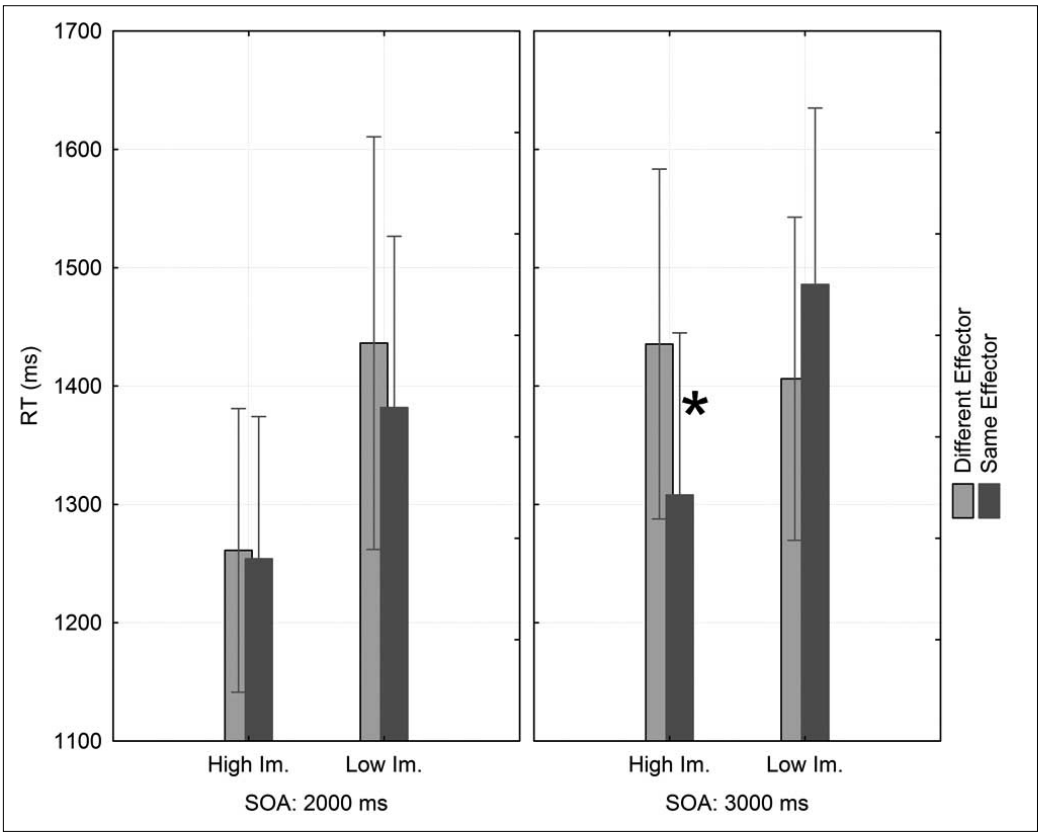

Figure 2. Effector Matching by Imageability by SOA, item means (vertical bars denote 0.95 confidence intervals). * p<0.05.

on our previous research (Gradinarova & Janyan, 2011a; 2011b), a processing advantage as well as an interference effect were expected to appear for highly imageable idioms. However, we had no specific prediction concerning motor activation timing due to the fact that the variety of previous research mentioned in the introduction has not yet led to the formulation of a systematic and clear principle describing the influence of time. We did hypothesize that the activation and integration processes would be influenced by the time given for their unfolding.

In keeping with Paivio's (1991) Dual Coding Theory and in accordance with various imagery data (Kosslyn et al. 2001; Kosslyn, 2005), we found a processing advantage for highly imageable idioms which are presumably well-represented not only in a verbal system but also in the sensory-motor system (Boulenger et al., 2009). In Experiment 1, any effects of the activation of overlapping motor circuitry might have been masked by the hand motor task. In Gradinarova and Janyan (2011b) an inhibition effect was observed for highly imageable idioms. The response was made by pressing a button following either an idiom containing a HAND-action verb or an idiom containing a FOOT-/MOUTH-action verb and thus the inhibition might have been due to competition between the motor activation triggered by the HAND-action idiom and the HAND-action response. Similarly, the current study's Experiment 1 revealed a tendency toward inhibition when same-effector idioms were presented with an SOA of 3000 ms. Experiment 2 excluded the possibility of inhibition by introducing an oral response. Facilitation was then observed at a later time window. The facilitation effect (RT difference between the same and different effector conditions) was valid for highly imageable idioms only. It might be that, given enough time to unfold, the motor activation from the first phrase facilitated the processing of the second. This might be explained in terms of better integration given a greater time difference between the stimuli, a hypothesis that would be in keeping with the TEC (Hommel et al., 2001). In terms of the TEC, the observed facilitation may reflect activation of all action-relevant features during the processing of both idioms. The TEC would predict that the facilitation effect could be reversed into inhibition at an even later stage, when the features activated by the first idiom would be integrated and the features activated by the second idiom would enter into competition within the same circuitry. The lack of an earlier effect could be a result of a slower activation of motor features in the idiomatic phrases. However, when a HAND-response was required, in addition to the two idiomatic phrases, which already had integrated features, response would interfere strongly with the two previous activations of the hand circuitry and would result in inhibition. This could account for the presence of inhibition rather than facilitation with the manual response. An additional possibility is that it is generally more difficult for motor activations accompanying actual manual responses to be integrated with motor activations from language processing. Thus, the present study suggests that researchers should be careful when implementing a motor task in experiments in the grounded cognition paradigm.

An alternative explanation for the facilitation effect could be that it was due to pure lexical associations between words that share the same effector. That is, the verb *stir* embedded in an idiom would spread the activation over the lexico-semantic system and activate all lexically associated words *extend* being among them. Then, given time, lexical associations might have been triggered resulting in faster recognition of *extend* within an idiom and, hence, overall processing facilitation compared to the different

effector condition. There are observations, however, that speak against such an interpretation. First, a lexical association effect would be obtained in low imageability idiom processing, too; this is not the case. Second, it is not clear why a lexical association effect would disappear if a manual response was required. An interaction of motor activations could, however, account for this sort of result.

Further research is needed to resolve the questions raised by the current study. The differences between the results of the two experiments presented here suggest that the processes of motor activation and motor integration might be complicated and dependent on a variety of factors, such as time, word properties such as imageability, and the nature of the task implemented. Special attention should also be devoted to the methodology used in experiments in this field, as demonstrated by the consequences of implementing an interfering motor task, as well as differences in the order of stimuli presentation. To conclude, besides methodological issues, the studies provided some initial evidence for the timeline of the grounding of idiomatic language and of sensorimotor involvement in abstract idiomatic language processing that can be captured by response times.

References

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617–645. doi: 10.1146/annurev.psych.59.103006.093639

Bergen, B., Lau, T. T. C., Narayan, S., Stojanovic, D., & Wheeler, K. (2010). Body part representations in verbal semantics. *Memory & cognition, 38*(7), 969–981. doi: 10.3758/MC.38.7.969

Borreggine, K. L., & Kaschak, M. P. (2006). The action–sentence compatibility effect: It's all in the timing. *Cognitive Science, 30*, 1097–1112. doi: 10.1207/s15516709cog0000_91

Boulenger, V., Hauk, O., Pulvermüller, F. (2009). Grasping ideas with the motor system: semantic somatotopy in idiom comprehension. *Cerebral Cortex, 19*(8), 1905–1914. doi: 10.1093/cercor/bhn217

Boulenger, V., Roy, A. C., Paulignan, Y., Deprez, V., Jeannerod, M., & Nazir, T. A. (2006). Cross-talk between language processes and overt motor behavior in the first 200 ms of processing. *Journal of Cognitive Neuroscience, 18*(10), 1607–1615. doi: 10.1162/jocn.2006.18.10.1607

Buccino, G., Riggio, L., Melli, G., Binkofski, F., Gallese, V., & Rizzolatti, G. (2005). Listening to action-related sentences modulates the activity of the motor system: a combined TMS and behavioral study. *Cognitive Brain Research, 24*(3), 355–363. doi: 10.1016/j.cogbrainres.2005.02.020

Cacciari, C., Bolognini, N., Senna, I., Pellicciari, M. C., Miniussi, C., Papagno, C. (2011). Literal, fictive and metaphorical motion sentences preserve the motion component of the verb. A TMS study. *Brain and Language, 119(3)*, 149–157. doi: 10.1016/j.bandl.2011.05.004

Fischer, M. H. & Zwaan, R. A. (2008). Embodied language: a review of the role of the motor system in language comprehension. *Quarterly Journal of Experimental Psychology, 61*, 825–850. doi: 10.1080/17470210701623605

Glenberg, A. M. & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review, 9*(3), 558–565. doi: 10.3758/BF03196313

Gradinarova, G. & Janyan, A. (2011a). Effector-specific motor simulation in idiom processing. In B. Kokinov, A. Karmiloff-Smith, N.J. Nersessian (Eds.), *European Perspectives on Cognitive Science*. Sofia: New Bulgarian University Press.

Gradinarova, G. & Janyan, A. (2011b). Motor simulation and verbal association in idiom-idiom verification: Effects of imageability. In L. Carlson, C. Hoelscher, & T.F. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society* (pp. 3052–3057). Austin, TX: Cognitive Science Society.

Hommel, B., Musseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849–937. doi: 10.1017/S0140525X01000103

Jirak, D., Menz, M. M., Buccino, G., Borghi, A. M., & Binkofski, F. (2010). Grasping language – A short story on embodiment. *Consciousness and cognition, 19*(3), 711–720. doi: 10.1016/j.concog.2010.06.020

Kosslyn, S. M. (2005). Mental images and the brain. *Cognitive Neuropsychology, 22*(3/4), 333–347. doi: 10.1080/02643290442000130

Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2001) Neural foundations of imagery. *Nature Reviews Neuroscience, 2*, 635–642. doi: 10.1038/35090055

Lakoff, G. (1994). What is metaphor? In J. Bardnen & K. Holyoak (Eds.), *Advances in Connectionist and Neural Computational Theory. Analogy, Metaphor, and Reminding* (pp. 203–258). *Vol.3*. Norwood, NJ: Ablex.

Markova, V. (2011). Motor simulations in idiom processing (in Bulgarian, Unpublished manuscript) [*Bachelor thesis*] Sofia: NBU.

Matlock, T. (2004). Fictive motion as cognitive simulation. *Memory & Cognition, 32*, 1389–1400. doi: 10.3758/BF03206329

Paivio, A. (1991). Dual coding theory: Retrospect and current status. Canadian Journal of Psychology, 45(3), 255–287. doi: 10.1037/h0084295

Pulvermüller, F., Hauk, O., Nikulin, V. V., & Ilmoniemi, R. J. (2005). Functional links between motor and language systems. *European Journal of Neuroscience, 21*(3), 793–797. doi: 10.1111/j.1460-9568.2005.03900.x

Pulvermüller, F., Häerle, M. & F. Hummel (2001). Walking or talking?: Behavioral and neurophysiological correlates of action verb processing. *Brain and Language, 78*(2), 143–168. doi: 10.1006/brln.2000.2390

Raposo, A., Moss, H. E., Stamatakis, E. A. & Tyler, L. K. (2009). Modulation of motor and premotor cortices by actions, action words and action sentences. *Neuropsychologia, 47*, 388–396. doi: 10.1016/j.neuropsychologia.2008.09.017

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime: User's guide*. Psychology Software Incorporated.

Scorolli, C., Borghi, A. M. (2007). Sentence comprehension and action: Effector specific modulation of the motor system. *Brain Research, 1130*, 119–124. doi: 10.1016/j.brainres.2006.10.033

Tettamanti, M., Buccino, G., Saccuman, M. C., Gallese, V., Danna, M., Scifo, P., Fazio, F., Rizzolatti, G., Cappa, S. F., Perani, D. (2005). Listening to action-related sentences activates fronto-parietal motor circuits. *Journal of Cognitive Neuroscience, 17*, 273–281. doi: 10.1162/0898929053124965

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*(4), 625–636. doi: 10.3758/BF03196322

Растянуть время и дать волю воображению: влияние представимости и доступного времени на специфическую моторную активацию при восприятии идиом

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Аннотация. Большой фактический материал указывает на то, что многие аспекты познания, в том числе язык и речь, тесно связаны с сенсомоторным опытом различных модальностей, «укоренены» в нем. В этой связи интересна еще слабо разработанная линия исследований, посвященная поиску активации сенсомоторных зон мозга при обработке переносных значений. Мы провели два эксперимента для ответа на следующие вопросы: во-первых, возможно ли обнаружить свидетельства специфической для упоминаемого эффектора моторной активации при обработке идиом; во-вторых, если это возможно, то какова будет динамика такой активации, как она будет разворачиваться во времени? Мы предположили, что идиомы с высокой представимостью имеют более выраженные репрезентации в разных модальностях и, следовательно, будут быстрее обрабатываться, и при их восприятии с большей вероятностью можно будет получить свидетельство активации в моторной коре. Мы также предположили, что на характеристики ответа будет влиять длительность интервалов между последовательным предъявлением двух стимулов-идиом, поскольку требуется время на разворачивание сложных процессов реконструкции, вовлекающих двигательную сферу в восприятие речи (моторную симуляцию), а в случае сосуществования двух противоположных тенденций активации — на их интеграцию. Испытуемые просматривали пары из двух последовательно предъявляемых идиом и должны были определить, знакомы ли им оба прочитанных выражения. В эксперименте 1 ответ осуществлялся путем нажатия на кнопку и таким образом вовлекал движения рук. В эксперименте 2 ответ был устным. Результаты обоих экспериментов продемонстрировали более быструю обработку идиом с высокой представимостью, чем с низкой, что указывает на преимущество в обработке, связанное с представимостью. Что еще важнее, в эксперименте 2 было обнаружено взаимодействие третьего порядка между факторами: при асинхронии включения стимулов в 3000 мс наблюдалось ускорение обработки высоко представимых идиом в условии совпадения упоминаемого эффектора в двух стимулах по сравнению с условием, где упоминаемые эффекторы различались. Данный результат свидетельствует в пользу предположения, что разворачивание моторной симуляции может занимать значительное время.

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Литература

Маркова В. (2011). Моторни симулации при обработка на идиоми (Бакалавърска теза). Нов български университет, София, България.

Barsalou L.W. Grounded cognition // Annual Review of Psychology. 2008. Vol. 59. P. 617–645. doi: 10.1146/annurev.psych.59.103006.093639

Bergen B., Lau T.T.C., Narayan S., Stojanovic D., Wheeler K. Body part representations in verbal semantics // Memory & Cognition. 2010. Vol. 38. №7. P. 969–981. doi: 10.3758/MC.38.7.969

Borreggine K.L., Kaschak M.P. The action–sentence compatibility effect: It's all in the timing // Cognitive Science. 2006. Vol. 30. P. 1097–1112. doi: 10.1207/s15516709cog0000_91

Boulenger V., Hauk O., Pulvermüller F. Grasping ideas with the motor system: semantic somatotopy in idiom comprehension // Cerebral Cortex. 2009. Vol. 19(8). P. 1905–1914. doi: 10.1093/cercor/bhn217

Boulenger V., Roy A.C., Paulignan Y., Deprez V., Jeannerod M., Nazir T.A. Cross-talk between language processes and overt motor behavior in the first 200 ms of processing // Journal of Cognitive Neuroscience. 2006. Vol. 18(10). P. 1607–1615. doi: 10.1162/jocn.2006.18.10.1607

Buccino G., Riggio L., Melli G., Binkofski F., Gallese V., Rizzolatti G. Listening to action-related sentences modulates the activity of the motor system: a combined TMS and behavioral study // Cognitive Brain Research. 2005. Vol. 24(3). P. 355–363. doi: 10.1016/j.cogbrainres.2005.02.020

Cacciari C., Bolognini N., Senna I., Pellicciari M.C., Miniussi C., Papagno C. Literal, fictive and metaphorical motion sentences preserve the motion component of the verb. A TMS study // Brain and Language. 2011. Vol. 119(3). P. 149–157. doi: 10.1016/j.bandl.2011.05.004

Fischer M.H., Zwaan R.A. Embodied language: a review of the role of the motor system in language comprehension // Quarterly Journal of Experimental Psychology. 2008. Vol. 61. P. 825–850. doi: 10.1080/17470210701623605

Glenberg A.M., Kaschak M.P. Grounding language in action // Psychonomic Bulletin & Review. 2002. Vol. 9(3). P. 558–565. doi: 10.3758/BF03196313

Gradinarova G., Janyan A. Effector-specific motor simulation in idiom processing // B. Kokinov, A. Karmiloff-Smith, N.J. Nersessian (Eds.) European Perspectives on Cognitive Science. Sofia: New Bulgarian University Press, 2011a.

Gradinarova G., Janyan A. Motor simulation and verbal association in idiom-idiom verification: Effects of imageability // L. Carlson, C. Hoelscher, T.F. Shipley (Eds.) Proceedings of the 33rd Annual Conference of the Cognitive Science Society . Austin, TX: Cognitive Science Society, 2011b. P. 3052–3057.

Hommel B., Musseler J., Aschersleben G., Prinz W. The theory of event coding (TEC): A framework for perception and action planning // Behavioral and Brain Sciences. 2001. Vol. 24. P. 849–937. doi: 10.1017/S0140525X01000103

Jirak D., Menz M.M., Buccino G., Borghi A.M., Binkofski F. Grasping language – A short story on embodiment // Consciousness and cognition. 2010. Vol. 19(3). P. 711–720. doi: 10.1016/j.concog.2010.06.020

Kosslyn S.M. Mental images and the brain // Cognitive Neuropsychology. 2005. Vol. 22(3/4). P. 333–347. doi: 10.1080/02643290442000130

Kosslyn S.M., Ganis G., Thompson, W.L. Neural foundations of imagery // Nature Reviews Neuroscience. 2001. Vol. 2. P. 635–642. doi: 10.1038/35090055

Lakoff G. What is metaphor? // J. Bardnen, K. Holyoak (Eds.) Advances in Connectionist and Neural Computational Theory. Analogy, Metaphor, and Reminding. Vol. 3. Norwood, NJ: Ablex, 1994. P. 203–258.

Matlock T. Fictive motion as cognitive simulation // Memory & Cognition. 2004. Vol. 32. P. 1389–1400. doi: 10.3758/BF03206329

Paivio A. Dual coding theory: Retrospect and current status // Canadian Journal of Psychology. 1991. Vol. 45(3), P. 255–287. doi: 10.1037/h0084295

Pulvermüller F., Hauk O., Nikulin V.V., Ilmoniemi R.J. Functional links between motor and language systems // European Journal of Neuroscience. 2005. Vol. 21(3). P. 793–797. doi: 10.1111/j.1460-9568.2005.03900.x

Pulvermüller F., Häerle M., Hummel F. Walking or talking?: Behavioral and neurophysiological correlates of action verb processing // Brain and Language. 2001. Vol. 78(2). P. 143–168. doi: 10.1006/brln.2000.2390

Raposo A., Moss H.E., Stamatakis E.A., Tyler, L.K. Modulation of motor and premotor cortices by actions, action words and action sentences // Neuropsychologia. 2009. Vol. 47. P. 388–396. doi: 10.1016/j.neuropsychologia.2008.09.017

Schneider W., Eschman A., Zuccolotto A. E-Prime: User's guide. Psychology Software Incorporated. 2002.

Scorolli C., Borghi A.M. Sentence comprehension and action: Effector specific modulation of the motor system // Brain Research. 2007. Vol. 1130. P. 119–124. doi: 10.1016/j.brainres.2006.10.033

Tettamanti M., Buccino G., Saccuman M.C., Gallese V., Danna M., Scifo P., Fazio F., Rizzolatti G., Cappa S.F., Perani D. Listening to action-related sentences activates fronto-parietal motor circuits // Journal of Cognitive Neuroscience. 2005. Vol. 17. P. 273–281. doi: 10.1162/0898929053124965

Wilson M. Six views of embodied cognition // Psychonomic Bulletin & Review. 2002. Vol. 9(4). P. 625–636. doi: 10.3758/BF03196322

Влияние языковых стимулов на вертикальное смещение внимания

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Аннотация. Цель данной работы — проверить на русском материале гипотезу Dudschig et al. (2012) о том, что при обработке языковых стимулов без непосредственного пространственного значения (например, *солнце, трава*) происходит смещение внимания в том направлении, где находится референт слова (так, если демонстрируется слово *солнце*, то внимание человека смещается вверх в его перцептивном поле). В двух проведенных для этого экспериментах также использовался разный тип задач, чтобы понять, влияет ли тип задачи для испытуемых на эффекты, производимые описанными стимулами (эффект усиления, или фасилитации, vs. эффект интерференции). Первый эксперимент показал отсутствие значимого взаимодействия факторов типичной локализации референта слова и расположения визуальных объектов, которые предъявляются вслед за этим словом в ходе эксперимента. Второй эксперимент обнаруживает значимое взаимодействие между факторами, но вместо ожидаемого интерференционного эффекта получен эффект усиления, или фасилитации.

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Ключевые слова: обработка языка; зрительно-пространственное внимание; моделирующая семантика; время реакции (ВР).

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Введение

Идея о том, что процесс понимания языка тесно связан с моторным, перцептивным, социальным опытом человека разрабатывалась рядом исследователей в области когнитивной лингвистики и психологии (Lakoff, Johnson, 1999; Varela, Thompson, Rosch, 1991; Barsalou, 2008; Zwaan, Madden, 2005). При восприятии и понимании слов опыт, который был связан с этим словом, активируется, происходит так называемая симуляция (*mental simulation*) ситуации или объекта. Взаимосвязь языка и пространственной ориентировки неоднократно становилась предметом экспериментальных исследований. Зачастую эксперименты в этой области исследования связаны именно со словами или предложениями с пространственной семантикой. Предполагается, что при восприятии «пространственных» слов или предложений активируются те же мозговые процессы, как если бы события происходили реально.

Так, например, если ребенок слышит фразу «*птица летит в небе*», он неосознанно поднимает голову, как бы стараясь найти этот объект. Это отсылает к теории о зеркальных нейронах, согласно которой при действии и наблюдении за этим действием работают одни те же нейроны, которые получили название *зеркальных* (Риццолатти, Сенегалья, 2012).

Экспериментальные исследования в этой области лежат в сфере поиска и изучения двух эффектов: *эффектов усиления, фасилитации (compatibility effects)* и *интерференционных эффектов (interferential effects)*. Как правило, параллельно с обработкой стимула (текста, слова, изображения) испытуемым предлагается решение некоторой задачи (совершить определенное движение рукой или решить задачу на категоризацию,

например, изображения; обзор этих экспериментов можно найти в статье Zwaan, Madden (2005)). При этом измеряется время реакции, так как предполагается, что понимание языковых единиц, имеющих в своей семантике пространственный компонент, запускает процессы моделирования определенных пространственных отношений. Следовательно, эти процессы будут влиять на время выполнения задания, либо подготавливая испытуемого к восприятию последующего стимула или выполнению задачи (и тогда время реакции уменьшается), либо определенным образом конфликтуя с задачей или последующим стимулом (и тогда выполнение задачи потребует сравнительно больших усилий, что проявится в увеличении времени реакции).

Эффект усиления, или фасилитации, проявляется в уменьшении времени реакции, в противоположность интерференционным эффектам, которые заключаются в увеличении времени реакции. Исследования интерференционных эффектов опираются на представление о том, что за понимание одних и тех же смыслов (например, пространственных) отвечают одни и те же группы нейронов, независимо от того, выражены эти смыслы вербально или визуально. Следовательно, если «занять» соответствующие группы нейронов обработкой информации, предложенной в одной системе (например, вербальной), то одновременное решение задачи, требующей участия той же группы нейронов, но представленной в другой системе (например, визуальной) будет замедлено (Richardson, Spivey, Barsalou, McRaec, 2003).

До сих пор не совсем ясно, при каких условиях проявляются эти разные эффекты, хотя некоторые гипотезы насчет причины появления противоположных эффектов уже выдвигались (Dudschig, Souman, Lachmair, de la Vega, Kaup, 2012). Так или иначе, обнаруженные эффекты при восприятии языковых стимулов приближают нас к пониманию того, как происходит обработка языка.

Когда речь идет о пространственных отношениях и их отражении в языке, то можно выделить три различных системы координат. М. К. Тимофеева описывает эти системы следующим образом: *«1) относительная, базирующаяся на точке зрения участника ситуации; 2) абсолютная, базирующаяся на характеристиках окружения (обычно это направление гравитации); 3) внутренняя, базирующаяся на предопределённых свойствах объектов внутри рассматриваемой ситуации»* (Тимофеева, 2010, с. 58).

В нашем исследовании мы опирались как на работы по изучению эффекта фасилитации, так и на исследования эффектов интерференции. Зачастую в исследованиях в качестве стимулов используются предложения, описывающие какое-либо пространственное действие. Объектом внимания в данной статье служат не предложения, а слова.

Эти слова не имеют непосредственного пространственного значения, но их референты, как правило, находятся в окружающем пространстве либо вверху, либо внизу, то есть имеют типичную локализацию в пространстве (*небо, земля, птица, ботинок*).

Предложения, часто используемые в разных экспериментах, описывают расположение в пространстве или указывают на действие, связанное с передвижением/перемещением в пространстве («*Книга упала со стола. Садовник посмотрел на орла в небе*»). Слова, выбранные нами в качестве экспериментального материала, во-первых, напрямую не описывают передвижение или положение в пространстве, во-вторых, появляются перед респондентом без контекста. Таким образом, обнаружение каких-либо эффектов на подобном стимульном материале свидетельствует в пользу теории о «воплощенности» сознания, давая нам возможность приблизиться к пониманию когнитивных процессов при обработке языка.

Эти слова — названия объектов с типичной локализацией в пространстве — в англоязычных исследованиях получили условное название *object words*. Данный термин синонимичен, как нам представляется, понятию целевого объекта (target), то есть объекта, который предлагается респонденту для локализации в пространстве относительно ориентира (landmark). В рассматриваемых ниже экспериментах ориентиром служит само перцептивное поле испытуемого и область экрана монитора (то есть используется относительная система координат), а моделирование пространственных отношений происходит без сознательных усилий испытуемого (непроизвольно, в процессе понимания слова). При описании экспериментов мы будем использовать словосочетание *название целевого объекта* в значении *слово с типичной локализацией референта в пространстве в относительной системе координат* и в качестве альтернативы английскому *object word*. Мы рассматриваем только те эксперименты, в которых предметом изучения служит вертикальная ориентировка в пространстве (то есть все названия целевых объектов предполагают локализацию референта в рамках оппозиции «верх — низ»; соответственно, стимульные слова делятся на так называемые *up-words* и *down-words*, то есть имеющие референт в верхней или нижней части зрительного поля соответственно).

Эффект интерференции при предъявлении названий целевых объектов изучался в серии экспериментов (Estes, Verges, Barsalou, 2008). Названия целевых объектов демонстрировались в центре экрана, после чего в верхней или в нижней части экрана появлялся визуальный объект (буква X или O), относительно которого испытуемый должен был выполнить задачу на категоризацию, отреагировав нажатием соответствующей клавиши на клавиатуре (X или O). В этих экспериментах стимульное слово сопровождалось другим словом (из того же семантического поля), что должно было ограничить круг воспринимаемых значений, конкретизировать его. Эксперименты показали наличие значимого эффекта интерференции. Время реакции, затраченное на обнаружение и категоризацию визуального объекта, увеличивается, если перед этим демонстрировалось название целевого объекта с соответствующим «направлением» («верх» или «низ»): то есть если появлялось слово *небо*, а далее — визуальный стимул в верхней части экрана, то время на категоризацию этого визуального стимула было больше.

Другой эксперимент, посвященный изучению эффекта фасилитации, был проведен Dudschig et al. (2012) на материале немецкого языка. Слова-стимулы (названия целевых объектов) были отобраны в ходе предварительного тестирования при помощи пятибалльной шкалы Лайкерта, по которой респондентам предлагалось оценить пространственную локализацию того или иного объекта. В ходе эксперимента на черном экране демонстрировалось слово, и в это же время в верхней и нижней части экрана были расположены два квадратных контура (boxes). Когда слово исчезало, один из квадратов окрашивался в белый цвет («заполнялся»), и задачей испытуемого было нажать клавишу пробела на клавиатуре, как только он увидит закрашенный квадрат. Эксперимент подтвердил гипотезу, выдвигаемую исследователями: испытуемые действительно быстрее реагировали на стимул, расположенный в верхней или нижней части перцептивного поля, после того, как были подготовлены к его восприятию семантикой названия целевого объекта. Исследователи предполагают, что моделирование абстрактных реалий (как, например, Бог или Дьявол) в пространстве происходит так же, как конкретных, при этом авторы ссылаются на работу по изучению эффектов смещения внимания на примере слов с абстрактным референтом (Chasteen, Burdzy, Pratt, 2010). Той же группой исследователей (Dudschig, Souman, Lachmair, de la Vega, Kaup, 2013) на материале немецкого языка был проведен эксперимент по исследованию эффекта фасилитации при помощи методики регистрации движений глаз (eye-tracking). В данном эксперименте исследовалось влияние языковых стимулов на скорость саккад. Наряду со словами использовались *неслова* (nonwords), то есть *произвольные наборы букв, не значимые, но внешне похожие на слова* (в рассматриваемой серии экспериментов в качестве неслов использовались анаграммы, составленные из слов, не входящих в набор стимулов). Участникам было предложено выполнить задачу на лексическое решение (*lexical decision task*), то есть решить, является ли последовательность букв словом данного языка или нет. В том случае, если в центре экрана возникало слово, испытуемые должны были перевести взгляд вверх (или вниз[1]); если же перед ними было неслово, то они должны были посмотреть в противоположном направлении. Исследователи обнаружили значимую связь между семантикой названия целевого объекта и скоростью саккад при выполнении последующей задачи: скорость саккад была выше, если испытуемому нужно было совершить саккаду в том же направлении, где располагался референт названия целевого объекта.

В целом можно заметить, что при схожих процедурах экспериментаторы получают различные (и даже противоположно направленные) эффекты. Это объясняется тем, что разные типы задач по-разному соотносятся с моделирующей семантикой названий целевых объектов. В тех случаях, когда задача оказывается легкой (то есть заключается в обнаружении объекта), названием целевого объекта уже подготовлено смещение внимания в соответствующую сторону, и исследователь наблюдает эффект фасилитации. В тех же случаях, где испытуемому предлагается решение более сложной задачи (такой, как категоризация объекта) в соответствующей области перцептивного поля, возникает эффект интерференции: два процесса одновременно обращаются к одним и тем же нейронным структурам.[1]

Целью экспериментов данного исследования было, во-первых, проверить, действительно ли задача является определяющим фактором, способным вызвать тот или иной эффект. Кроме того, мы не встречали подобных исследований на русском языке, и поэтому второй своей задачей мы определили проверку результатов экспериментов, описанных выше, на материале русского языка.

Нами были проведены два эксперимента, один из которых повторял Dudschig et al. (2012) на русском языке, другой же требовал задачи на категоризацию.

В первом эксперименте, как и в эксперименте Dudschig et al. (2012), ожидается увидеть эффект фасилитации, то есть мы предполагаем, что время реакции на визуальные стимулы будет ниже, если их расположение будет совпадать с типичной локализацией референтов слов.

Во втором эксперименте мы ожидаем увидеть эффект интерференции, если действительно тип задания влияет на тип эффекта.

Отбор стимулов и претест

В обоих экспериментах использовался один и тот же набор стимулов. Стимулы были отобраны при помощи словаря частотности (Ляшевская, Шаров, 2009), а затем прошли предварительное тестирование по шкале Лайкерта (как в эксперименте Dudschig et al., 2012), содержащей семь возможных оценок. Шестидесяти восьми респондентам было предложено оценить слова, руководствуясь следующей инструкцией: «Есть такие предметы и явления в мире, которые мы ожидаем увидеть в пространстве либо наверху, либо внизу. Расположите следующие слова по шкале от 1 до 7, где, по вашему мнению, 1 — предмет располагается на самом верху, 2 — предмет находится наверху, 3 — предмет находится скорее вверху, чем внизу, 4 — предмет находится ни вверху, ни внизу, или посередине, 5 — предмет находится скорее внизу, чем вверху, 6 — предмет находится внизу, 7 — предмет находится в самом низу. Для вашего удобства рядом находится шкала, по которой вы можете ориентироваться. Постарайтесь проставлять значения последовательно, не исправляя и не возвращаясь». Рядом со стимулами была представлена вертикальная шкала, которая позволяла испытуемым зрительно представить пространственные отношения.

Поскольку изначально было отобрано большое количество слов (240), существительные были поделены для удобства на группы, и поэтому не каждый респондент оценил все слова. В среднем на каждый

[1] Как правило, подобного рода задания балансируются, то есть если для половины испытуемых условием было «смотреть вниз при X и вверх при Y», то вторая половина получает задание с противоположным ключом («смотреть вверх, если X, и вниз, если Y»). Это делается для того, чтобы исключить возможное взаимодействие задания и способа реагирования на него.

стимул было получено лишь около 20 оценок, на основании которых мы вычислили среднее арифметическое для каждого стимула. На этом этапе были отобраны 80 названий целевых объектов, получивших наиболее высокие (40 слов) и наиболее низкие (40 слов) баллы. Остальные слова (200 слов) не использовались на последующих этапах.

Частота стимулов была взята из словаря частотности, указанного выше, длина подсчитана в буквах для каждого слова. В двух наборах данных эти существительные не различаются значимо по длине ($p = 0.45$) и частоте ($p = 0.31$), но различаются по признаку расположения в пространстве ($p = 0.00$). Значимость различий проверялась по критерию Стьюдента. Средние и стандартные отклонения по каждому из признаков приведены в таблице 1.

Факторы	Средняя длина среднее (ст. отклонение)	Средняя частота среднее (ст. отклонение)	Среднее расположение в пространстве среднее (ст. отклонение)
Слова «верх»	6.025 (1.4)	1.12 (0.60)	1.95 (0.42)
Слова «низ»	5.78 (1.51)	1.24 (0.43)	6.14 (0.26)

Таблица 1. Средние и стандартные отклонения по условиям. Претест.

Эксперимент 1

Участники

В первом эксперименте приняли участие 42 испытуемых в возрасте от 18 до 21 года (из них 14 мужского пола), все испытуемые — русскоговорящие студенты университета.

Дизайн и процедура эксперимента

Каждая проба начиналась с появления фиксационного креста (500 мс) и двух квадратных контуров без заливки («незаполненных») в верхней и нижней части экрана. Затем появлялось название целевого объекта, находившееся на экране 300 мс. Была использована та же длительность предъявления целевого объекта, что и в оригинальном эксперименте на материале немецкого языка Dudschig et al. (2012), поскольку средняя длина слова в оригинальном эксперименте и в нашем не различалась. Спустя 400 мс после исчезновения стимула один из квадратов закрашивался (рис. 1). Квадрат, который будет закрашен, выбирался случайным образом, однако общее количество проб с расположением закрашенного квадрата в верхней и нижней части экрана было одинаковым. Испытуемым было дано задание нажимать на клавишу пробела при виде закрашенного («заполненного») квадрата. Если испытуемый не реагировал на стимул в течение двух секунд, начиналась следующая проба. Стимулы демонстрировались белым шрифтом на черном фоне. Помимо проб, вошедших в эксперимент, демонстрировались 16 проб, не входящих в эксперимент, которые составляли тренировочное задание для испытуемого. Эксперимент продолжался около пяти минут. Предъявление стимулов как в первом эксперименте, так и в последующем, осуществлялось при помощи программы E-prime 2.0.

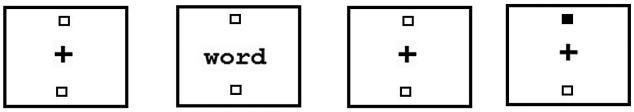

Рисунок 1. Процедура эксперимента 1

Результаты

Так как разброс значений во времени реакции был очень большим, из последующего анализа были исключены пробы со временем реакции больше 800 мс и меньше 100 мс (4.2 %), а также пробы, время реакции в которых отличалось от среднего на два или более стандартных отклонения (4.2 %).

Пробы со временем реакции больше 800 мс были исключены в связи с тем, что подобное задание не требует большого времени реагирования, следовательно, время реакции испытуемого более 800 мс скорее свидетельствует о случайности ситуации.

Пробы со временем реакции меньше 100 мс были исключены потому, что столь краткое время реакции может свидетельствовать о том, что испытуемый не старался выполнить данное ему задание, а просто нажимал на клавиши в определенный промежуток времени. Распределение времени реакции после исключения этих проб было нормальным.

Был проведен анализ данных о времени реакции по испытуемым (by subject) и по стимулам (by item). В таблице 2 показаны средние и стандартные отклонения по четырем условиям. Дисперсионный анализ с повторными измерениями (Repeated Measures) 2×2 («расположение референта слова: "верх" и "низ"» × «расположение закрашенного квадрата: "соответствует" и "не соответствует" типичной локализации объектов»). Для измерения эффектов проводились тесты межсубъектных и внутрисубъектных факторов. По результатам анализа взаимодействия между типичной локализацией референта слова и целевыми объектами не обнаружилось (анализ by-item и by-subject): $F1 (1, 78) = 0.29$, $p = 0.4$, $\eta^2 = 0.11$ (рис. 2), $F2 (1, 41) = 1.11$, $p = 0.30$, $\eta^2 = 0.11$. Не значимым оказался и фактор соответствия-несоответствия закрашенного квадрата локализации референта слова: $F1 (1, 41) = 0.04$, $p = 0.85$, $\eta^2 = 0.01$, $F2 (1, 78) = 0.2$, $p = 0.66$, $\eta^2 = 0.01$. Обнаружен был только главный эффект семантики самого слова: время реакции на названия целевых объектов, отнесенных в ходе претеста к имеющим локализацию референтов вверху (*up-words*), было в целом больше, чем на названия целевых объектов, расположенных внизу (*down-words*): $F1 (1, 78) = 13.17$, $p = 0.0005$, $\eta^2 = 0.09$, $F2 (1, 41) = 8.24$, $p = 0.01$, $\eta^2 = 0.15$.

Таким образом, эксперимент 1 показал отсутствие каких-либо искомых эффектов, исключая главный эффект фактора локализации референта.

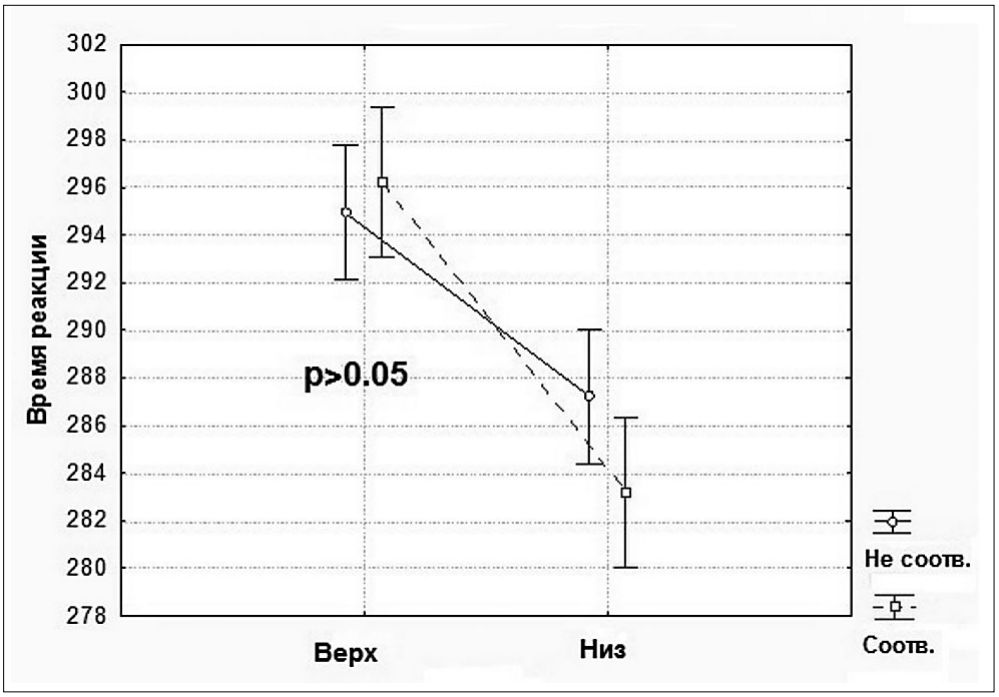

Рисунок 2. Взаимодействие между факторами «расположение референта слова: "верх" и "низ"» × «расположение закрашенного квадрата: "соответствует" и "не соответствует" типичной локализации объектов» в эксперименте 1. Вертикальные столбцы отражают стандартные ошибки

Факторы	Соотв. среднее (станд.отклонение), мс	Несоотв. среднее (станд. отклонение), мс
Слова «Верх»	296 (18)	295 (18)
Слова «Низ»	283 (21)	287 (17)

Таблица 2. Средние и стандартные отклонения по условиям (усреднение по стимулам (by item)). Эксперимент 1

Эксперимент 2

Второй эксперимент проводился с теми же стимулами, но с измененной задачей для испытуемого. Испытуемым была дана задача, требующая больше времени на ее решение, — категоризация объектов.

Участники

Во втором эксперименте в качестве испытуемых выступала другая группа русскоговорящих студентов в возрасте от 18 до 21 года (всего — 39, из них 18 — мужского пола).

Дизайн и процедура эксперимента

Вместо закрашенных/незакрашенных квадратов в верхней или нижней части экрана появлялись в случайном порядке либо круг, либо квадрат. Испытуемым была дана задача категоризовать каждую увиденную фигуру нажатием клавиши (нажать 1 при появлении квадрата, 2 — при появлении круга). Следующая проба начиналась, если испытуемый не реагировал на стимул в течение двух секунд. Стимулы так же демонстрировались белым шрифтом на черном фоне.

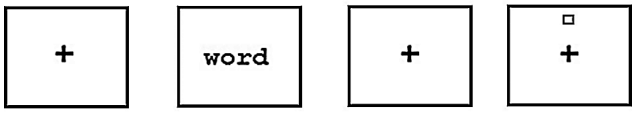

Рисунок 3. Процедура эксперимента 2

Результаты

После получения данных был реализован дисперсионный анализ с повторными измерениями (Repeated Measures) с таким же, как в первом эксперименте, дизайном. Из набора данных были исключены пробы со временем реакции больше 1000 мс и меньше 100 мс (5.7 %), а также пробы, время реакции в которых отличалось от среднего на два или более стандартных отклонения (3 %). Задание этого эксперимента было сложнее, чем задание первого, поэтому мы исключили пробы со временем реакции уже больше 1000 мс, но по той же причине, что и в первом эксперименте. В таблице 3 указаны средние и стандартные отклонения четырех условий. Анализ как по стимулам (by-item), так и по испытуемым (by-subject) показал значимый главный эффект фактора локализации референта ($F1\ (1, 78) = 7.71$, $p = 0.01$, $\eta^2 = 0.09$, $F2\ (1, 37) = 6.71$, $p = 0.01$, $\eta^2 = 0.15$): в пробах со словами, референт которых находится вверху, время реакции в целом было меньше, чем со словами с референтом внизу (см. таблицу 3). Главный эффект фактора фигуры (то есть появлялся перед испытуемым квадрат или круг) был незначим ($F1\ (1, 78) = 0.85$, $p = 0.36$, $\eta^2 = 0.01$, $F2\ (1, 37) = 0.30$, $p = 0.58$, $\eta^2 = 0.01$). Взаимодействие факторов показало ($F1\ (1, 78) = 9.68$, $p = 0.00$, $\eta^2 = 0.11$, $F2\ (1, 37) = 4.47$, $p = 0.04$, $\eta^2 = 0.11$), что эффект фасилитации проявился только при появлении слова с референтом вверху (*up-words*) ($p = 0.03$, тест Бонферрони). Если же демонстрировались слова с референтом внизу (*down-words*), например, *трава, шнурок*, то расположение целевых фигур для испытуемых оказалось не важным (рис. 4).

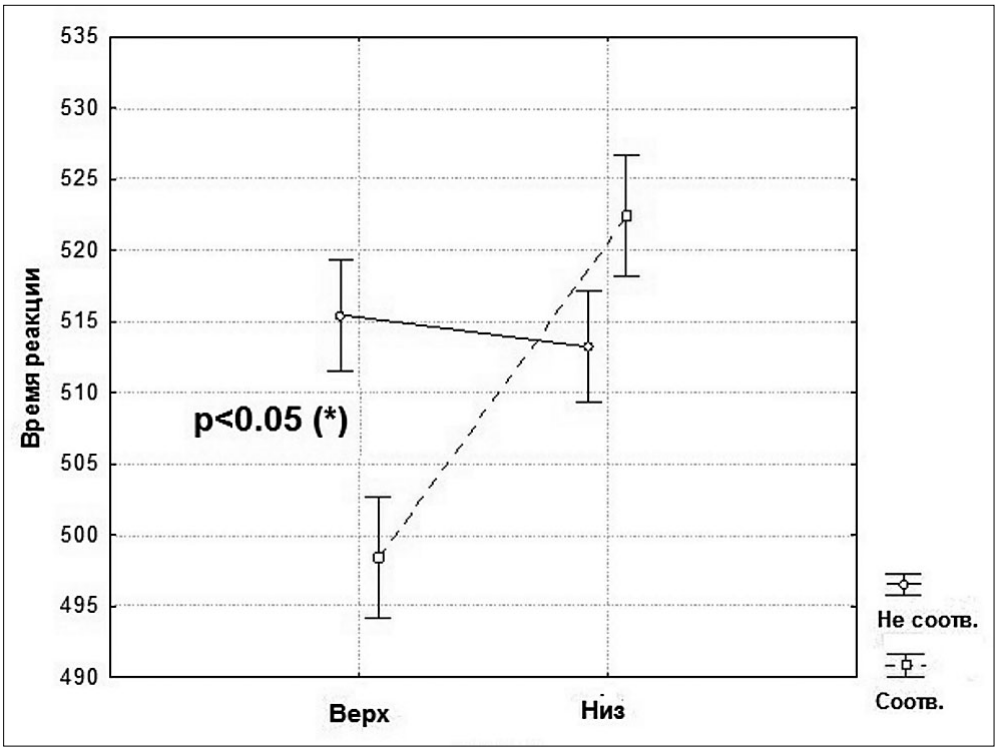

Рисунок 4
Взаимодействие между факторами «расположение референта слова: “верх” и “низ”» × «расположение круга/квадрата: “соответствует” и “не соответствует” типичной локализации объектов» в эксперименте 2. Вертикальные столбцы отражают стандартные ошибки

Факторы	Соотв. среднее (станд. отклонение), мс	Несоотв. среднее (станд. отклонение), мс
Слова «Верх»	498 (28)	515 (23)
Слова «Низ»	522 (25)	513 (26)

Таблица 3. Средние и стандартные отклонения по условиям (усреднение по стимулам (by item)). Эксперимент 2

Обсуждение

В первом эксперименте не было обнаружено искомых эффектов, кроме значимой разницы во времени реакции при реагировании на названия целевых объектов с референтом в верхней части зрительного поля (*up-words* в сравнении с *down-words*). На данном этапе мы предположили следующее:

– задание на обнаружение объекта оказалось слишком легким для испытуемого, время задержки (400 мс) в каждой пробе было одним и тем же, и ключ для ответа использовался всего один (пробел), поэтому испытуемые уже через несколько проб знали, когда именно нужно нажимать пробел;

– задача, требующая ответа, не требовала понимания стимульного слова, и испытуемые не читали слова.

Тем не менее, ни одно из этих предположений не объясняет, почему эффект был получен в оригинальном эксперименте Dudschig et al. (2012) (все эти условия соблюдались и там); кроме того, они не объясняют полученную разницу во времени реакции.

Во втором эксперименте вместо ожидаемого эффекта интерференции нами был получен эффект фасилитации, который, однако, проявлялся только после названий целевых объектов, локализованных в верхней части перцептивного поля (up-words).

Время реакции на слова с референтом наверху в первом эксперименте было больше, чем время реакции на слова с референтом внизу, что отличается от результатов второго эксперимента. Этот факт может объясняться наличием взаимодействия факторов во втором эксперименте, в то время как в первом эксперименте влияния фактора расположения целевых фигур не было обнаружено. Еще в одном проведенном нами эксперименте (Tsaregorodtseva, Miklashevsky, Janyan, 2014), не описанном в данной статье, время реакции на слова с референтом наверху было меньше, чем время реакции на слова с референтом внизу, как и в эксперименте 2 данной статьи. Это говорит о том, что нет единой закономерности во времени реакции на использованный набор стимулов и что этот вопрос требует дальнейшего изучения.

Поскольку процедуры наших экспериментов в целом не отличаются (или незначительно отличаются) от оригинальных экспериментов, мы предполагаем, что причина разницы в результатах может быть связана с особенностями стимульного материала. Данное утверждение требует пояснения: речь идет, во-первых, о возможном различии языковых систем (оригинальные эксперименты проводились на немецком и английском языках), и, во-вторых, об особенностях формулировки задания во время претеста. Возможно, что респонденты, участвовавшие в претесте, оценивали слова в рамках абсолютной системы координат, в то время как задачей было отбирать слова именно в относительной системе. Кроме того, можно было бы балансировать на данном этапе исследования шкалу Лайкерта, предложив одной половине испытуемых оценивать большим баллом объекты в верхней

части перцептивного поля, а меньшим — в нижней, другой же половине предложить противоположные оценки для названий целевых объектов.

Под различиями же языковых систем мы понимаем в данном случае возможные коннотативные смыслы, которые закреплены за некоторыми словами в одних языках, однако отсутствуют в других. Так, например, конкретное существительное *шляпа* может иметь переносное значение «вялый, неэнергичный, ненаходчивый человек», активация которого во время эксперимента также влияет на результаты (в частности, на время реакции). Эту проблему можно решить при помощи лингвистического анализа стимулов и, кроме того, при помощи использования так называемых *контекстных слов*, которые поддерживают требуемое значение стимула, исключая активацию побочных значений.

Заключение

При продолжении данного исследования мы считаем необходимым подвергнуть дополнительной проверке список стимульных слов, использовать перед стимульными контекстные слова, которые будут актуализировать соответствующие семантические поля и способствовать процессам ментального моделирования, а также продолжить проверку предположения о влиянии на результаты эксперимента разного типа задач, так как для решения этого вопроса по результатам проведенных нами экспериментов было получено недостаточно данных. Кроме того, мы также считаем необходимым использовать в качестве стимулов слова с абстрактными референтами (на материале русского языка) для проверки наличия значимых эффектов фасилитации и интерференции при обработке слов с абстрактным значением.

Литература

Риццолатти Дж., Сенегалья К. Зеркала в мозге: о механизмах совместного действия и сопереживания. М.: Языки славянских культур, 2012.

Тимофеева М.К. Введение в экспериментальную когнитивную лингвистику. Новосибирск: Новосиб. гос. ун-т, 2010.

Bergen B. Experimental methods for simulation semantics // Methods in cognitive linguistics. 2007. P. 277–301.

Chasteen A.L., Burdzy D.C., Pratt J. (2010) Thinking of god moves attention // Neuropsychologia. 2010. Vol. 48. №2. P. 627–630. doi:10.1016/j.neuropsychologia.2009.09.029

Dudschig C., Lachmair M., de la Vega I., De Filippis M., Kaup B. (2012). From top to bottom: Spatial shifts of attention caused by linguistic stimuli // Cognitive processing. 2012. Vol. 13. № 1. P. 151–154. doi:10.1007/s10339-012-0480-x

Dudschig C., Lachmair M., de la Vega I., De Filippis M., Kaup B. Reading «sun» and looking up: The influence of language on the planning of saccadic eye movements // PLoS ONE. 2013. Vol. 8. № 2. P. e56872. doi:10.1371/journal.pone.0056872

Estes Z., Verges M., Barsalou L.W. Head up, foot down: object words orient attention to the object's typical location // Psychological Science. 2008. Vol. 19. №2. P. 93–97. doi:10.1111/j.1467-9280.2008.02051.x

Lakoff G., Johnson M. Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought. New York: Basic Books, 1999.

Richardson D.C., Spivey M.J., Barsalou L.W., McRaec K. Spatial representations activated during real-time comprehension of verbs // Cognitive science. 2003. Vol. 27. № 5. P. 767–780. doi:10.1207/s15516709cog2705_4

Tsaregorodtseva O.V., Miklashevskiy A.A., Janyan A. Orientations of attention: words referring to the typical spatial location (up-down) // Night Whites 2014. Abstracts. Retrieved from http://nightwhites2014.wordpress.com/abstracts/

Varela F., Thompson E., Rosch E. The Embodied Mind. Cognitive Science and Human Experience. Cambridge, Mass.: MIT Press, 1991.

Zwaan, R.A., Madden, C.J. Embodied sentence comprehension // D. Pecher, R.A. Zwaan (Eds.) Grounding cognition: The role of perception and action in memory, language, and thinking. Cambridge: Cambridge University Press, 2005. P. 115–128.

Influence of linguistic stimuli on the vertical attention shift

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Abstract. The aim of the current study was to test the hypothesis of Dudschig et al. (2012) in the speakers of Russian. That hypothesis states that linguistic stimuli which do not convey spatial information in their meaning (e.g., *sun, grass*) produce vertical attention shifts in the direction of the typical location of the word's referent in the world (for example, person's attention is shifted upward in his perceptual field when he sees the word *sun*). Two experiments were conducted, each using a different type of task in order to understand whether the type of task also influences the effects produced by the described stimuli (compatibility effects vs. interference effects). The first experiment showed no significant interaction between the factor of the typical location of the word's referent in the world and the factor of location of visual objects that were shown to participants after this word was presented. The second experiment revealed a significant interaction between the two factors, but a compatibility effect was obtained instead of the expected interference effect.

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References

Bergen, B. (2007). Experimental methods for simulation semantics. In *Methods in cognitive linguistics* (pp. 277–301).

Chasteen, A. L., Burdzy, D. C., & Pratt, J. (2010). Thinking of god moves attention. *Neuropsychologia, 48*(2), 627–630. doi:10.1016/j.neuropsychologia.2009.09.029

Dudschig, C., Lachmair, M., de la Vega, I., De Filippis, M., & Kaup B. (2012). From top to bottom: Spatial shifts of attention caused by linguistic stimuli. *Cognitive Processing 13*(1),151–154. doi:10.1007/s10339-012-0480-x

Dudschig, C., Lachmair, M., de la Vega, I., De Filippis, M., & Kaup B. (2013). Reading "sun" and looking up: The influence of language on the planning of saccadic eye movements. *PLoS ONE , 8*(2):e56872. doi:10.1371/journal.pone.0056872

Estes, Z., Verges, M., Barsalou, L. W. (2008). Head up, foot down: object words orient attention to the object's typical location. *Psychological Science 19*(2), 93–97. doi:10.1111/j.1467-9280.2008.02051.x

Lakoff, G. & Johnson, M. (1999). *Philosophy in the Flesh: The mbodied Mind and its Challenge to Western Thought.* New York: Basic Books.

Richardson, D. C., Spivey, M. J., Barsalou, L. W., & McRaec, K. (2003). Spatial representations activated during real-time comprehension of verbs. *Cognitive science, 27*(5),767–780. doi:10.1207/s15516709cog2705_4

Rizzolatti, G., Sinigaglia, C., & Anderson, F. T. (2008). *Mirrors in the brain: How our minds share actions and emotions*. Oxford University Press.

Timofeeva M.K. (2010). *Vvedenie v eksperimentalnuyu kognitivnuyu lingvistiku*. [Introduction into experimental cognitive linguistics] (in Russian). Novosibirsk: Novosibirsky gosudarstvenny universitet.

Tsaregorodtseva, O. V., Miklashevskiy, A. A., & Janyan, A. (2014). Orientations of attention: words referring to the typical spatial location (up-down). In *Night Whites 2014* Retrieved from http://nightwhites2014.wordpress.com/abstracts/

Varela, F., Thompson, E., & Rosch, E. (1991). *The Embodied Mind. Cognitive Science and Human Experience*. Cambridge, Mass.: MIT Press.

Zwaan, R. A. & Madden, C. J. (2005). Embodied sentence comprehenion. In D. Pecher & R. A. Zwaan (Eds.), *Grounding cognition: The role of perception and action in memory, language, and thinking* (pp. 115–128). Cambridge: Cambridge University Press.

The influences of intentionality and effectiveness of adults' behavior on infants' imitation of object-related actions

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Abstract. In the second year of life, infants are actively interested in objects used by adults, despite the number of experienced difficulties in achieving their goals while handling these objects. What causes the child attempt to handle an object for a designated purpose while watching the adult? One of the evident explanations concerns the effectiveness of the adult's behavior and the child's desire to achieve the same result. However, multiple studies have shown that a child is guided not exclusively by the hoped-for result, but also by the adult's intention. In our study, we verified the reason guiding a child's choice in an ambiguous condition modeled by situations which contrast intentional and effective adult behavior. We discovered that infants between 17 and 20 months old preferred to copy an adult's intentional action even if this action did not result in positive outcome, but did not copy an adult's accidental action, even if the action ended up with an attractive result. However, the child's tendency to follow the adult's intention develops during the process of growing, as no similar pattern is observed in children between 12 and 16 months old. Here we also discuss this phenomenon in terms of its relation to the existing data on the overimitation effect and the age range of its manifestation. The current study provides a view of social learning development which is an alternative to the traditional view which treats social learning only as an increase in the complexity of acquired actions with age. Our results suggest that what changes with development is that actions learned and demonstrated by the child become more and more relevant to planning and control of behavior.

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Introduction

The core problem in the research field of object-related activity in children is uncertainty about the reasons for object usage; it is not clear why children use object-related actions and what benefit they obtain (Jel'konin, 1997a). Until small children acquire the correct way to use a new object, they achieve better results without it. For example, an initial inept handling of a spoon for eating is significantly less effective compared to direct hand delivery of food to the mouth; it is also initially easier to use a finger to draw a circle than to attempt to use a pencil for the same task in the early period of childhood. Nevertheless, the toddler reaches for the objects with enthusiasm and persistence, trying to handle them the same way as they are used by adults. This fact raises assumptions that a child is acquiring the manner to act with the novel objects not just for effectiveness, but rather basing on their meaning for others (Jel'konin, 1997a; Uzgiris, 1981; Keupp, Behne, & Rakoczy, 2013).

However, the child's particular way to figure out such a meaning remains hidden for developmental psychologists. Recent investigations of a child's ability to identify an adult's intention aimed at the discovery of its origins (Meltzoff, 1988; Carpenter, Call, & Tomasello, 2002; Gergely & Csibra, 2003). In fact, an adult's object-related actions are almost always intentional, and thus, the deliberate manipulations on an artifact precisely reveal its cultural function. To illustrate this point, consider that an infant may observe an adult touching a spoon accidentally while removing it along with other objects off the table, but in order to learn to use a spoon purposefully, a child needs to distinguish the food-related actions performed by the adult. What are the limits of this ability for an infant?

A number of empirical studies show evidence for an early competence of 3 to 6-months-old infants to determine the intentionality of adults (Woodward, 1998; Woodward, Sommerville, & Guajardo, 2001). In these studies, the experimenters employed a habituation paradigm by demonstrating repeatedly grasping arm actions on two reachable toys with fixed positions. Then, the objects' positions were reversed and infants viewed two kinds of test trials: during new-goal trials, an adult reached toward the same location to grasp the new object; thus, her physical movements were the same, but her goal had changed. On new-side trials, the person reached toward the other side to grasp the same object; thus, she moved in a new direction, but still acted on the same goal. The results revealed that children showed a stronger visual novelty response during new-goal trials than on new-side trials. This proves that an infant is able to distinguish an action's direction and goal; that is the child can interpret the adult's actions in terms of intentional relations.

It is worth mentioning that the goal of a grasping action is visually presented and relatively obvious, so understanding the goal in this case is quite easy for an infant if she reads human movements as intentional. However, it is more complicated when it comes to the attribution of intentionality to the higher order manipulations performed by adults, because adults execute multiple movements while handling the same object, wherein these movements may represent parts of complex goal-directed actions, independent intentional actions or indirect movements included as part of an intentional action with another object. For example, in an experiment by Carpenter, Call, and Tomasello (2005), toddlers watched how an adult moved a toy mouse from one table edge to another using one of two action styles: hopping ("beebeebee"), or sliding ("beeeee"). In one of conditions there were two houses at the end of a table, and the mouse as a result of its movement reached one of them, in the other condition there were no houses and the mouse simply crossed a table. After the instruction "Your turn", the method of movement of a mouse (hopping or sliding) was repeated only by children from the second group. The children, seeing how the mouse got to the house, applied casual options of movement, which did not correspond to the action style. Thus, the authors concluded that at the age of 12 months the child understands the intention of this or that manipulation with an object — whether it is an independent action (to jump / to slide a mouse) or an intermediate, operation for other action (to place a mouse in the right or left house) — instead of, and in this sense, whether the action is worth copying.

As a whole, modern experiments have proven an infant's ability to imitate intended actions regardless of whether the outcome is actually observed (Meltzoff, 1988; Gergely, Bekkering, & Király, 2002; see review in Sergienko, 2006). However, infants observe intentional adult behavior, which usually turns out to be effective. Therefore, we hereby face the question of whether infants are guided by the outcome of an adult's goal-directed action or rather by the mere fact that the observed action is intentional. For example, Carpenter, Akhtar, and Tomasello (Carpenter et al., 1998) conducted an experiment in which infants observed a model's intentional and accidental actions, where both types of actions had positive effective outcomes. A demonstrator carried out manipulations on the objects, which consisted of two mobile parts and was specially made for this test. Results showed that, infants copied more of the adult's intentional than accidental actions, although both actions were effective.

Still, the results mentioned above do not clarify existing doubts about whether rationality influences the infant's choice to follow an adult's intentionality or not. It is possible, as demonstrated in the experiment by Carpenter et al. (1998), that children imitated the intentional actions because of their efficacy, considering such an intention as a bonus; that is, effective actions per se possessed some extra attractive properties, which encouraged the infant to copy it.

Thus, while considering Carpenter and colleagues' study, it remains of interest to find out whether an infant imitates the adult's intentional action in case of no observed relation to its result. Such an opposing condition is widely studied within the research on the so-called overimitation effect (Whiten, Custance, Gomez, Texidor, & Bard, 1996; Call, Carpenter, & Tomasello, 2005; Lyons, Young, & Keil, 2007; Keupp, Behne, & Rakoczy, 2013; Király, Csibra, & Gergely, 2013). Most of the studies describe the overimitation effect in preschoolers (see review in Kotova & Kotov, 2014), but we consider here Nielson's research of infants (2006).

In Nielson's study, 12-, 18-, and 24-month-olds watched an adult retrieving a toy from a closed box by disengaging a switch located on the front of the box

(Nielsen, 2006). Although the box could be easily opened by hand, the adult complicated the demonstration by using an additional object to operate the switch; that is, the adult performed redundant actions according to the usual testing within the overimitation paradigm. Results showed that, unlike 12-month-olds, 18- and 24-month-olds persevered in copying the model's exact but redundant actions, which for most children resulted in a failure to open the box. Particularly, twelve-month-old subjects only copied the redundant actions of the model when they were given a logical reason to do so; otherwise, they focused on reproducing the outcome of the demonstrated actions.

Evidently, imitation of the intentional action occurs, despite the absence of its goal outcome. The above-mentioned experiment (Nielsen, 2006) implies that the borderline age of such imitative behavior pattern is 18 months, and that 12-month-olds imitate only the effective actions. It is worth noting that such an age pattern correlates with Vygotsky-Jel'konin's periodization theory according to which an infant is able to engage in a joint object-related activity in the second year of life, just after the so-called one-year-crisis is over (Jel'konin, 1997b).

However, the above-mentioned experiments differ in the level of complexity of the action structure. Additionally, these experiments differ in the relationship between action and result. Thus, Carpenter et al.'s experiment showed that visible result caused the direct action, while Nielsen's procedure represented the action's result, which caused a possibility for the following effective action.

It is possible, that the change of priorities between intention and productivity happens at an earlier age under the condition of a simpler operational structure. The picture of cognitive development can be described as a "nested" structure in relation to the different levels of action complexity. For example, experiments in terms of a child's understanding of goal-directed grasping actions (Woodward, 1998) and gaze direction (Woodward, 2003) involve phenomena of the same type which could be observed sooner or later depending on the level of action complexity. Besides, whereas the structure of the above experiments considered the intention and the result to be equally significant factors, it did not provide for opposition of the action's intentionality to its goal outcome.

Therefore, the present study creates the conditions for a possible choice between two types of actions on the same object: an effective but unintentional one versus an ineffective intentional one. We expect that our results will shed light on the reason for the change of priority in a child's choosing between the intentionality per se and the goal outcome. The results will also reveal whether using a less complex action for the testing procedure would change the age at which the aforementioned switching of priority is observed.

Method

Participants

Group 1: 21 infants aged 12-16 months (mean age 14.2 months), including nine boys and 12 girls.

Group 2: 11 infants aged 17-20 months (mean age 18.1 months), including six boys and five girls.

All participants were recruited from local leisure centers and family clubs within Moscow and the Moscow Region. All of the parents provided informed consent to participate in the study.

Materials

In the experiment we used two objects unfamiliar to the infant. Each of the objects was characterized by details which allowed attractive manipulations by a child with respect to his or her age. For example, there was a transparent ball containing plastic beads inside which could be rotated by pushing, or a plastic butterfly wing which could be turned by holding its edge. Each object had several such details.

Manipulation of one of the details led to the so-called effective event: an easily perceived outcome, attractive for a child of a corresponding age, such as flashing of rolling beads inside the plastic transparent ball or musicial ringing sound. Such a manipulation we named an *effective action*.

Manipulating another detail in each of the objects did not lead to any perceptually attractive event for the child, such as a soundless and colorless turn of the butterfly's wing, when the manipulated detail was moved. Such a manipulation we named a *non-effective action*.

Procedure

This procedure is the modified version of Carpenter et al.'s experiment (1998). In the original version of the experiment, all actions of the demonstrator (both intentional and accidental) were effective. Our main modification provides one more contrasting condition in which intentional behavior does not achieve its goal; that is, we include a condition where the adult's intentional action is not effective.

As in Carpenter's experiment (1998), an adult demonstrates to an infant an unfamiliar object with the words "Watch, I'm going to show you how this works. There!" <following a display of the intentional action> "Woops!" <following a display of the action which is produced accidentally>. Then, the experimenter hands over the object to an infant, saying "Your turn!"

Unlike Carpenter et al.'s experiment (1998), our experiment featured following conditions:

1. Consistent demonstrator behavior: the effective action is carried out intentionally, while the non-effective action is accidental. This condition was a control one, supposing to correspond to what infants usually observe in daily adult behavior. Thus an adult intentionally manipulating an object (saying "There!") resulted in an attractive event, while touching another detail in accidental way (saying "Woops!") resulted in no noticeable event, besides moving this detail.

2. Non-consistent demonstrator behavior: the effective action is accidental, and the non-effective action is intentional. This is the experimental condition, which disrupts infants' "expectations". This experimental condition is expected to reveal the cues assessed by the infant as reliable in the adult's behavior while transmitting the experience.

The experiment has a within-subjects design; each of the conditions was presented to each of the subjects. The order of conditions, their combinations with the object and the order of the intentional and accidental actions within one condition were counterbalanced.

After the demonstration of actions and saying the words "And now it's your turn!", the experimenter moved an object towards the child and waited for their manipulations on the object. The first manipulation was registered. The whole procedure was videotaped.

We conducted a pre-test playing session with each of the participants in order to establish contact between the experimenter and the child. All participants were accompanied by a parent during the experiment, who was instructed about the terms of the purpose and conditions of the study. In particular, the experimenter instructed the parent not to let the child recognize the correct detail by means of either gaze direction, movement, or any verbal cue.

The expectation was that in the condition of consistent demonstrator behavior, the infant would copy the effective intentional manipulation. We were especially interested in the infant's response in the non-consistent condition. If, according to our assumption, children advantageously monitor the intentions of adults when learning new object-related actions, our participants would copy the intentional action of the demonstrator even when this action is ineffective. But if the tendency to follow the adult's intention only plays an auxiliary role and develops from typical everyday situations when observed intentional actions are also effective, then in the *non-consistent* condition our participants would copy the accidental action because it is followed by an obvious outcome.

Moreover, we assess the distinction in children's behavior within different age groups: 12–16 months and 17–20 months.

Results

The dependent variable in our experiment is the first action of the infant, represented by the detail for manipulation on a novel object, just after the demonstration. After an adult says "And now it's your turn!", an infant reaches for the detail, touches it and moves it. The participant may choose either the intentionally touched detail (imitation of an intentional action), or the detail previously used by the experimenter for accidental manipulation (imitation of an accidental action), or the detail which the adult did not touch at all (another action).

Data received for Group 1 are presented in Table 1. The statistical analyses indicates that the first action performed by an infant between 12 and 16 months of age is significantly influenced by the demonstrated adult behavior ($\chi 2=10.13$ $p<0.01$). Thus, given consistent demonstrator behavior, most children copy the intentional action, that is, exhibit the ability to distinguish and to follow the intention. However, non-consistent demonstrator behavior mostly causes the infants to perform "another" action, ignoring both the intentional and the effective action. It appears that the participants in the youngest age group do not prefer to copy the effective action per se: in case of its accidental manner, the infants mainly choose an action which has not been performed by the adult.

Demonstrator behavior style	First object-related action of an infant following actions demonstrated by adult			
	Imitation of an intentional action	Imitation of an accidental action	Another action	Total
Consistent behavior	13	3	5	21
	62 %	14 %	23 %	100 %
Non-consistent behavior	3	6	12	21
	14 %	29 %	57 %	100 %

Table 1. **First object-related action of an infant after the demonstration under consistent and non-consistent behavior conditions (for 12 to 16-month-old)**

Demonstrator behavior style	First object-related action of an infant following actions demonstrated by adult			
	Imitation of an intentional action	Imitation of an accidental action	Another action	Total
Consistent behavior	9	1	1	11
	82 %	9 %	9 %	100 %
Non-consistent behavior	7	2	2	11
	63 %	18 %	18 %	100 %

Table 2. **First object-related action of an infant after the demonstration under consistent and non-consistent behavior conditions (for 17 to 20-month-old)**

At the same time, variations of the consistent adult behavior were not significant in Group 2 ($\chi^2=0.92$, $p>0.5$): all of the participants persistently imitated only the intentional action regardless of whether the action was effective or not, while absolutely ignoring accidental action even in case of its attractive result in one of the series. Thus, while making the choice for imitation, participants in Group 2 were guided more by an adult's intention than by the action's effectiveness.

The interaction of participant age and congruency of adult behavior was also tested directly. The distribution of children's reactions was significantly different ($\chi^2=9.03$, $p=0.01$) between the two age groups (12–16 and 17–20 months) which also justifies the selection of age ranges as appropriate for our experiment's design.

Discussion

The obtained results allow us to conclude that starting from the age of 18-months, on the average, infants definitely rely on an adult's intentionality while choosing which object-related action to imitate among other observed actions. According to the results, at the average age of 14 months, infants are guided by both the goal outcome and the intentionality of an object-related action. In the condition of non-consistent adult behavior with opposition of intention to the goal outcome, infants avoid such contradiction, performing instead another, not demonstrated action.

As we mentioned above, an infant's ability to identify the concrete goal of a grasping motion has already emerged at the age of three to five months (Woodward, 1998; Woodward, Sommerville, & Guajardo, 2001). Beginning at least from 12 months of age infants already prefer the intentional action to the accidental one among two goal-directed actions (Carpenter et al., 1998). Still, our experiment discovered that only at the age of 17 to 20 months are the infants able to ignore the goal outcome of imitation. This means that there is a definite developmental characteristic, evidently preceding the further development of instrumental activity at an early age.

The ability to read an adult's intention when selecting a particular action to copy could be a useful strategy within the cultural learning process. Entering the world of typical cultural objects, the infant possess insufficient cognitive abilities for independent selection of goal-directed and effective instrumental actions within the whole picture of observed manipulations.

On the one hand, this may be caused by far too remote adult goals, which, in fact, are often mediated by other events. As an example, while preparing to go for a walk, we put on our coats before exiting a warm space, guided by our awareness of the lower temperature outside. It is too difficult for a one-year-old to imagine "not to feel cold" as a goal in such a situation. On the other hand, it is obvious that an infant is able to achieve most of the current goals by ignoring any existing corresponding artifacts. For example, for a two-year-old infant it is a much more reliable method to tear off a piece of paper than to cut it off with scissors. Moreover, the relation between the manipulation per se and its result is too complicated, often regulated by objective laws, which are hardly understandable even for an adult: why from pressing the button the lamp lights up can hardly be thoroughly explained by someone who is not a physicist.

All the facts mentioned above would make early object-related action learning too slow and hardly accessible if an infant is guided primarily by the outcome of goal-directed adult behavior. That is, the early ability to follow an adult's intentions, described in many studies (Meltzoff, 1988; Carpenter et al., 1998; Carpenter, Call, & Tomasello, 2002; Gergely & Csibra, 2003) is quite essential and functional. Indeed, the adult's intent is well noticeable by its preparation, its nature, reaction to the events following it; the rule "to copy everything that is intentional" would be rather convenient during the acquisition of experience at learning how to manipulate objects.

Our data show the need for a more complicated model, describing the selective mechanism within the imitation process. Thus, our results show that the above rule does not always guide the infant. That is, at the earliest stages of childhood both the goal outcome and the adult's intention influence an infant's imitating behavior, but while growing up, infants focus on the adult's intentionality within a selective imitating process. How is it turn that, while growing older, the child seems to follow a less "objective" guidance? Previous research has proven the infant's ability to understand adults' intentions which we suggest could be explained by the infant's ability to read the adult's reaction at the end result and, thereby, detecting the fact of action intentionality. For example, within Meltzoff's experiment (1995), the adult "was trying" to put some beads on a thread into a narrow glass cylinder but as a result, the thread kept hanging from the sides of the cylinder which seemed to disappoint the experimenter who consequently reacted with a sad voice, gaze, and an exclamation of "Whoops!" just after the action. It is remarkable that such a reaction may assist an infant in understanding the exact adult intention of this action.

Indeed, most research on intentional relations shows co-variation between the adult intent and the end result (Meltzoff, 1988; Carpenter et al., 1998; Carpenter, Call, &Tomasello, 2002; Gergely & Csibra, 2003), and, hence, the child's preference to imitate the intentional action is explained rather by the infant's identification of the adult's reaction at the goal outcome, but not by an infant's general ability to understand the intentions. Recent studies of Kiraly, Csibra and Gergely (2013) showed the corresponding results of the experiment wherein 14-month-old infants did not copy the adult's action in the absence of the goal outcome, although the action was performed intentionally and, moreover, it was supported by ostensive communicative cues.

Such a focus tends to interpret the behavior of the eldest group in our research not as simpler and less "objective" but as highly organized. Evidently, an 18-months old child determines action intentionality not by reading the adult's reaction to the external event, but rather by means of detected preparation of the action and action properties. To our opinion, such markers are closer related to the internal perception of the intention, contributing to joint attention engagement and to preserving the shared experience (Tomasello, Carpenter, Call, Behne, & Moll, 2005).

Moreover, such a strategy provides the infant with an understanding of the remote goal-directed actions described above. This explanation can also be applied to the above-mentioned overimitation effect. We suppose that the current results contribute to the research on both intentionality and overimitation effect, showing the close relation between these fields. Research of the first mentioned field was mainly directed towards assessing a child's ability to detect the intentions of others (Woodward, 1998; Woodward et al., 2003; Carpenter et al., 1998; Gergely & Csibra, 2003), however, the procedure usually included a test situation with a child reproducing the adults' actions. The second research direction mentioned above was mainly dedicated to discovering the reasons for the overimitation effect in child behavior (Whiten, Custance, Gomez,

Texidor, & Bard, 1996; Call, Carpenter, & Tomasello, 2005; Lyons, Young, & Keil, 2007; Keupp, Behne, & Rakoczy, 2013; Király, Csibra, & Gergely, 2013), considering intentionality as influential factor in this phenomenon.

In our opinion, this situation indicates the relation of the two problems and calls for the creation of a common model explaining the development of intentional relations being the meaningful factor within the structure of social learning. Our data show that such a model has to include both stages: when social learning is formed by an understanding of intent depending on the adult reaction which follows the goal outcome, and when social learning is based upon the properties of the adult action per se. However, an 'independence' from the outcome at the latter stage does not imply that children recklessly copy every adult's intentional action; they use cues of competent adult behavior. For example, preschoolers do not imitate adults' actions that are intentional but displayed in an unconfident manner, as if performed for the first time (Kotova & Preobrazhenskaya, 2009).

One of the purposes of the current paper was to compare results obtained in M. Nielsen's study (2006) and ours. His work discovered similar results in terms of the age limits for a child's tendency to follow the intentionality of the adult regardless of the goal outcome. The procedure was arranged in a usual manner within the overimitation research paradigm: an ineffective action was operationalized as irrelevant for the goal outcome (such an action was redundant for obtaining the goal), and the goal outcome did not follow the adult action automatically but the adult action opened a way to achieve the goal outcome at the next step (e.g., retrieving a toy).

Evidently, compared to Nielsen's study (2006), our results would have to exhibit an earlier age limit due to the lower complexity level of the action structure in the described design. As a reminder, we state that a preference for intentionality over effectiveness in children's imitation is a manifestation of the emerging ability to identify intentions of the adult using not only the adult's reaction to the end result, but also cues that precede or accompany the action. In terms of our reasoning, the procedure of Nielsen's experiment met the similar requirements for testing an infant's ability to attribute adult intention. Therefore, it was quite expected that our study revealed the similar age limitation despite the differences in the complexity levels.

Such converging evidence allowed us to make one more important conclusion for the research fields of both overimitation and social learning. If we discuss social learning as learning how to perform certain actions from adult behavior, then according to the traditional view we should expect that acquired actions become more and more complex with age. But our results suggest that what changes with development is that the actions acquired by the child become more and more relevant to planning and control of behavior. That is, the older the child becomes, the more they are ready to adopt the way that adults select their actions and control for performance. Indirectly, it provides for a child is acquiring more complex actions. However, complexity is not a key factor, but rather a by-product of the development of social learning. We argue that the organization, selection and planning components of the acquired action, which cause the increased complexity of instrumental activity, is the real achievement in social learning development.

As a whole, our study, arranged in a novel way to contrast two conditions pertaining to the intention and goal outcome in adult behavior, has shown that 17 to 20-month-old children prefer to imitate an adult's intentional action rather than an accidental one, regardless of the obtained end results. Moreover, we found that in the experimental condition 12 to 16-month-old infants select some other action but none of the two actions demonstrated by adult. While comparing our results to other research (including the overimitation effect studies), we have reached the conclusion, that the revealed priority of intentional actions in children's imitation under the condition of non-consistent adult behavior is caused by the adult's action preparation and properties, which guide an infant in determining adult's intentional behavior.

References

Kotova, T. N. & Kotov, A. A. (2014). Raspoznavanie chuzhih namerenij rebenkom pri osvoenii instrumental'nyh dejstvij. [In Russian] In V. F. Spiridonov (Ed.), *Kognitivnaja psihologija: fenomeny i problemy* (pp. 216–228). Moscow: Lenand.

Kotova, T. N. & Preobrazhenskaja, A.D. (2009). Rol' namerenija vzroslogo v jeffekte chrezmernogo podrazhanija. [In Russian] *Psihologija. Zhurnal VShJe*, *6*(1), 152–158.

Jel'konin, D. B. (1997a). Zametki o razvitii predmetnyh dejstvij v rannem detstve. [In Russian] In D. I. Fel'dshtejn (Ed.), *Psihicheskoe razvitie v detskih vozrastah: Izbrannye psihologicheskie trudy* (pp. 87–100). Moscow: Izdatel'stvo «Institut prakticheskoj psihologii», Voronezh: NPO «MODJeK».

Jel'konin, D. B. (1997). K probleme periodozatsii psikhicheskogo razvitiya v detskom vozraste. [In Russian] In D. I. Fel'dshtejn (Ed.), *Psihicheskoe razvitie v detskih vozrastah: Izbrannye psihologicheskie trudy* (pp. 87–100). Moscow: Izdatel'stvo «Institut prakticheskoj psihologii», Voronezh: NPO «MODJeK».

Sergienko E.A. (2006) Rannee kognitivnoe razvitie. Novyj vzgljad. [In Russian] Moscow: IPRAN.

Call, J., Carpenter, M., & Tomasello, M. (2005). Copying results and copying actions in the process of social learning: Chimpanzees (*Pan troglodytes*) and human children (*Homo sapiens*). *Animal Cognition, 8*(3), 151–163. doi:10.1007/s10071-004-0237-8

Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior and Development, 21*(2), 315–330. doi:10.1016/S0163-6383(98)90009-1

Carpenter, M., Call, J. & Tomasello, M. (2002). Understanding 'prior intentions' enables 2-year-olds to imitatively learn a complex task. *Child Development, 73*(5), 1431–1441. doi:10.1111/1467-8624.00481

Carpenter, M., Call, J., & Tomasello, M. (2005). Twelve- and 18-month-olds imitate actions in terms of goals. *Developmental Science, 8*(1), F13–F20. doi:10.1111/j.1467-7687.2004.00385.x

Gergely, G., and *Csibra* G. (2003). Teleological reasoning in infancy: the naive theory of rational action. *Trends in Cognitive Sciences, 7*(7), 287–292. doi:10.1016/S1364-6613(03)00128-1

Gergely, G., Bekkering, H., & Király, I. (2002). Rational imitation in preverbal infants. *Nature, 415*(6873), 755. doi:10.1038/415755a

Keupp, S., Behne, T., & Rakoczy, H. (2013). Why do children overimitate? Normativity is crucial. *Journal of Experimental Child Psychology, 116*(2), 392–406. doi:10.1016/j.jecp.2013.07.002

Király, I., Csibra, G., Gergely, G. (2013). Beyond rational imitation: learning arbitrary means actions from communicative demonstrations. *Journal of Experimental Child Psychology, 116*(2), 471–486. doi:10.1016/j.jecp.2012.12.003

Lyons, D.E., Young, A.G., & Keil, F.C. (2007). The hidden structure of overimitation. *Proceedings of the National Academy of Sciences, 104*(50), 19751–19756. doi:10.1073/pnas.0704452104

Meltzoff, A.N. (1988). Infant imitation and memory: Nine-month- olds in immediate and deferred tests. *Child Development, 59*(1), 217–225. doi:10.2307/1130404

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental psychology, 31*(5), 838-850.

Nielsen, M. (2006). Copying actions and copying outcomes: Social learning through the second year. Developmental *Psychology, 42*(3)*, 555–565.* doi:10.1037/0012-1649.42.3.555

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences, 28*(5), 675–691. doi:10.1017/S0140525X05000129

Uzgiris, I.C. (1981). Two functions of imitation during infancy. *International Journal of Behavioral Development, 4*(1), 1–12. doi:10.1177/016502548100400101

Whiten A., Custance D.M., Gomez J.-C., Texidor P., Bard K. A. (1996). Imitative learning of artificial fruit processing in children (*Homo sapiens*) and chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 110*(1), 3–14. doi:10.1037/0735-7036.110.1.3

Woodward, A. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition, 69*(1), 1–34. doi:10.1016/S0010-0277(98)00058-4

Woodward, A. L. (2003). Infants' developing understanding of the link between looker and object. *Developmental Science, 6*(3), 297–311. doi:10.1111/1467-7687.00286

Woodward, A.L., Sommerville, J.A., & Guajardo, J. J. (2001). How infants make sense of intentional action. In B. F. Malle, L. J. Moses, & D. A. Baldwin (Eds.), *Intentions and intentionality: Foundations of social cognition* (pp. 149–171). Cambridge, MA: MIT Press.

Роль целенаправленности и результативности действий взрослого в освоении предметных действий у детей на втором году жизни

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Аннотация. В возрасте от года до двух лет ребенок активно интересуется предметами, которыми на его глазах пользуется взрослый, хотя удобства при достижении цели эти предметы ему еще не предоставляют. Что заставляет ребенка, глядя на взрослого, стараться использовать предмет по назначению? Один из очевидных ответов связан с результативностью поведения взрослого и желанием ребенка достигнуть того же результата. Однако многие современные исследования показывают, что ребенок ориентируется не только на результат, но и на намерение взрослого. В своем эксперименте мы заостряем возможность выбора для ребенка, противопоставляя намеренное и результативное поведение взрослого. Мы обнаружили, что дети 17–20 месячного возраста предпочитают повторять действие, которое взрослый выполнил намеренно (пусть даже он и не достиг при этом интересного результата), а не случайно (хотя в данном случае это действие и завершилось интересным результатом). При этом, полученные данные также показывают, что возможность ориентироваться на намерение развивается у ребенка с возрастом, так как у 12–16-месячных испытуемых подобной склонности не наблюдается. В статье обсуждается сходство и различия полученного феномена с классическими данными по эффекту чрезмерного подражания и возрастным границам его проявления. Также обсуждается важное для данной проблематики предположение, вытекающее из полученных данных: развитие усвоения опыта из взаимодействия со взрослым идет не по линии усложнения доступных для него действий, а по линии близости усваиваемого опыта к планированию действия.

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Введение

В изучении процессов становления предметных действий ребенка одной из ключевых проблем является неопределенность адаптивного значения этих действий (Эльконин, 1997а). До того, как ребенок полноценно освоил способ действия с новым предметом, применение этого предмета не дает ему ощутимого прироста в эффективности достижения цели, с которой обычно применяется данный предмет: неумелое использование ложки во время еды на первых порах существенно менее эффективно, чем непосредственная доставка пищи в рот рукой, а пальцем нарисовать круг легче, чем первый раз сделать это карандашом. Тем не менее, ребенок на втором году жизни с воодушевлением и упорством тянется к предметам, используемым взрослым, и старается использовать именно их. Такое положение дел заставляет психологов развития предполагать, что ребенок стремится к освоению действий с предметами не ради их удобства или полезности, а исходя из их значения для окружающих взрослых (Эльконин, 1997а; Uzgiris, 1981; Keupp, Behne, Rakoczy, 2013).

Однако остается непонятным, каким именно образом ребенок вычленяет это значение. Одним из современных направлений в области поиска ответа на этот вопрос является изучение распознавания ребенком намерений взрослого (Meltzoff, 1988; Carpenter, Call, Tomasello, 2002; Gergely, Csibra, 2003). Дело в том, что предметные действия взрослого, как правило, являются намеренными действиями, и именно намеренные манипуляции с культурным предметом выделяют его культурную функцию. Ребенок может видеть, как мы случайно касаемся ложки, отодвигая ее вместе с другими предметами, находящимися на столе, но, чтобы научиться пользоваться ложкой, он должен пропустить этот наблюдаемый опыт и выделить из всего потока действий взрослого с ложкой только движения, связанные с использованием ее для еды. В какой мере это доступно маленькому ребенку?

В ряде эмпирических работ показано, что понимание ребенком целенаправленности движений другого человека можно зафиксировать с очень раннего возраста — 3–6 месяцев от рождения (Woodward, 1998; Woodward, Sommerville, Guajardo, 2001). В этих исследованиях испытуемым показывают повторяющиеся ситуации схватывания рукой одного и того же из двух объектов, всякий раз стоящих на одних и тех же местах. Когда младенец начинает значимо реже смотреть на эту сцену, то есть «привыкает» к ней, объекты меняют местами. Количество фиксаций взора увеличивается только в том случае, если рука схватывает новый объект (хотя она и тянется при этом к прежнему месту), и не увеличивается, если рука схватывает тот же объект, несмотря на новизну места его расположения. Это говорит о том, что младенец видит определенное различие между сменой направления движения и сменой цели, то есть рассматривает данное движение как целенаправленное.

Однако цель схватывания относительно наглядна, и если ребенок исходит из некоторой презумпции целенаправленности движений человека, ему довольно просто обнаружить объект, на который это движение направлено. В случае с определением намеренности тех или иных манипуляций взрослого с объектом задача становится более сложной, поскольку с одним и тем же предметом взрослый совершает множество движений, в том числе являющихся и частями определенного действия, и самостоятельными намеренными действиями, и побочными движениями, цель которых связана с другими предметами. Недавние исследования распознавания ребенком намерений взрослого в отношении предметов указывают на довольно широкие возможности детей в самом начале раннего возраста. Так, например, в эксперименте М. Карпентер с соавт. (Carpenter, Call, Tomasello, 2005) дети видели, как взрослый проводит игрушечную мышку от одного края стола до другого одним из двух способов: короткими прыжками с прерывистым звуком «Пи-пи-пи» или скользящим движением с длительным звуком «пиииии». При этом в одном из условий в конце стола стояли 2 домика, и мышка в итоге движения попадала в один из них, а в другом — таких домиков не было, мышка просто пересекала стол. После инструкции «А теперь — ты» способ передвижения мышки (прыжки или скольжение) устойчиво повторяли только дети из второй группы, а дети, видевшие, как мышка попадала в домик, применяли случайные варианты передвижения, вне соответствия с тем, какой способ показывал экспериментатор.

Таким образом, авторы делают вывод, что уже в 12 месяцев ребенок определяет, для чего взрослый совершает ту или иную манипуляцию с объектом — является ли она самостоятельным действием (попрыгать/поскользить мышкой) или промежуточной, обслуживающей операцией для другого действия (поместить мышку в правый/левый домик), и в этом смысле — стоит ли ее повторять. В целом за последние десятилетия можно перечислить множество исследований, где так или иначе показано, что при наблюдении действий взрослого с объектом дети в возрасте 12–18 месяцев воспроизводят то действие, которое намеревался совершить взрослый, порой, даже если реально наблюдаемое действие было другим (Meltzoff, 1988; Gergely, Bekkering, Király, 2002; см. также обзор Сергиенко, 2006).

В рамках рассматриваемого нами вопроса, однако, важно понимать, ориентируются ли дети на намеренность действий взрослого как таковую или для них важно, что намеренное действие, как правило, приводит к успеху, к достижению привлекательного результата? Что произойдет, если такая типичная связь будет нарушена? Такие условия были созданы в исследовании М. Карпентер с соавт. (Carpenter, Akhtar, Tomasello, 1998), в котором испытуемым 12 и 14-месячного возраста экспериментатор показывал новый, незнакомый для них объект — созданное специально для эксперимента небольшое механическое устройство, состоящее из нескольких подвижных частей. Каждое из использовавшихся устройств допускало, по крайней мере, две манипуляции с разными частями объекта (например, переключение рычага или раскачивание колечка), в результате которых происходило привлекательное, интересное для ребенка событие (например, надувание разворачивающегося бумажного «языка»).

Экспериментатор говорил испытуемому: «Смотри, что у меня есть! Я сейчас покажу тебе, как с этим надо играть», а затем совершал подряд обе манипуляции, одну сопровождая восклицанием «Вот так!», а другую — «Ой!». То есть подразумевалось, что одна из манипуляций является намеренной, а другая — нечаянной, случайной. При этом обе они были результативными, производили привлекательный, интересный для ребенка эффект. Поэтому авторы ожидали, что если ребенок при повторении действий взрослого руководствуется стремлением к результату, повторяет успешные действия, то ни одна из показанных манипуляций не должна иметь приоритета для него и обе они должны воспроизводиться с одинаковой частотой. Однако дети в обеих возрастных группах существенно чаще повторяли намеренное действие взрослого, то, которое он сопровождал восклицанием «Вот так!», и не выбирали пусть и результативное, но «случайное» движение, сопровождавшееся междометием «Ой!».

И все же подобный результат не снимает описанных выше сомнений, связанных с тем, что намеренность действий взрослого является не самостоятельным ориентиром для выбора образца при подражании, а служебным, повышающим вероятность успешности выбранного действия. Возможно, в эксперименте М. Карпентер и соавт. (1998) дети повторяют намеренное действие не просто потому, что оно намеренное, а потому что оно успешное и намеренное, то есть обладает дополнительными привлекательными характеристиками по сравнению с другим успешным действием.

В таком случае, противопоставление намеренного и результативного действия в полной мере в работе М. Карпентер и соавт. (1998) не произошло, осталось непонятным, будет ли ребенок подражать намеренному действию, если оно наглядным образом не связано с результатом. Подобное противопоставление активно исследуется в работах, посвященных так называемому феномену чрезмерного подражания (Whiten, Custance, Gomez, Texidor, Bard, 1996; Call, Carpenter Tomasello, 2005; Lyons, Young, Keil, 2007; Keupp, Behne, Rakoczy, 2013; Király, Csibra, Gergely, 2013). Преимущественно этот феномен изучается в работе с дошкольниками (см. обзор: Котова, Котов, 2014), мы же рассмотрим исследование М. Нильсена (Nielsen, 2006), в котором приняли участие дети раннего возраста.

В своем эксперименте М. Нильсен (2006) показывал испытуемым новый для них предмет, представляющий собой небольшую коробку с крышкой и переключателем на боковой панели, внутри которой находилась игрушка. Некоторые испытуемые видели, что экспериментатор брал лежащий рядом дополнительный объект (к примеру, игрушечный молоток или погремушку), с его помощью передвигал переключатель и, таким образом открывая коробочку, извлекал игрушку. Испытуемым из другой группы демонстрировали, как экспериментатор просто передвигает переключатель на коробке рукой (дополнительный объект при этом лежал рядом). Затем экспериментатор собирал объект в обратном порядке (клал игрушку в коробочку и накрывал крышкой) и предлагал ребенку самому достать игрушку.

В рамках такой процедуры использование дополнительного объекта является ненужным для результата — извлечения игрушки, то есть неэффективным, не связанным с успехом действием. Как и в любом эксперименте, посвященном эффекту чрезмерного подражания, чтобы убедиться в том, что ребенок в состоянии оценить неэффективность того или иного действия, то есть отсутствие необходимости в нем, в процедуру включается условие без предварительной демонстрации действий с объектом со стороны взрослого. В этой группе испытуемые М. Нильсена (2006) в возрасте и 12, и 18, и 24 месяцев открывали коробку, передвигая переключатель рукой, то есть понимали, что использование дополнительного объекта не нужно для достижения результата.

И, тем не менее, при таком понимании устройства объекта испытуемые в группе с демонстрацией взрослым неэффективного действия повторяли его, передвигая переключатель с помощью объекта. Такое поведение было характерным в этом условии для детей 18-месячного возраста и, в еще большей степени, для двухлетних. Годовалые дети открывали крышку рукой, даже если взрослый открывал ее с помощью объекта. Интересно, что если взрослый при этом предварительно изображал попытки передвинуть переключатель рукой и вел себя так, словно бы у него не получилось, и только потом передвигал его дополнительным объектом, уже и 12-месячные дети открывали коробку с помощью объекта, без предварительных проб.

Таким образом, в эксперименте М. Нильсена (2006) видно, что ребенок действительно готов подражать намеренному действию взрослого, даже если оно не является эффективным, обеспечивающим результат. Кроме того, мы видим определенную возрастную границу такого поведения — 18 месяцев. 12-месячные дети также распознают намеренное поведение взрослого и могут ему подражать, если оно оказывается оправданным, но в противном случае не ориентируются на него. Такое возрастное соотношение оказывается совпадающим с ожиданиями, которые можно было бы экстраполировать из периодизации Л. С. Выготского — Д. Б. Эльконина (Эльконин, 1997b), поскольку именно после прохождения кризиса одного года и вступления в ранний возраст ребенок, по этой периодизации, включается в совместную со взрослым деятельность по освоению предметных действий.

По сравнению с экспериментом М. Карпентер и соавт. (1998) действие, демонстрируемое взрослым в эксперименте М. Нильсена (2006), является операционально более сложным: в первом случае нужно просто привести в движение деталь объекта, а во втором необходимо взять отдельный предмет и с его помощью произвести манипуляции с деталью объекта; кроме того, само соотношение между действием и результатом в них отличается: раскачивание колечка непосредственно приводит к надуванию бумажного «языка», а после открытия крышки палочкой игрушку из объекта еще нужно достать отдельным движением.

Возможно, что в условиях более простого операционального состава смена приоритетов между целенаправленностью и результативностью происходит в более раннем возрасте. Это конечно, несколько про-

тиворечит высказанному выше, в связи с данными эксперимента М. Нильсена (2006), выводу об обусловленности этого изменения общим ходом психического развития, переходом к новой форме совместной деятельности со взрослым после кризиса одного года. Но эмпирически картина психического развития довольно часто оказывается имеющей «вложенную» структуру по отношению к разным уровням сложности действия (ср., например, с освоением понимания целенаправленности схватывания (Woodward, 1998) и взгляда (Woodward, 2003)), словно бы кризисные явления и новообразования одного и того же типа можно наблюдать раньше или позже в зависимости от уровня сложности действия, о развитии которого идет речь.

Кроме того, в эксперименте М. Нильсена (2006) структура действия не позволяет в полной мере противопоставить целенаправленность действия его эффективности: для этого необходимо, чтобы действия, сравниваемые по эффективности и намеренности, были рядоположенными по своему операциональному статусу.

В связи с этими объяснительными трудностями возникает необходимость создания экспериментальной методики, в которой бы ребенку предоставлялась возможность выбора между двумя действиями с одним и тем же объектом, из которых одно является результативным, но нецеленаправленным, а другое — целенаправленным, но при этом не приводит к результату. Подобный эксперимент мы и провели в рамках данной работы, предполагая проверить, будет ли при обсуждавшейся выше рядоположенности действий по операциональному статусу наблюдаться смена приоритета успешности/намеренности с возрастом, и если да — произойдет ли она в той же возрастной группе, что и подобная смена в отношении действия с отдельной деталью.

Метод

Испытуемые

Группа 1: 21 ребенок в возрасте 12–16 месяцев (средний возраст 14.2 месяцев), среди них 9 мальчиков, 12 девочек.

Группа 2: 11 детей в возрасте 17–20 месяцев (средний возраст 18.1 месяцев), среди них 6 мальчиков, 5 девочек.

Все испытуемые являются посетителями досуговых центров и клубов для родителей с детьми г. Москва и Подмосковья.

Материал

В эксперименте были использованы два новых, незнакомых для ребенка объекта, каждый из которых содержал детали, допускающие заметные, воспроизводимые ребенком исследуемого возраста манипуляции (к примеру, прозрачный шар с пластиковыми бусинами внутри, который можно вращать, толкая его; или пластиковое крыло бабочки, которое можно поворачивать, держа за край). На каждом объекте несколько таких деталей.

При этом манипуляция одной из таких деталей в каждом из объектов приводит к так называемому результативному событию: перцептивно-яркое событие, привлекательное для ребенка исследуемого возраста (например, звон и мелькание перекатывающихся разноцветных бусин внутри пластикового прозрачного шара или мелодичный звук звонка). Такую манипуляцию мы называли *результативным действием*.

Манипуляция другой деталью в каждом объекте завершается без перцептивно-яркого события, заметного для наблюдающего ребенка, «нерезультативно» (например, поворот крыла бабочки происходит бесшумно, и не следует никакого звука, изменения цвета; изменяется только положение детали, которой манипулирует экспериментатор). Такую манипуляцию мы будем называть *нерезультативным действием*.

Процедура

Данная процедура является модифицированным вариантом эксперимента, описанного в работе М. Карпентер с соавторами (1998). Наше главное изменение заключается в том, что в оригинальном эксперименте М. Карпентер с соавторами (1998) все действия экспериментатора (и выполняемые преднамеренно, и как бы случайные) были результативными. Мы же хотим противопоставить намеренность поведения взрослого его результативности, то есть ввести условие, при котором намеренное действие взрослого будет нерезультативным.

Так же, как и в эксперименте М. Карпентер с соавторами (1998), в нашей процедуре взрослый показывает ребенку ранее не знакомый ему объект со словами «Смотри, что у меня есть! Сейчас я покажу тебе, как с этим играть. С этим надо играть вот так! <производит действие> Ой! <производит действие>». Затем передает предмет ребенку, говоря: «А теперь — ты!»

В отличие от эксперимента М. Карпентер с соавторами (1998), в нашем эксперименте было два условия.

1. Согласованное поведение взрослого: результативное действие выполняется целенаправленно, а нерезультативное — нецеленаправленно. Это условие было контрольным и соответствовало, как мы полагаем, обычной картине поведения взрослого, наиболее часто наблюдаемой ребенком раннего возраста при предъявлении ему нового предмета: взрослый намеренно (говоря «Вот так!») манипулирует с деталью объекта, в результате чего случается интересное, привлекательное событие, и когда при этом он случайно касается другой детали (говоря «Ой!»), то никакого заметного события, кроме передвижения самой детали, не происходит.

2. Несогласованное поведение взрослого: результативное действие выполняется нецеленаправленно, а нерезультативное — целенаправленно. Это экспериментальное условие, мы в нем вводим некое нарушение ожиданий ребенка для того, чтобы увидеть, на какую из характеристик поведения взрослого ребенок в действительности опирается в ходе передачи опыта. В этом случае экспериментатор намеренно (говоря «Вот так!») манипулирует с деталью объекта,

но никакого заметного события, кроме передвижения самой детали, не происходит; а когда он случайно касается другой детали (говоря «Ой!»), случается интересное, привлекательное событие.

Эксперимент был внутрисубъектным, каждое условие предъявлялось каждому испытуемому. Порядок предъявления условий, сочетания их с объектом и порядок целенаправленного и нецеленаправленного действия внутри одного условия был проконтролирован с помощью позиционного уравнивания.

После предъявления действий и сообщения: «А теперь — ты!» экспериментатор подвигал объект к ребенку и ожидал его манипуляций с объектом. Фиксировалась деталь, с которой ребенок осуществлял первую манипуляцию. В течение всей процедуры велась видеозапись.

С каждым испытуемым проводилась предварительная игровая серия со знакомыми для ребенка игрушками в целях установления контакта между ребенком и экспериментатором. Все испытуемые принимали участие в эксперименте в сопровождении родителя, предварительно проинструктированного о целях и условиях проведения исследования. В частности, экспериментатор просил родителя ни направлением взора, ни движением, ни словесным указанием не давать ребенку понять, какой именно детали нужно коснуться, и следил за выполнением правила.

Таким образом, мы имеем основания ожидать, что в условиях согласованного поведения взрослого ребенок будет повторять целенаправленную, намеренную манипуляцию, являющуюся одновременно результативной. Нас интересует поведение ребенка в *несогласованных* условиях. Если, как мы предполагаем, для ребенка при освоении предметного действия критичным является отслеживание намерений взрослого, испытуемые будут повторять намеренное действие, даже несмотря на его нерезультативность. Если же выделение намерения играет служебную роль, связанную с типичным положением дел, когда намеренное действие приводит к результату, то в созданной нами *несогласованной* ситуации испытуемый должен воспроизводить ненамеренное действие, потому что именно оно было результативным.

Кроме того, нас интересует различие в поведении детей из разных возрастных групп: 12–16 мес. и 17–20 мес.

Результаты

В качестве зависимой переменной в нашем эксперименте выступает первое действие ребенка с новым объектом, которое выражается в выборе ребенком детали для манипуляции непосредственно после демонстрации взрослым объекта. Ребенок после слов взрослого «А теперь — ты!» дотягивается до детали, касается ее и передвигает. Это может быть деталь, с которой взрослый манипулировал намеренно (повтор намеренного действия), деталь, которой взрослый манипулировал ненамеренно (повтор ненамеренного действия), деталь, которой взрослый не манипулировал (другое действие).

Данные для группы испытуемых 12–16-месячного возраста представлены в таблице 1. Статистический анализ показывает, что для испытуемых этого возраста тип демонстрируемого поведения взрослого оказывается значимым с точки зрения влияния на первое производимое ребенком действие ($\chi^2 = 10.13$, $p < 0.01$). Так, при согласованном поведении экспериментатора большинство детей выбирают целенаправленное действие, то есть проявляют умение распознавать намерения и в соответствии с этим поступать. Однако несогласованное поведение экспериментатора ведет к тому, что большая часть детей совершает «другое» действие, не наблюдается ни предпочтений целенаправленного действия, ни предпочтения результативного действия. Таким образом, даже испытуемые в младшей возрастной группе не склонны повторять именно результативное действие: в условиях, когда оно выполняется ненамеренно, они преимущественно выбирают действие, не производившееся взрослым.

Тип поведения экспериментатора	Первое действие ребенка с объектом после демонстрации действий взрослого			
	Повтор намеренного действия взрослого	Повтор ненамеренного действия взрослого	Другое действие	В целом
Согласованное поведение	13	3	5	21
	62 %	14 %	23 %	100 %
Несогласованное поведение	3	6	12	21
	14 %	29 %	57 %	100 %

Таблица 1. Соотношение согласованности поведения экспериментатора и первого действия ребенка по отношению к объекту после демонстрации действий взрослого (для испытуемых 12–16-месячного возраста)

Тип поведения экспериментатора	Первое действие ребенка с объектом после демонстрации действий взрослого			
	Повтор намеренного действия взрослого	Повтор ненамеренного действия взрослого	Другое действие	В целом
Согласованное поведение	9	1	1	11
	82 %	9 %	9 %	100 %
Несогласованное поведение	7	2	2	11
	63 %	18 %	18 %	100 %

Таблица 2. Соотношение согласованности поведения экспериментатора и первого действия ребенка по отношению к объекту после демонстрации действий взрослого (для испытуемых 17–20-месячного возраста)

В то же время для группы 17–20-месячного возраста вариации согласованности поведения взрослого не имели значения ($\chi^2 = 0.92$, $p > 0.5$): результа-

тивным или нерезультативным было намеренное действие взрослого, дети все равно повторяли именно его и игнорировали ненамеренное, несмотря на то что оно в одной из серий имело привлекательный результат. Таким образом, в этом возрасте испытуемые опирались в выборе повторяемого действия на намерения взрослого, а не на эффективность самого действия.

При этом в целях обоснования разделения испытуемых на предложенные возрастные группы мы сравнили распределение реакций в условиях с разной согласованностью в двух возрастных группах. Мы обнаружили, что это распределение статистически значимо связано с тем, в какую возрастную группу (12–16 мес., 17–20 мес.) попадает испытуемый ($\chi^2 = 9.03$, $p = 0.01$).

Обсуждение

По результатам проведенного эксперимента мы можем сделать вывод, что в среднем с 18-месячного возраста дети начинают использовать именно намеренность поведения взрослого для того, чтобы решить, какое из действий взрослого с объектом стоит повторять. В возрасте 12–16 месяцев они ориентируются, как видно из полученных данных, одновременно и на результативность действий взрослого, и на их намеренность. При столкновении же с несогласованным поведением, с противоречием между двумя названными критериями, они предпочитают «уходить» от него, выполняя действие с деталью, которой взрослый не манипулировал вообще.

Как мы упоминали выше, уже с трех месяцев ребенок может выделять цель схватывающего движения взрослого (Woodward, 1998; Woodward, Sommerville, Guajardo, 2001), и, по крайней мере, с 12-месячного возраста при выборе из двух результативных действий взрослого предпочитает повторять намеренное (Carpenter et al., 1998). И все же, как видно по поведению испытуемых в нашей процедуре, совсем отказаться от ориентации на результат действия при подражании могут только испытуемые 17–20-месячного возраста. То есть мы говорим о развивающемся качестве, которое, по-видимому, действительно лежит в основе скачка в освоении предметных действий в раннем возрасте, непосредственно предваряя его.

Ориентация на намерение взрослого при выборе повторяемого действия действительно могла бы быть полезной стратегией для освоения культуры на уровне использования типичных в данной культуре предметов. В начале своего вхождения в культуру ребенок имеет слишком мало когнитивных возможностей для самостоятельного отбора эффективных, полезных действий с предметами из всего объема наблюдаемых им манипуляций взрослых с ними.

С одной стороны, это выражается в том, что часто сами цели, преследуемые взрослым, опосредованы другими событиями, имеют слишком далеко отстоящие последствия: к примеру, мы надеваем шапку, находясь в теплой квартире потому, что собираемся на улицу и знаем, что там мы без нее замерзнем, но годовалому ребенку здесь и сейчас трудно воспринимать «согреться» как цель. С другой стороны, как мы уже отмечали выше, многих целей, которых взрослый достигает с помощью предметов, ребенок на существующем уровне его двигательных навыков с бóльшим успехом может достигнуть без предмета: для двухлетнего ребенка способ оторвать кусочек бумаги руками будет надежнее, чем способ с использованием ножниц. Да и сама связь выполняемых манипуляций с достигаемой целью в большинстве случаев оказывается основанной на закономерностях, подчас сложных для понимания даже взрослого: почему от нажатия на выключатель загорается лампа, неспециалист в области физики объяснит лишь приблизительно.

Все эти обстоятельства сделали бы освоение предметных действий в раннем возрасте очень медленным и практически недоступным, если бы ребенок опирался на самостоятельную оценку результативности поведения взрослого. Поэтому описанные в литературе данные о ранней ориентации ребенка на намеренность поведения взрослого (Meltzoff, 1988; Carpenter, et al., 1998; Carpenter, Call, Tomasello, 2002; Gergely, Csibra, 2003) выглядят вполне ожидаемыми. Действительно, намерение человека довольно хорошо заметно по подготовке движения, его характеру, реакции на события, следующие за ним, и для освоения предметных действий правило «повторять все, что взрослый делает намеренно» для ребенка было бы довольно удобным.

Однако наши данные указывают на необходимость еще более сложной модели, описывающей выбор действий взрослого для подражания. Согласно полученным результатам, ребенок не всегда следует такому правилу: на ранних этапах его выбор обусловлен одновременно и результативностью действий взрослого и их намеренностью, а становясь старше, он словно бы начинает использовать менее «объективный» ориентир — лишь намерение взрослого. Однако проявление ребенком распознавания намеренности во многих предыдущих исследованиях можно было бы объяснить тем, что он считывает реакцию взрослого на результат его действия и по ней определяет, было ли данное действие намеренным. К примеру, когда в исследовании Э. Мельтзоффа (1995) взрослый «старается» опустить нитку бус в узкий стеклянный цилиндр, и бусы повисают то с одной, то с другой стороны цилиндра, именно реакция на это событие (расстроенный голос, направление взора, «Ой», следующее сразу же за событием) могут помочь ребенку понять, что намерение было другим.

Действительно, в большинстве исследований распознавания намеренности намерение взрослого сопутствует наличию результата (Meltzoff, 1988; Carpenter et al., 1998; Carpenter, Call, Tomasello, 2002; Gergely, Csibra, 2003), поэтому повтор ребенком намеренного действия взрослого можно объяснить не способностью считывать намеренность в целом, а распознаванием реакции взрослого на результат. С этим рассуждением согласуются и недавние данные И. Кирали с соавт. (Kiraly et al., 2013), в эксперименте которых 14-месячные испытуемые не повторяли действие взрослого (склонявшегося лбом к пластиковой панели-лампочке на столе), если у этого действия не было результата (лампочка после этого не зажигалась). Это происхо-

дило, несмотря на то, что действие взрослого выполнялось намеренно и даже сопровождалось остенсивно-коммуникативными признаками.

При таком рассмотрении поведение старшей группы в нашем эксперименте начинает выглядеть не более простым и менее «объективным», а напротив, более тонко и сложно организованным. По-видимому, 18-месячный ребенок выделяет намерение взрослого не по его реакции на внешне наблюдаемое событие, а по характеристикам, предваряющим и сопровождающим само действие. Такие маркеры, как можно было бы ожидать, в большей степени внутренне связаны с переживанием намерения, что должно способствовать установлению совместного внимания и сохранению совместного опыта (Tomasello, Carpenter, Call, Behne, Moll, 2005).

Наряду с этим, ориентация на такие маркеры может помогать ребенку усваивать действия взрослого с далеко отстоящими во времени результатами, как те, что были описаны в начале обсуждения. Такая интерпретация может также быть применима, по нашему мнению, к объяснению эффекта чрезмерного подражания, описанного в начале данной статьи. В полученном результате происходит необходимое, на наш взгляд, сближение исследований проблемы распознавания намерения и чрезмерного подражания. Логика первого направления состояла долгое время в оценке возможностей ребенка по обнаружению целенаправленности действий взрослого (Woodward, 1998; Woodward et al., 2003; Carpenter et al., 1998; Gergely, Csibra, 2003), но процедурно это выполнялось часто с помощью предложения ребенку воспроизвести действие взрослого. Логика же второго с самого начала состояла в том, чтобы понять основания для подражания, которым следует ребенок (Whiten, Custance, Gomez, Texidor, Bard, 1996; Call, Carpenter, Tomasello, 2005; Lyons, Young, Keil, 2007; Keupp, Behne, Rakoczy, 2013; Király, Csibra, Gergely, 2013), и в качестве проверяемых факторов со временем активно начали изучать именно намеренность действия взрослого.

На наш взгляд, это положение дел говорит об общности проблематики данных направлений и указывает на необходимость модели, объясняющей развитие распознавания намерения как включенного в механизм социального научения у человека. Наши данные показывают, что подобная модель с необходимостью должна включать в себя этапы, когда социальное научение обусловлено распознаванием намерения по реакции взрослого на результат его действия, и переход к этапам, когда социальное научение основывается на характеристиках самого действия, производимого взрослым. При этом «независимость» от результата не означает, что ребенок на этом этапе безоглядно копирует любое намеренное действие взрослого. К примеру, ему удается сохранить опору на внешние признаки экспертности, осведомленности в поведении взрослого: пробующее, словно бы в первый раз производимое, пусть и намеренное, действие без определенного результата дошкольники не повторяют (Котова, Преображенская, 2009).

В качестве одной из целей данного исследования мы называли сопоставление данных, получаемых при проведении модифицированной процедуры М. Карпентер с соавт. (1998), с результатами М. Нильсена (2006). В его работе был показан сходный с обнаруженным нами возрастной переход в ориентации на намеренность вопреки результату. Напомним, выше мы говорили о том, что процедура в его исследовании была в большей степени выстроена в соответствии с типичными исследованиями чрезмерного подражания: нерезультативность действия была операционализирована как его иррелевантность конечной цели (то есть и без данного действия цель была достижима), а результат был не перцептивно-заметным событием, наступающим автоматически после манипуляции взрослого, а скорее возможностью реализации следующего действия (извлечения игрушки).

С точки зрения операциональной сложности наблюдаемых ребенком действий было бы разумно ожидать, что в нашей более простой процедуре возрастная граница искомого феномена будет более ранней по сравнению с результатами М. Нильсена (2006). Но, с точки зрения предлагаемой нами интерпретации (заключающейся, напомним, в том, что предпочтение намеренности результату означает появление возможности распознавать намерение взрослого не по его реакции на результат, а по характеристикам, предваряющим и сопровождающим действие), процедура в эксперименте М. Нильсена (2006) оказывается предъявляющей сходные требования к способности ребенка распознавать намеренность. Поэтому мы считаем, что, при различиях в уровне сложности наблюдаемого действия в нашем эксперименте и в исследовании М. Нильсена (2006), выявление аналогичной возрастной границы в наших результатах является вполне закономерным.

Такое сопоставление позволяет сделать еще один важный для проблематики чрезмерного подражания и социального научения в целом вывод: развитие усвоения опыта из взаимодействия со взрослым идет, вероятно, не по линии усложнения доступных для ребенка действий, а по линии близости усваиваемого опыта к планированию действия. То есть чем старше становится ребенок, тем больше он готов перенимать из поведения взрослого способы, с помощью которых он выбирает то или иное действие, регулирует их исполнение, переключается между ними. Хотя косвенно это дает ребенку возможность осваивать более сложные по своей структуре действия, но, как мы видим из данного исследования и его соотношения с существующими результатами, не сама по себе эта сложность описывает прирост в развитии механизма социального научения, а обусловливающие ее особенности организации, выбора и планирования действий.

В целом, благодаря построению эксперимента с противопоставлением намеренности и результативности в поведении взрослого, нам удалось обнаружить, что дети 17–20 месячного возраста предпочитают повторять действие, которое взрослый выполнил намеренно (пусть даже он и не достиг при этом интересного результата), а не случайно (хотя это действие и завершилось интересным результатом). Кроме того,

мы выяснили, что 12–16-месячные испытуемые в этом случае скорее предпочитают выполнять действие, не показанное взрослым. Сопоставление с данными других исследований (в том числе, из области изучения чрезмерного подражания) привело нас к выводу о том, что предпочтение намеренного действия при несогласованном поведении взрослого связано прежде всего с появлением возможности распознавать намеренность не по реакции взрослого на результат, а по характеристикам, предваряющим и сопровождающим действие.

Литература

Котова Т. Н., Котов А. А. Распознавание чужих намерений ребенком при освоении инструментальных действий // Когнитивная психология: феномены и проблемы. / Сост., предисл. В. Ф. Спиридонова. М.: Ленанд, 2014. 216–228 с.

Котова Т. Н., Преображенская А. Д. Роль намерения взрослого в эффекте чрезмерного подражания // Психология. Журнал ВШЭ. 2009. Т. 6. № 1. С. 152–158.

Эльконин Д. Б. Заметки о развитии предметных действий в раннем детстве // Психическое развитие в детских возрастах: Избранные психологические труды / Д. Б. Эльконин; Под редакцией Д. И. Фельдштейна. Издание 2-е, стереотипное. М.: Издательство «Институт практической психологии», Воронеж: НПО «МОДЭК», 1997a. С. 87–100.

Эльконин Д. Б. К проблеме периодизации психического развития в детском возрасте // Психическое развитие в детских возрастах: Избранные психологические труды / Д. Б. Эльконин; Под редакцией Д. И. Фельдштейна. Издание 2-е, стереотипное. М.: Издательство «Институт практической психологии», Воронеж: НПО «МОДЭК», 1997b. С. 87–100.

Сергиенко Е. А. Раннее когнитивное развитие. Новый взгляд. М.: ИПРАН, 2006.

Call J., Carpenter M., Tomasello M. Copying results and copying actions in the process of social learning: Chimpanzees (*Pan troglodytes*) and human children (*Homo sapiens*) // Animal Cognition. 2005. Vol. 8. № 3. P. 151–163. doi:10.1007/s10071-004-0237-8

Carpenter M., Akhtar N., Tomasello M. Fourteen through 18-month-old infants differentially imitate intentional and accidental actions // Infant Behavior and Development. 1998. Vol. 21. № 2. P. 315–330. doi:10.1016/S0163-6383(98)90009-1

Carpenter M., Call J., Tomasello M. Understanding 'prior intentions' enables 2-year-olds to imitatively learn a complex task // Child Development. 2002. Vol. 73. № 5. P. 1431–1441. doi:10.1111/1467-8624.00481

Carpenter M., Call J., Tomasello M. Twelve- and 18-month-olds imitate actions in terms of goals // Developmental Science. 2005. Vol. 8. № 1. F13–F20. doi:10.1111/j.1467-7687.2004.00385.x

Gergely G., Csibra G. Teleological reasoning in infancy: the naive theory of rational action // Trends in Cognitive Sciences. 2003. Vol. 7. № 7. P. 287–292. doi:10.1016/S1364-6613(03)00128-1

Gergely G., Bekkering H., Király I. Rational imitation in preverbal infants // Nature. 2002. Vol. 415. № 6873. P. 755. doi:10.1038/415755a

Keupp S., Behne T., Rakoczy H. Why do children overimitate? Normativity is crucial // Journal of Experimental Child Psychology. 2013. Vol. 116. № 2. P. 392–406. doi:10.1016/j.jecp.2013.07.002

Király I., Csibra G., Gergely G. Beyond rational imitation: learning arbitrary means actions from communicative demonstrations // Journal of Experimental Child Psychology. 2013. Vol. 116. № 2. P. 471–486. doi:10.1016/j.jecp.2012.12.003

Lyons D. E., Young A. G., Keil F. C. The hidden structure of overimitation // Proceedings of the National Academy of Sciences. 2007. Vol. 104. № 50. P. 19751–19756. doi:10.1073/pnas.0704452104

Meltzoff A. N. Infant imitation and memory: Nine-month-olds in immediate and deferred tests // Child Development. 1988. Vol. 59. № 1. P. 217–225. doi:10.2307/1130404

Meltzoff A. N. Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children // Developmental psychology. 1995. Vol. 31. № 5. P. 838-850.

Nielsen M. Copying actions and copying outcomes: Social learning through the second year // Developmental Psychology. 2006. Vol. 42. № 3. P. 555–565. doi:10.1037/0012-1649.42.3.555

Tomasello M., Carpenter M., Call J., Behne T., Moll H. Understanding and sharing intentions: The origins of cultural cognition // Behavioral and Brain Sciences. 2005. Vol. 28. № 5. P. 675–691. doi:10.1017/S0140525X05000129

Uzgiris I. C. (1981). Two functions of imitation during infancy // International Journal of Behavioral Development. 1981. Vol. 4. № 1. P. 1–12. doi:10.1177/016502548100400101

Whiten A., Custance D. M., Gomez J.-C., Texidor P., Bard K. A. Imitative learning of artificial fruit processing in children (*Homo sapiens*) and chimpanzees (*Pan troglodytes*) // Journal of Comparative Psychology. 1996. Vol. 110. № 1. P. 3–14. doi:10.1037/0735-7036.110.1.3

Woodward A. Infants selectively encode the goal object of an actor's reach // Cognition. 1998. Vol. 69. № 1. P. 1–34. doi:10.1016/S0010-0277(98)00058-4

Woodward A. L. Infants' developing understanding of the link between looker and object // Developmental Science. 2003. Vol. 6. № 3. P. 297–311. doi:10.1111/1467-7687.00286

Woodward A. L., Sommerville J. A., Guajardo J. J. How infants make sense of intentional action // B. F. Malle, L. J. Moses, D. A. Baldwin (Eds.) Intentions and intentionality: Foundations of social cognition. Cambridge, MA: MIT Press, 2001. P. 149–171.

The Dopamine Impels Us to Action as Suggested by the Neuronal Activity in the Ventral Tegmental Area during Avoidance Conditioning

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Abstract. The mesolimbic dopamine system is believed to be a key component in the processing of rewarding information by the brain, although the precise nature of dopamine release remains unknown. Avoidance conditioning combines reward (positive) and aversion (negative) phenomena. Here the activity of 60 neurons in the ventral tegmental area (VTA) was studied in freely moving rabbits during the acquisition and performance of an active avoidance. A total of 48 % of the recorded neurons responded to the conditioned stimulus (CS). A significant predominance of excitatory responses to the (CS) was demonstrated. Two main patterns of cell responses to the CS were identified: the reaction with short latency to the CS onset and the instrumental movement related activity. The proportion of neurons reactive to the CS onset significantly decreased between the initial and final stages of learning, but the proportion of movement related neurons significantly increased. Thus our results suggest that the signaling of VTA neurons is better associated with the processes of motivated action.

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Introduction

Dopamine participates in a wide range of behavioral and cognitive functions in the brain, including movement, reward processing, and creativity (Flaherty, 2005). Of the central monoamine neurotransmitters, dopamine presents the greatest challenge in terms of deducing its main physiological role. Midbrain dopamine neurons of the ventral tegmental area (VTA) send projections to many regions including the striatum and prefrontal cortex and are together referred to as the mesocorticolimbic dopaminergic (DA) system. This system has traditionally been viewed as a single "neural currency" of reward and this view has numerous experimental confirmations (Berridge, 2007; Tsai et al., 2009; Wise, 2012; Rossi, Sukharnikova, Hayrapetyan, Yang, & Yin, 2013; Steinberg et al., 2013). How exactly the midbrain DA system is involved in the processes of learning, and what aspects or specific links of the phys-

iological mechanisms of reinforcement it represents are an important focus of ongoing research (Berridge, 2007; Ivlieva, 2010; Bromberg-Martin, Matsumoto, & Hikosaka, 2010; Steinberg & Janak, 2013).

Current hypotheses suggest that (1) DA itself induces pleasure (Wise & Bozarth, 1985), (2) DA provides the universal teaching signal that induces learning (Schultz, 1998; Schultz, 2013), (3) DA mediates motivation or incentive salience (Berridge, 2007) and (4) DA energizes behavior (Salamone, Correa, Farrar, & Mingote, 2007).

Each viewpoint is based on extensive experimental data, and it is believed that they are not mutually exclusive. However, there are at least two main discrepancies within these explanations. First, it is paradoxical that the activation of the same brain substratum should be both reinforcing and drive-inducing, so hypotheses (1) and (3) are conflicting. Second, it is hard to explain the activation of the DA system, which is believed to be engaged in reward processes, in response to aversive stimuli. If midbrain dopamine neurons actually encode value-related signals, their activity should be inhibited by aversive stimuli because aversive stimuli have negative motivational values. However, the results are inconsistent, with many studies showing excitation by aversive stimuli (Anstrom & Woodward, 2005; Anstrom, Miczek, & Budygin, 2009; Brischoux et al., 2009, Matsumoto & Hikosaka, 2009; Wang & Tsien, 2011). At the intersection of such contradictory aspects of DA system functions is instrumental active avoidance, because in this paradigm aversive stimulation as well as motivational and reward processes (in the form of omission of a harmful event) take place.

Thus, the present study recorded VTA neurons during the acquisition of active avoidance. The study of neuronal activity in behavior is one of the most appropriate methods of functional specificity investigation because of the possibility of precise spatial localization of recorded changes with high temporal resolution and minimal invasiveness. Previous studies have shown that the phasic activation of midbrain dopamine neurons strongly resembles the prediction error; that is, dopamine neurons burst when an animal receives an unexpected reward (Schultz, 1998). However, if the animal has learned to associate a conditioned stimulus (CS) with a reward, dopamine neurons burst at the presentation of the CS but not the reward. Furthermore, if the CS is presented but then the predicted reward is omitted, dopamine neurons are inhibited at the approximate time at which the reward should have been delivered. It was assumed that all of these findings are consistent with the idea that dopamine neurons report reward prediction errors (RPE): a positive prediction error signal that the outcome was better than expected, or a negative prediction error signal that the outcome was worse than expected. It has been suggested that such activity can in turn serve as a teaching signal in the projection structures of the VTA (Schultz, 2013). This assumption underlies the most influential hypothesis on the specific role of mesencephalic dopamine in learning processes. In many neuronal studies which consider this idea, the obtained results were in good agreement with the viewpoint's basic assumptions (Satoh, Nakai, Sato, & Kimura, 2003; Bromberg-Martin et al., 2010; Cohen, Haesler, Vong, Lowell, & Uchida, 2012; Schultz, 2013). In most of these studies, classical conditioning procedures were used.

Data about the relationship between DA neurons activity and instrumental movement are rather contradictory (Schultz, Ruffieux, & Aebischer, 1983; Schultz, 1986; Nishino, Ono, Muramoto, Fukuda, & Sasaki, 1987; Satoh et al., 2003). In electrochemical studies of food conditioning, it was shown that DA release precedes the onset of instrumental movement execution (Roitman, Stuber, Phillips, Wightman, & Carelli, 2004; Puryear, Kim, & Mizumori, 2010; Cacciapaglia, Wightman & Carelli, 2011; Oleson, Gentry, Chioma, & Cheer, 2012). In response to the unexpected reward omission, DA level in the projection structures increases, and conversely, when the rate of food supply suddenly increases, a sharp decrease in the DA concentration is observed (Richardson & Gratton, 1996, 1998, 2008). Together, these findings contradict the notion of the role of dopamine as a signal of RPE.

While it is widely assumed that DA neurons exhibit homogenous reward coding across the entire population (Schultz, 1998), studies of dopaminergic system activity under immediate aversive stimuli exposures are also a source of controversy. This is because a neuron's response to aversive events provides a crucial test of its functions in motivational control. In these studies, conflicting results have been obtained in anesthetized (Ungless, Magill, & Bolam, 2004; Brischoux, Chakraborty, Brierley, & Ungless, 2009; Brown, Henny, Bolam, & Magill, 2009) as well as in conscious animals (Anstrom & Woodward, 2005; Anstrom, Miczek, & Budygin, 2009; Wang & Tsien, 2011). Rather contradictory are data on the location and properties of neurons somehow reacting to aversive stimulation in the VTA and the surrounding areas

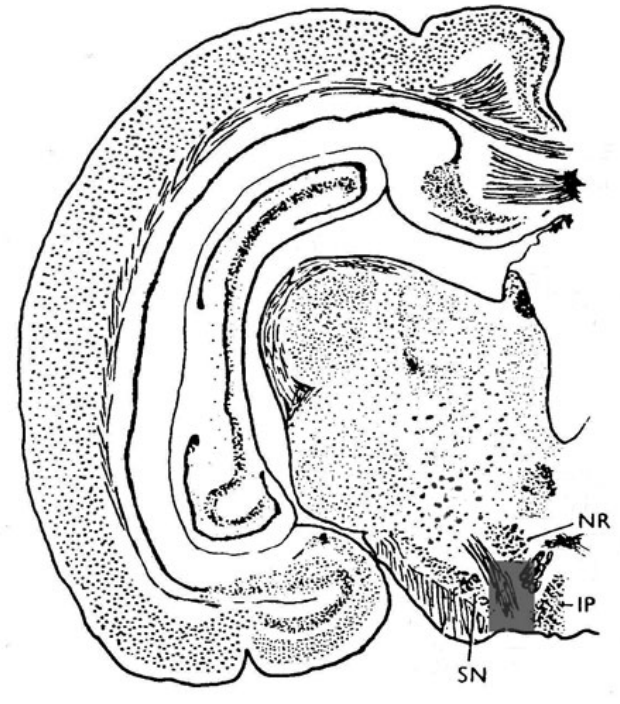

Figure 1. Location of registration area (shaded rectangle) on atlas section (AP 6) diagram. Abbreviations: IP, interpeduncular nucleus; NR, nucleus rubber; SN, substantia nigra.

(Brischoux et al., 2009; Matsumoto & Hikosaka, 2009; Lammel, Ion, Roeper, & Malenka, 2011; Valenti, Gill, & Grace, 2012). Most histochemically identified DA neurons are inhibited in response to fear of the CS (Mileykovskiy & Morales, 2011). In the context of classical conditioning based on unpleasant but not harmful stimuli, conflicting data about the sign of the reaction were obtained (Joshua, Adler, Mitelman, Vaadia, & Bergman, 2008; Matsumoto & Hikosaka, 2009; Cohen et al., 2012; Wang & Tseien, 2012). Studies of DA neurons responding during active avoidance when an animal learns to control aversive stimuli are rare (Mirenovizc & Schultz, 1996) and that study was carried out under mild defensive incentives.

Method

Animals. Four adult male rabbits weighing 2.5–3.5 kg were involved in an experiment which recorded neuronal activity in conditions of free behavior.

Surgeries. Surgical procedures were performed under Nembutal anesthesia (sodium ethaminal, 55 mg/kg) after a period of acclimating the animal to the experimental apparatus for 7 to 14 days. The animal's head was fixed in a stereotaxic apparatus and two trepanned openings were made in the skull without damaging the dura mater. One opening was 2.5 mm in diameter and was either in the region of the projection of the VTA, with coordinates of AP = 6 – 7, L = 1–2, H = – (4 – 6) (Fig. 1; Fifkova & Marsala, 1960); a micromanipulator holder was positioned over the first hole. The second hole was made in the occipital region to accommodate the indifferent electrode, which consisted of a steel screw contacting the dura mater.

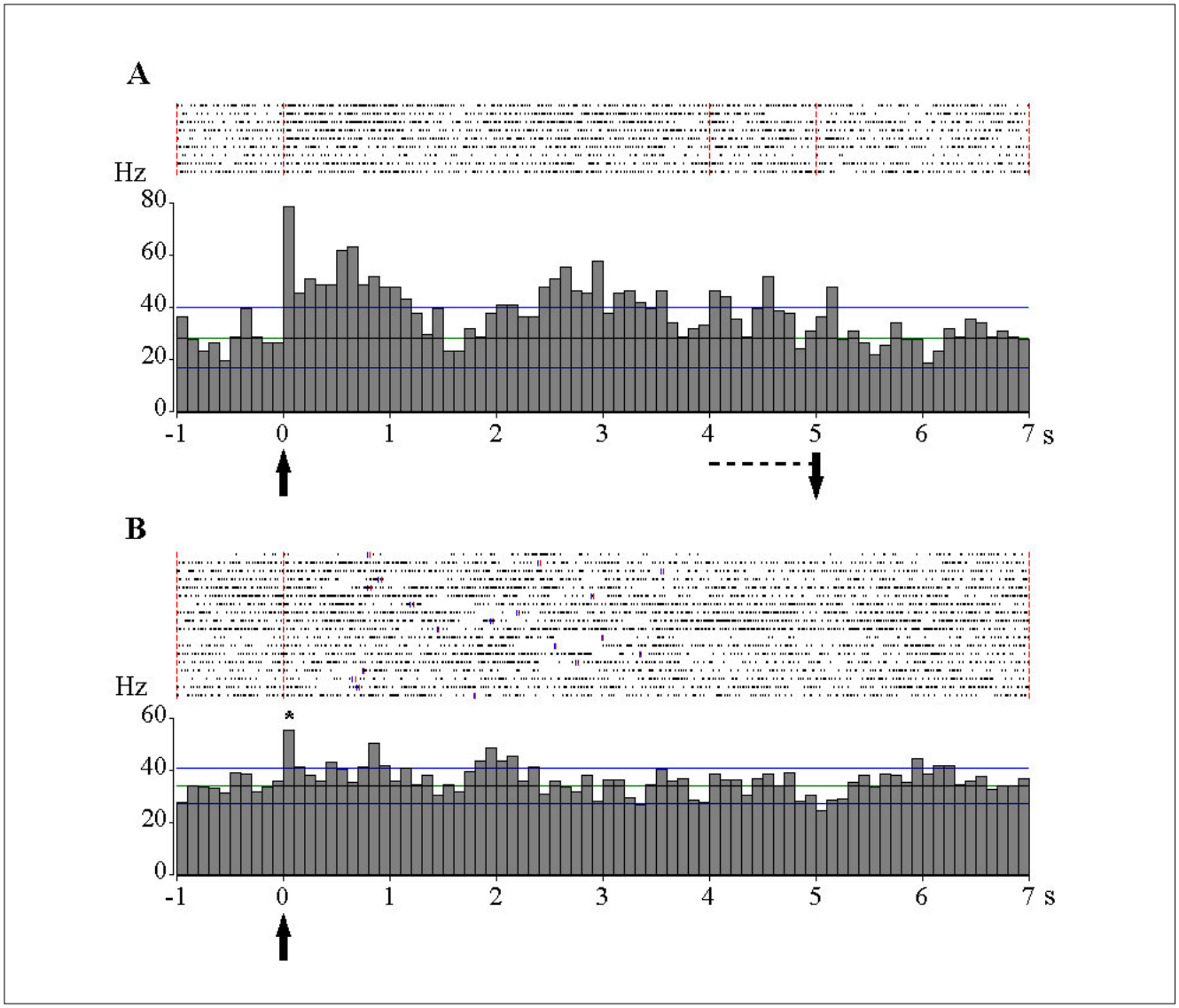

Figure 2. The activity of a neuron in the VTA of the rabbit during the omission (A) or the performance (B) of ear-twitching response to the CS. Spike raster plot and peristimulus time histograms (100 ms bin) aligned to the CS onset illustrate different magnitudes of short excitatory responses to the CS onset as a function of performance (presence or absence of instrumental movement). * indicates significant differences of amplitude of neuronal responses (two-tailed Mann–Whitney test, p = .03). Vertical axis is neuronal firing rate (Hz). The green horizontal line in the histograms indicates the value of the average background discharge rate, the blue lines show twice the standard deviation. The upward arrow indicates the moment of CS onset. The downward arrow indicates the moment of CS offset. The short dotted line under the x-axis indicates the period of electrocutaneous stimulus.

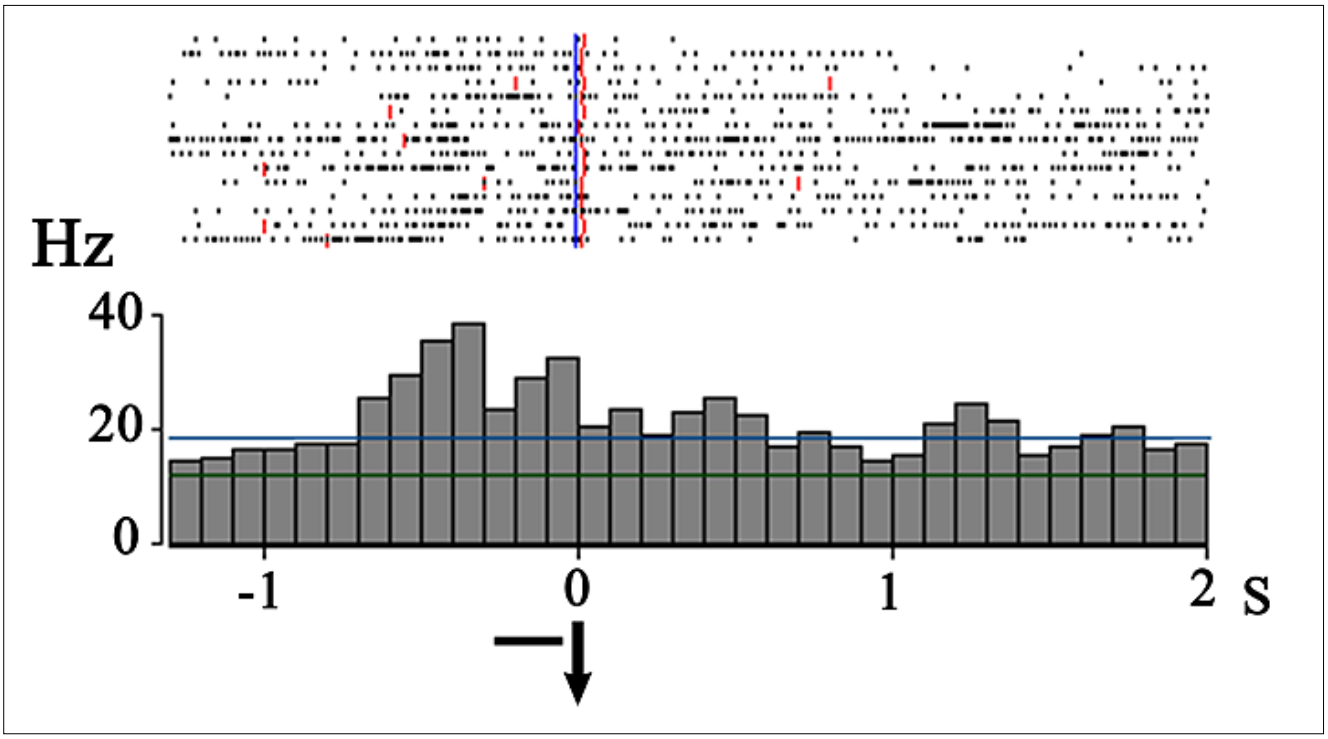

Figure 3. The activity of the single VTA neuron in one of the rabbits during an ear-twitching response to the CS. Spike raster plot and peristimulus time histograms (100 ms bins) aligned to the moment of CS offset after instrumental movement execution. The short line under the x-axis indicates instrumental movement.

Unit activity collection. During the experiment, a micromanipulator was used to insert a microelectrode (a tungsten wire 100 mm in diameter and coated with viniflex lacquer, tip diameter 5–7 mm, resistance 800–2500 kΩ at 1 kHz) into the brain. A biopotential minitransmitter was also attached to the head, and transmitted neuron spikes to the amplification system, from which signals were transferred to an amplitude-time spike discriminator. Standard impulses from the discriminator output were passed to a computer.

Behavioral procedures. Experiments involving the recording of neuronal activity started 5 to 7 days after surgery. Animals were trained and experiments were performed in an electrically shielded sound-attenuated chamber with dimensions of 60 cm × 80 cm and fitted with an observation system for monitoring the animal's behavior. The defensive conditioned reaction (CR) was developed by pairing the CS with electrocutaneous stimulation (ECS) applied to the ear as an unconditioned stimulus (US). The CS was switched off when the animal completed the species-specific ear-twitching response within seven seconds of the start of the CS during the initial period of acquisition of the CR, and within four seconds of the start of the CS once the reflex had formed. When this occurred, ECS was stopped. If the rabbit did not perform the conditioned reflex movement, the US was presented during the last second of the CS. The CS was a sound tone at 400 Hz; ECS consisted of square-wave impulses of 10 ms in duration, at frequency of 10 Hz and amplitude of 10–30 , generated using an ES-50-1 electrostimulator. ECS was delivered via electrodes attached to the animal's ear; the duration of stimulation was one second. ECS parameters did not exceed threshold values inducing responses in the form of twitching movements of the ear and were selected individually in each experiment.

Statistics. Initial processing of neuronal activity consisted of averaging the discharge frequencies over specified periods of time; discharge frequencies were determined at the following intervals: 1) during the single second before presentation of the CS; 2) during the first 100 ms and one second of exposure to the CS; 3) during the period between the end of one second of CS exposure and the beginning of the period preceding the operant movement (only for latent periods of movement responses of greater than two seconds; 4) during the second immediately preceding the movement; 5) during the second immediately after completion of the movement; and 6) during the second after the CS was switched off. When there was no CR to the CS, the mean discharge frequency was determined during each second of exposure to the CS and the poststimulus period.

Statistical analysis of data consisted of 1) calculation and construction of peristimulus histograms of neuron spike activity in the presence and absence of positive behavioral responses; 2) the use of the two-tailed signs test to establish significant ($p < 0.05$) changes in discharge frequencies in response to the CS; and 3) the use of the two-tailed Mann–Whitney test to identify significant ($p < 0.05$) differences in discharge frequency and pattern in background conditions, in responses to the CS, and in the poststimulus period in the presence and absence of behavioral conditioned responses. The significance of differences in the percentage compositions of the neuron groups identified here was determined by analysis of 2 × 2 tables. Statistical analysis of results was performed using Statistica 6.0 for Windows.

Character of changes in the activity of neurons	stage of generalization			stage of specialization		
	n	1	2	n	1	2
All	33	100 %		27	100.0 %	
I. Significant reaction to CS:	17	51.5 %	100 %	12	44.4 %	100.0 %
Reactive to the CS onset	14	42.4 %	82.4 %*	1	3.7 %	8.3 %*
- excited	12	36.4 %	70.6 %	1	3.7 %	8.3 %
- inhibited	2	6.1 %	11.8 %	0	0 %	0 %
Reactive in relation to instrumental movement	4 of 26	15.4 %	23.5 %*	10	37.0 %	83.3 %*
- excited	2	7.7 %	11.8 %	9	33.3 %	75.0 %
- inhibited	2	7.7 %	11.8 %	1	3.7 %	8.3 %
Other	2	6.1 %	11.8 %	4	14.8 %	33.3 %
No response	16	48.5 %		15	55.6 %	
	Of 27:					
II. Changes in PSP:	7	25.9 %	100 %	6	22.2 %	100 %
- excited	2	7.4 %	28.6 %	4	14.8 %	66.7 %
- inhibited	5	18.5 %	71.4 %	2	7.4 %	33.3 %
III. Interrelation of reactivity to CS and in PSP						
- reactive to the CS only	0	0 %		7	25.9%	
- reactive in the PSP only	0	0 %		2	7.4 %	
- reactive both to the CS and in PSP	7	25.9 %		4	14.8 %	

Table 1. The distribution of different patterns of VTA neuron activity during active avoidance in different stages of conditioning

n – number of neurons; 1 – proportion of the total number of studied neurons, 2 – proportion of the number of neurons exhibiting significant change of firing rate; *– significant differences of indicated shares (2 × 2 table, χ^2, p = .0025)

Results

Since there is no generally accepted electrophysiological criteria that identify DA neurons and applicability of such criteria in different experimental conditions is under debate in the literature (Ungless & Grace, 2012), we hereby describe all the neurons recorded in the VTA. During instrumental conditioning, the activity of 60 VTA neurons was recorded. Statistically significant ($p < 0.05$) changes in the frequency and pattern of discharge in response to the CS were found for 29 (48 %) of the 60 VTA neurons. Evaluation of the sign of reaction to the CS revealed a statistically significant ($p < 0.01$) prevalence of activation responses. So, in 18 (62 %) of the 29 recorded cells with a firing rate modification, an increase in discharge frequency was observed while in five (17 %) of the neurons a decrease occurred.

The activity of the VTA neurons in response to CS when performing the instrumental movement. The most characteristic patterns of discharge during the period of CS were defined as follows: (1) the reaction at the CS onset, which manifests itself during the first 100 ms or the first 1000 ms of the CS; (2) a change in discharge frequency during the period of the CS immediately before and/or during instrumental movement; (3) an increase or decrease of the firing rate throughout the action of the CS, and excitatory-inhibitory or inhibitory-excitatory responses, which together constituted a minority of recorded neurons and were referred to as "others".

The most numerous reaction was an excitatory response to the onset of the CS, which was observed in 13 eurons (45 % of the number of cells reactive to CS) (Fig. 2), as well as the activation associated with the instrumental movement, registered in 11 cells (42 % of the number of cells changing activity in the period of the CS and analyzed in relation to movement) (Fig. 3).

Three of eight cells with a reaction to the CS onset, as recorded in the presence and in the absence of instrumental responses to CS, showed significant differences in the severity of this reaction (see Fig. 2).

In the post-stimulus period (PSP) after the instrumental movement or lack thereof, the one-second time interval immediately following the turning off of the CS was analyzed. Significant differences in discharge rates compared to background activity during this period were found in 13 of the 54 neurons ($p < 0.05$).

Dynamics of neuronal activity at different stages of the conditioning. The activity of VTA neurons was recorded at different stages of conditioning. These stages differed in terms of the probability of instrumental responses to CS, and in the amount of interstimulus reactions, in latent periods of the motor responses. Two main stages were identified: generalization, and specialization of CR.

The generalization stage was characterized by: an increase in the number of positive behavioral responses to the CS from 0 % to 60–80 % in different animals; large numbers of intersignal reactions; a variable movement repertoire in response to the CS (startle responses to switching on of the CS, active movement in the arena, turning of the head towards the sound source, intense twitching movements of the head, and multiple twitching movements of the ear lasting into the poststimulus period); and an unstable latent period for the behavioral response. Since the instrumental movement was identical to those caused by unconditioned stimulus action, and strength of US was matched to

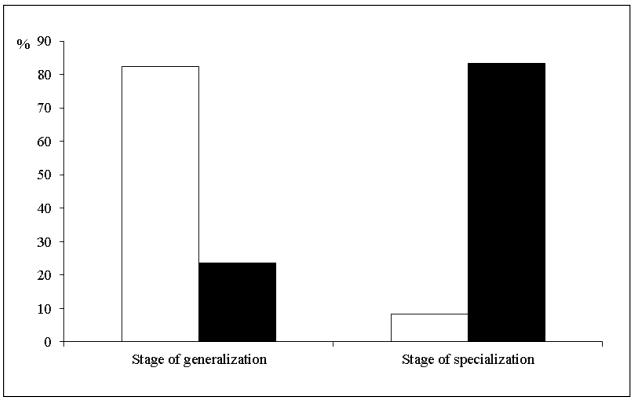

Figure 4. Redistribution of percentages of VTA neurons with the reaction to the CS onset (light bar) and with the reaction in connection with a defensive instrumental movement (dark bars) at different stages of the CR acquisition (2×2 table, $\chi^2 = 9.12$, $p = 0.0025$).

the threshold level, the development of avoidance was quite fast, and the period before the first instrumental movement emergence was short. The probability of performing operant movements in response to the CS reached an average of 70%, though increases in positive conditioned responses at this stage were accompanied by increases in the proportion of operant responses during the interstimulus intervals. At the specialization stage, the proportion of adequate responses was greater than 70% while the proportion of intersignal responses relative to the number of CS presentations decreased to 0–30% and the efferent generalization of responses to the CS was transformed into single twitching responses with a stable latent period.

This stage has been described in greater detail in Ivlieva and Timofeeva (2003).

A comparison of the dynamics of learning and of neuronal activity has revealed a small decline in the proportion of neurons reactive to CS at the stage of specialization compared with the stage of generalization of CR (see Table 1). The acquisition of CR was sufficiently rapid, therefore in the period before the first instrumental movements only two neurons reactive to CS were recorded, but it should be noted that the responses of the cells were inhibitory in nature.

At different stages of learning, there was a significant redistribution of ratio of neurons with certain types of reactions (2×2 table, $\chi^2 = 9.12$, $p = .0025$). From the initial to the final stage of learning the proportion of neurons reactive to the CS onset decreased significantly, while the proportion of cells that changed activity in connection with the instrumental movement significantly increased (see Table 1, Fig. 4).

In the post-stimulus period (PSP), the proportion of neurons modifying activity as compared with the background level were equal in both stages of the conditioning. However, as in the case of the reaction to CS, the neurons redistributed in percentages of inhibitory and excitatory responses (see Table 1). The ratio of activity in the period of the CS and in the PSP also changed. In the generalization stage, no neuron was recorded with the response restricted by only the period of the CS, and at the stage of specialization of CR such neurons represent the majority of the reactive cells as shown in Table 1. That is, we can talk about the transition from the more generalized reactions to CS to the time-limited responses as the result of instrumental reflex consolidation.

Discussion and Conclusions

In the present study the activity of neurons in the ventral tegmental area (VTA) is investigated during the acquisition of avoidance conditioning in a freely moving rabbits. 48% of the neurons investigated were shown to alter their activity in response to conditioned stimulus (CS) during the experiment.

Mirenowicz and Schultz, during avoidance conditioning in macaques (Mirenowicz & Schultz, 1996), showed that only about 10% of the presumably dopaminergic neurons recorded change their discharge rate. This discrepancy with our data has at least three possible explanations: firstly, these authors used tactile and gustatory (not painful) stimuli as unconditioned stimuli; secondly, they recorded neural activity at the stage of an automated instrumental movement; and thirdly, they used a short CS and the neural activity in connection with the movement was not considered by the authors. In the present study, we also found that at the stage of specialization, the proportion of neurons reactive to the onset of CS decreased, and the proportion of neurons activated before or during of the movement increased, and thus the percentage of neurons reactive to the CS onset at the stage of specialization in our study is actually similar to that identified by Mirenowicz and Schultz (1996).

As was mentioned in the introduction, current hypotheses suggest that DA neurons signaling is associated with (1) stimuli with hedonic value (Wise & Bozarth, 1985), (2) situations when positive outcomes (rewards) are better than expected thus signaling RPE that drives learning (Schultz, 2013), (3) motivation or incentive salience (Berridge, 2007) and (4) energization of behavior (Salamone, Correa, Farrar, & Mingote, 2007).

Our results are not consistent with the hedonic hypothesis (1), since this hypothesis predicts that DA neurons' activation may be strongly associated with termination of the US as well as of CS, given that relief from shock or avoidance of shock is pleasurable. The activation of neurons in response to the CS onset, which is more pronounced at the stage of generalization when an aversiveness of stimulus is doubtless, also contradicts the hedonic hypothesis. Finally, the preferential activation of neurons before and during instrumental movement in the late stage of learning (stage of specialization) does not correspond with any pleasurable events.

According to RPE hypothesis (2), neuronal activation should be expected primarily in sessions when the first successful instrumental movements lead to the abolition of the US; that is, immediately after the turning off of the CS, which we have observed in the activity of only one neuron. This, of course, might be due to the fact that this stage is very short and a few specific cells recorded at this stage showed no expected response. However, the predominance of excitatory reactions of neurons in response to the onset of the aversive stimulus and in the period before movement execution is difficult to explain in terms of the RPE hypothesis, if we do not assume that the majority of neurons recorded are not dopaminergic.

To a greater extent, our data agree with the salience hypothesis (3): there is a preferential activation of cells in response to CS onset on the stage of generalization, as

well as a significant decrease in the proportion of these cells during the transition to the stage of specialization, when, a) the skill becomes automated, and b) the number of electric shocks is reduced, which together reduces the significance of the stimulus. However, in light of this hypothesis, the meaning of neuronal activation before the instrumental movement at the stage of specialization is not entirely clear. Nonetheless, of all experimental events the movement becomes the most significant one.

Our data are well suited to the last hypothesis (4): in the stage of specialization, a majority of reactive cells significantly changed, with most increasing their discharge rate during and sometimes before the execution of the instrumental movement. Also, in the stage of generalization, the activation responses to the CS onset were predominant which is consistent with the traditional view that effective stimuli for discharge responses of DA neurons should have a trigger or releasing function for immediate behavioral events that are important to the animal (Schultz, 1986).

This interpretation allows us to compare our results with those obtained under other behavioral paradigms where rewards instead of punishments were used. Similar to the dynamics of VTA neuronal reactivity as the consolidation of a CR are the dynamics of discharge pattern changes of a single neuron during the acquisition of delayed instrumental food reactions described by Nishino et al. (1987). They show that at the first trials in a situation with delay, the neuron responded to the presentation of the CS and to the series of motor responses, but in subsequent trials only the response that was associated with the instrumental movement remained. Sato et al. (2003) did not find significant modulation of neuronal activity in connection with appetitive instrumental movement, but unlike the behavioral task in our study, movement itself was the simplest part of the behavioral task for the animal in that experiment. After analyzing responses to the onset of stimuli initiating instrumental movements the authors suggested that the magnitude of neuronal reponse reflects the motivational properties of the CS. Applying this interpretation to our data, we can assume that if the motivational significance of the CS as a precursor of pain decreased during the avoidance acquisition, the decrease in the proportion of neurons activated in response to the onset of CS should be expected. Thus, our data confirm the assumption of Sato and colleagues.

Also of interest is an association of the neuronal response amplitude to CS onset with probability and intensity of the instrumental response (Fig. 2), which confirms the VTA involvement in the processes of sensorimotor integration (Berrige, 2007). In support of such participation is the rearrangement of general reactivity patterns in the direction from the sensory to the motor aspect during the consolidation of instrumental skills: as the instrumental movement is becoming more important than the CS, the response of neurons to CS decreases.

Of considerable interest are the data on the relationship between neuronal activity in the VTA and reinforcement in conditions of avoidance when the removal of the pain stimulus is the reward. We found great heterogeneity of neuronal responses in the period of poststimulus activity which is, on the one hand, consistent with different patterns of DA release in projection structures in aversive situations (Budygin et al., 2012, Badrinarayan et al., 2012), and on the other hand, requires assumptions about the neurochemical nature of the neurons. We note here that most of the cells inhibiting in this period (6 of 7) did not meet the criteria of DA neurons.

Data on the change of the dopamine level in the basic projection structures of the VTA during instrumental conditioning also showed maximum activity of the DA system at the moment of the instrumental movement. Studies conducted in unrestrained animals engaged in more naturalistic motivated behaviors to obtain rewards demonstrate that dopaminergic system activation precedes and accompanies the instrumental movement (Richardson & Gratton, 1996, 1998, 2008; Roitman et al., 2004; Puryear et al., 2010; Cacciapaglia et al., 2011; Wassum, Ostlund, & Maidment, 2012).

While it is well accepted that rewards and their CS elicit excitation of DA neurons, it remains a topic of discussion whether DA release plays a similar role in different aversive situations. Our data, as well as the results of a voltammetric study of Oleson et al. (2012), extend such a pattern of DA system activation on learned behaviors aimed at the reduction of harm or at punishment avoidance. Moreover, the association of decreased DA activity in aversive situations with a behavioral arrest connected with a failure to use active behavioral strategies or with a lack of behavioral control (Mileykovsky & Morales, 2011; Tye et al., 2011; Oleson et al., 2012), as well as our demonstrated dynamics of DA system activation from response to cue onset to activation before movement, suggests a crucial role of the DA system in the formation of active behavioral strategies.

References

Anstrom, K. K., Miczek, K. A., & Budygin, E. A. (2009). Increased phasic dopamine signaling in the mesolimbic pathway during social defeat in rats. *Neuroscience, 161*(1), 3–12. doi: 10.1016/j.neuroscience.2009.03.023

Anstrom, K. K. & Woodward, D. J. (2005). Restraint increases dopaminergic burst firing in awake rats. *Neuropsychopharmacology, 30*(10), 1832–1840. doi: 10.1038/sj.npp.1300730

Badrinarayan, A., Wescott, S. A., Vander Weele, C. M., Saunders, B. T., Couturier, B. E., Maren, S., & Aragona, B. J. (2012). Aversive stimuli differentially modulate real-time dopamine transmission dynamics within the nucleus accumbens core and shell. *Journal of Neuroscience, 32*(45), 15779–15790. doi: 10.1523/JNEUROSCI.355712.2012

Berridge, K. C. (2007). The debate over dopamine's role in reward: the case for incentive salience. *Psychopharmacology (Berl.), 191*, 391–431. doi: 10.1007/s00213-006-0578-x

Brischoux, F., Chakraborty, S., Brierley, D. I., & Ungless, M. A. (2009). Phasic excitation of dopamine neurons in ventral VTA by noxious stimuli. *Proceedings of the National Academy of Sciences USA, 106*(12), 4894–4899. doi: 10.1073/pnas.0811507106

Bromberg-Martin, E. S., Matsumoto, M., & Hikosaka, O. (2010). Dopamine in motivational control: rewarding, aversive, and alerting. *Neuron, 68*(5), 815–834. doi:10.1016/j.neuron.2010.11.022

Brown, M. T., Henny, P., Bolam, J. P., & Magill, P. J. (2009). Activity of neurochemically heterogeneous dopaminergic neurons in the substantia nigra during spontaneous and driven changes in brain state. *Journal of Neuroscience, 29*(9), 2915–2925. doi: 10.1523/JNEUROSCI.4423-08.2009

Budygin, E. A., Park, J., Bass, C. E., Grinevich, V. P., Bonin, K. D., & Wightman, R. M. (2012). Aversive stimulus differentially triggers subsecond dopamine release in reward regions. *Neuroscience, 201*, 331–337. doi: 10.1016/j.neuroscience.2011.10.056

Cacciapaglia, F., Wightman, R. M., & Carelli, R. M. (2011). Rapid dopamine signaling differentially modulates distinct microcircuits within the nucleus accumbens during sucrose-directed behavior. *Journal of Neuroscience, 31*, 13860–13869. doi: 10.1523/JNEUROSCI.1340-11.2011

Cohen, J. Y., Haesler, S., Vong, L., Lowell, B. B., & Uchida, N. (2012). Neuron-type-specific signals for reward and punishment in the ventral tegmental area. *Nature, 482*(7383), 85–88. doi: 10.1038/nature10754

Fifkova, E. & Marsala, J. (1960). Stereotaxic atlas for the cat, rabbit and rat. In: *Electrophysiological methods in biological research*. Prague. 426 p.

Flaherty, A.W. (2005). Frontotemporal and dopaminergic control of idea generation and creative drive. *Journal of Comparative Neurology, 493*(1), 147–153. doi: 10.1002/cne.20768

Ivlieva, N.Y. (2010). [Involvement of the mesocorticolimbic dopaminergic system in adaptive behavior]. In Russian. *Zhurnal Vysshei Nervnoi Deyatel'nosti imeni I. P. Pavlova, 60*(3), 259–278. Translation into English published as: Ivlieva, N. Yu. (2011). Involvement of the Mesocorticolimbic Dopaminergic System in Adaptive Behavior. *Journal of Neuroscience and Behavioral Physiology, 41*(7), 715–729. doi: 10.1007/s11055-011-9477-7

Ivlieva, N.Y. & Timofeeva, N. O. (2003). Neuron activity in the pedunculopontine nucleus during an operant conditioned defensive reflex. *Neuroscience and Behavioral Physiology, 33*(5), 499–506. doi: 10.1023/A:1023419418869

Joshua, M., Adler, A., Mitelman, R., Vaadia, E., & Bergman, H. (2008). Midbrain dopaminergic neurons and striatal cholinergic interneurons encode the difference between reward and aversive events at different epochs of probabilistic classical conditioning trials. *Journal of Neuroscience, 28*(45), 11673–11684. doi: 10.1523/JNEUROSCI.3839-08.2008

Lammel, S., Ion, D. I., Roeper, J., & Malenka, R. C. (2011). Projection-specific modulation of dopamine neuron synapses by aversive and rewarding stimuli. *Neuron, 70*(5), 855–862. doi: 10.1016/j.neuron.2011.03.025

Matsumoto, M. & Hikosaka, O. (2009). Two types of dopamine neuron distinctly convey positive and negative motivational signals. *Nature, 459*(7248), 837–841. doi: 10.1038/nature08028

Mileykovskiy, B. & Morales, M. (2011). Duration of inhibition of ventral tegmental area dopamine neurons encodes a level of conditioned fear. *Journal of Neuroscience, 31*(20), 7471–7476. doi: 10.1523/JNEUROSCI.5731-10.2011

Mirenowicz, J. & Schultz, W. (1996). Preferential activation of midbrain dopamine neurons by appetitive rather than aversive stimuli. *Nature, 379*, 449–451. doi: 10.1038/379449a0

Nishino, H., Ono, T., Muramoto, K., Fukuda, M., & Sasaki, K. (1987). Neuronal activity in the ventral tegmental area (VTA) during motivated bar press feeding in the monkey. *Brain Research, 413*(2), 302–313. doi: 10.1016/0006-8993(87)91021-3

Oleson, E. B., Gentry, R. N., Chioma, V. C., & Cheer, J. F. (2012). Subsecond dopamine release in the nucleus accumbens predicts conditioned punishment and its successful avoidance. *Journal of Neuroscience, 32*, 14804-14808. doi: 10.1523/JNEUROSCI.3087-12.2012

Puryear, C. B., Kim, M. J., & Mizumori, S. J. (2010). Conjunctive encoding of movement and reward by ventral tegmental area neurons in the freely navigating rodent. Behavioral Neuroscience, 124, 234–247. doi: 10.1037/a0018865

Richardson, N. R. & Gratton, A. (1996). Behavior-relevant changes in nucleus accumbens dopamine transmission elicited by food reinforcement: an electrochemical study in rat. *Journal of Neuroscience, 16*, 8160–8169.

Richardson, N. R. & Gratton, A. (1998). Changes in medial prefrontal cortical dopamine levels associated with response-contingent food-reward: an electrochemical study in rat. *Journal of Neuroscience, 18*, 9130–9138.

Richardson, N. R. & Gratton, A. (2008). Changes in nucleus accumbens dopamine transmission associated with fixed- and variable-time schedule-induced feeding. *European Journal of Neuroscience, 27*(10), 2714–2723. doi: 10.1111/j.1460-9568.2008.06236.x

Roitman, M. F., Stuber, G. D., Phillips, P. E., Wightman, R. M., & Carelli, R. M. (2004). Dopamine operates as a subsecond modulator of food seeking. Journal of Neuroscience, 24, 1265–1271. doi: 10.1523/JNEUROSCI.3823-03.2004

Rossi, M. A., Sukharnikova, T., Hayrapetyan, V. Y., Yang, L., & Yin, H. H. (2013). Operant self-stimulation of dopamine neurons in the substantia nigra. *PLoS One, 8*(6):e65799. doi: 10.1371/journal.pone.0065799

Salamone, J. D., Correa, M., Farrar, A., & Mingote, S. M. (2007). Effort-related functions of nucleus accumbens dopamine and associated forebrain circuits. *Psychopharmacology (Berl.), 191*, 461–482. doi: 10.1007/s00213-006-0668-9

Satoh, T., Nakai, S., Sato, T., & Kimura, M. (2003). Correlated coding of motivation and outcome of decision by dopamine neurons. *Journal of Neuroscience*, *23*(30), 9913–9923.

Schultz, W., Ruffieux, A., & Aebischer, P. (1983). The activity of pars compacta neurons of the monkey substantia nigra in relation to motor activation. *Experimental Brain Research, 51*, 377–387. doi: 10.1007/BF00237874

Schultz, W. (1986). Responses of midbrain dopamine neurons to behavioral trigger stimuli in the monkey. *Journal of Neurophysiology*, *56*(5), 1439–1461.

Schultz, W. (1998). Predictive reward signal of dopamine neurons. *Journal of Neurophysiology, 80*, 1–27.

Schultz, W. (2013). Updating dopamine reward signals. *Current Opinion in Neurobiology*, 23(2), 229–238. doi: 10.1016/j.conb.2012.11.012

Steinberg, E. E., Keiflin, R., Boivin, J. R., Witten, I.B., Deisseroth, K., & Janak, P. H. (2013). A causal link between prediction errors, dopamine neurons and learning. *Nature Neuroscience, 16*(7), 966–973. doi: 10.1038/nn.3413

Steinberg, E. E. & Janak, P. H. (2013). Establishing causality for dopamine in neural function and behavior with optogenetics. *Brain Research, 1511*, 46–64. doi: 10.1016/j.brainres.2012.09.036

Tsai, H. C., Zhang, F., Adamantidis, A., Stuber, G. D., Bonci, A., de Lecea, L., Deisseroth, K. (2009). Phasic firing in dopaminergic neurons is sufficient for behavioral conditioning. *Science, 324*(5930), 1080–1084. doi: 10.1126/science.1168878

Ungless, M. A., Magill, P. J., & Bolam, J. P. (2004). Uniform inhibition of dopamine neurons in the ventral tegmental area by aversive stimuli. *Science, 303*(5666), 2040–2042. doi: 10.1126/science.1093360

Ungless, M. A., & Grace, A. A. (2012). Are you or aren't you? Challenges associated with physiologically identifying dopamine neurons. *Trends in Neuroscience, 35*(7), 422–430. doi: 10.1016/j.tins.2012.02.003

Valenti, O., Gill, K. M., & Grace, A. A. (2012). Different stressors produce excitation or inhibition of mesolimbic dopamine neuron activity: response alteration by stress pre-exposure. *European Journal of Neuroscience, 35*(8), 1312–1321. doi: 10.1111/j.1460-9568.2012.08038.x

Wang, D. V. & Tsien, J. Z. (2011). Convergent processing of both positive and negative motivational signals by the VTA dopamine neuronal populations. *PLoS One, 6*(2):e17047. doi: 10.1371/journal.pone.0017047

Wassum, K. M., Ostlund, S. B., & Maidment, N. T. (2012). Phasic mesolimbic dopamine signaling precedes and predicts performance of a self-initiated action sequence task. *Biological Psychiatry, 71*, 846–854. doi: 10.1016/j.biopsych.2011.12.019

Wise, R. A. & Bozarth, M. A. (1985). Brain mechanisms of drug reward and euphoria. *Psychiatric Medicine, 3*, 445–460.

Wise, R. A. (2012). Dual roles of dopamine in food and drug seeking: The drive-reward paradox. *Biological Psychiatry, 73*(9), 819–826. doi: 10.1016/j.biopsych.2012.09.001

Активность нейронов вентральной области покрышки среднего мозга при выработке реакции активного избегания подтверждает роль дофамина в побуждении к действию

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Аннотация. Предполагается, что мезокортиколимбическая дофаминергическая система является ключевой структурой в процессах переработки информации о вознаграждении. Однако точная физиологическая роль активации этой системы остается спорной. Парадигма рефлекса избегания предполагает присутствие как негативных воздействий, так и явлений вознаграждения. Поэтому мы исследовали активность нейронов вентральной области покрышки среднего мозга свободно подвижных кроликов в процессе выработки и реализации рефлекса активного избегания. 48 % из 60 исследованных нейронов проявили реакцию в ответ на действие условного стимула (УС). Продемонстрированы преимущественно активационные ответы клеток на УС. Идентифицированы два основных типа реакций нейронов: коротколатентная реакция на включение УС и активация, связанная во времени с выполнением инструментального движения. Доли клеток, проявивших реакции такого типа, значительно различались на начальной и заключительной стадиях научения: по мере формирования рефлекса существенно снизилась доля нейронов, реагирующих на включение условного стимула и, наоборот, значительно возросла доля клеток, изменяющих активность в связи с инструментальным движением, что, по нашему мнению, говорит об участии мезокориколимбической системы в процессах побуждения к действию.

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Ключевые слова: дофамин, избегание, инструментальное научение, вознаграждение, подкрепление, нейрон, вентральная область покрышки среднего мозга.

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Ивлиева Н. Ю. Участие мезокортико-лимбической дофаминергической системы в адаптивном поведении. Журнал высшей нервной деятельности. 2010. Т. 60. № 3. С. 259–278.

Anstrom K. K., Miczek, K. A., Budygin E. A. Increased phasic dopamine signaling in the mesolimbic pathway during social defeat in rats // Neuroscience. 2009. Vol. 161. № 1. P. 3–12. doi: 10.1016/j.neuroscience.2009.03.023

Anstrom K. K., Woodward D. J. Restraint increases dopaminergic burst firing in awake rats // Neuropsychopharmacology. 2005. Vol. 30. № 10. P. 1832–1840. doi: 10.1038/sj.npp.1300730

Badrinarayan A., Wescott S. A., Vander Weele C. M., Saunders B. T., Couturier B. E., Maren S., Aragona, B. J. Aversive stimuli differentially modulate real-time dopamine transmission dynamics within the nucleus accumbens core and shell // Journal of Neuroscience. 2012. Vol. 32. № 45. P. 15779–15790. doi: 10.1523/JNEUROSCI.355712.2012

Berridge K. C. The debate over dopamine's role in reward: the case for incentive salience // Psychopharmacology (Berl.). 2007. Vol. 191. P. 391–431. doi: 10.1007/s00213-006-0578-x

Brischoux F., Chakraborty S., Brierley D. I., Ungless M. A. Phasic excitation of dopamine neurons in ventral VTA by noxious stimuli // Proceedings of the National Academy of Sciences USA. 2009. Vol. 106. № 12. P. 4894–4899. doi: 10.1073/pnas.0811507106

Bromberg-Martin E. S., Matsumoto M., Hikosaka O. Dopamine in motivational control:rewarding, aversive, and alerting // Neuron. 2010. Vol. 68. № 5. P. 815–834. doi:10.1016/j.neuron.2010.11.022

Brown M. T., Henny P., Bolam J. P., Magill P. J. Activity of neurochemically heterogeneous dopaminergic neurons in the substantia nigra during spontaneous and driven changes in brain state // Journal of Neuroscience. 2009. Vol. 29. № 9. P. 2915–2925. doi: 10.1523/JNEUROSCI.4423-08.2009

Budygin E. A., Park J., Bass C. E., Grinevich V. P., Bonin K. D., Wightman R.M. Aversive stimulus differentially triggers subsecond dopamine release in reward regions // Neuroscience. 2012. Vol. 201. P. 331–337. doi: 10.1016/j.neuroscience.2011.10.056

Cacciapaglia F., Wightman R. M., Carelli R. M. Rapid dopamine signaling differentially modulates distinct microcircuits within the nucleus accumbens during sucrose-directed behavior // Journal of Neuroscience. 2011. Vol. 31. P. 13860–13869. doi: 0.1523/JNEUROSCI.1340-11.2011

Cohen J. Y., Haesler S., Vong L., Lowell B. B., Uchida N. Neuron-type-specific signals for reward and punishment in the ventral tegmental area // Nature. 2012. Vol. 482. № 7383. P. 85–88. doi: 10.1038/nature10754

Fifkova E., Marsala J. Stereotaxic atlas for the cat, rabbit and rat // Electrophysiological methods in biological research. Prague, 1960. 426 p.

Flaherty A. W. Frontotemporal and dopaminergic control of idea generation and creative drive // Journal of Comparative Neurology. 2005. Vol. 493. № 1. P. 147–153. doi: 10.1002/cne.20768

Ivlieva N. Y., Timofeeva N. O. Neuron activity in the pedunculopontine nucleus during an operant conditioned defensive reflex // Neuroscience and Behavioral Physiology. 2003. Vol. 33. № 5. P. 499–506. doi: 10.1023/A:1023419418869

Joshua M., Adler A., Mitelman R., Vaadia E., Bergman H. Midbrain dopaminergic neurons and striatal cholinergic interneurons encode the difference between reward and aversive events at different epochs of probabilistic classical conditioning trials // Journal of Neuroscience. 2008. Vol. 28. № 45. P. 11673–11684. doi: 10.1523/JNEUROSCI.3839-08.2008

Lammel S., Ion D. I., Roeper J., Malenka R. C. Projection-specific modulation of dopamine neuron synapses by aversive and rewarding stimuli // Neuron. 2011. Vol. 70. № 5. P. 855–862. doi: 10.1016/j.neuron.2011.03.025

Matsumoto M., Hikosaka O. Two types of dopamine neuron distinctly convey positive and negative motivational signals // Nature. 2009. Vol. 459. № 7248. P. 837–841. doi: 10.1038/nature08028

Mileykovskiy B., Morales M. Duration of inhibition of ventral tegmental area dopamine neurons encodes a level of conditioned fear // Journal of Neuroscience. 2011. Vol. 31. № 20. P. 7471–7476. doi: 10.1523/JNEUROSCI.5731-10.2011

Mirenowicz J., Schultz W. Preferential activation of midbrain dopamine neurons by appetitive rather than aversive stimuli // Nature. 1996. Vol. 379. P. 449–451. doi: 10.1038/379449a0

Nishino H., Ono T., Muramoto K., Fukuda M., Sasaki K. Neuronal activity in the ventral tegmental area (VTA) during motivated bar press feeding in the monkey // Brain Research. 1987. Vol. 413. № 2. P. 302–313. doi: 10.1016/0006-8993(87)91021-3

Oleson E. B., Gentry R. N., Chioma V. C., Cheer J. F. Subsecond dopamine release in the nucleus accumbens predicts conditioned punishment and its successful avoidance // Journal of Neuroscience. 2012. Vol. 32. P. 14804–14808. doi: 10.1523/JNEUROSCI.3087-12.2012

Puryear C. B., Kim M. J., Mizumori S. J. Conjunctive encoding of movement and reward by ventral tegmental area neurons in the freely navigating rodent // Behavioral Neuroscience. 2010. Vol. 124. P. 234–247. doi: 10.1037/a0018865

Richardson N. R., Gratton A. Behavior-relevant changes in nucleus accumbens dopamine transmission elicited by food reinforcement: an electrochemical study in rat // Journal of Neuroscience. 1996. Vol. 16. P. 8160–8169.

Richardson N. R., Gratton A. Changes in medial prefrontal cortical dopamine levels associated with response-contingent food-reward: an electrochemical study in rat // Journal of Neuroscience. 1998. Vol. 18. P. 9130–9138.

Richardson N. R., Gratton A. Changes in nucleus accumbens dopamine transmission associated with fixed- and variable-time schedule-induced feeding // European Journal of Neuroscience. 2008. Vol. 27. № 10. P. 2714–2723. doi: 10.1111/j.1460-9568.2008.06236.x

Roitman M. F., Stuber G. D., Phillips P. E., Wightman R. M., Carelli R.M. Dopamine operates as a subsecond modulator of food seeking // Journal of Neuroscience. 2004. Vol. 24. P. 1265–1271. doi: 10.1523/JNEUROSCI.3823-03.2004

Rossi M. A., Sukharnikova T., Hayrapetyan V. Y., Yang L., Yin H. H. Operant self-stimulation of dopamine neurons in the substantia nigra // PLoS One. 2013. Vol. 8. № 6. P. e65799. doi: 10.1371/journal.pone.0065799

Salamone J. D., Correa M., Farrar A., Mingote S. M. (2007). Effort-related functions of nucleus accumbens dopamine and associated forebrain circuits // Psychopharmacology (Berl.). 2007. Vol. 191. P. 461–482. doi: 10.1007/s00213-006-0668-9

Satoh T., Nakai S., Sato T., Kimura M. Correlated coding of motivation and outcome of decision by dopamine neurons // Journal of Neuroscience. 2003. Vol. 23. № 30. P. 9913–9923.

Schultz W., Ruffieux A., Aebischer P. The activity of pars compacta neurons of the monkey substantia nigra in relation to motor activation // Experimental Brain Research. 1983. Vol. 51. P. 377–387. doi: 10.1007/BF00237874

Schultz W. Responses of midbrain dopamine neurons to behavioral trigger stimuli in the monkey // Journal of Neurophysiology. 1986. Vol. 56. № 5. P. 1439–1461.

Schultz W. Predictive reward signal of dopamine neurons // Journal of Neurophysiology. 1998. Vol. 80. P. 1–27.

Schultz W. Updating dopamine reward signals // Current Opinion in Neurobiology. 2013. Vol. 23 №2, P. 229–238. doi: 10.1016/j.conb.2012.11.012

Steinberg E. E., Keiflin R., Boivin J. R., Witten I. B., Deisseroth K., Janak P. H. A causal link between prediction errors, dopamine neurons and learning // Nature Neuroscience. 2013. Vol. 16. № 7. P. 966–973. doi: 10.1038/nn.3413

Steinberg E. E., Janak P. H. Establishing causality for dopamine in neural function and behavior with optogenetics // Brain Research. 2013. Vol. 1511. P. 46–64. doi: 10.1016/j.brainres.2012.09.036

Tsai H. C., Zhang F., Adamantidis A., Stuber G. D., Bonci A., de Lecea L., Deisseroth K. Phasic firing in dopaminergic neurons is sufficient for behavioral conditioning // Science. 2009. Vol. 324. № 5930. P. 1080–1084. doi: 10.1126/science.1168878

Ungless M. A., Magill P. J., Bolam J. P. Uniform inhibition of dopamine neurons in the ventral tegmental area by aversive stimuli // Science. 2004. Vol. 303. № 5666. P. 2040–2042. doi: 10.1126/science.1093360

Ungless M. A., Grace A. A. Are you or aren't you? Challenges associated with physiologically identifying dopamine neurons // Trends in Neuroscience. 2012. Vol. 35. № 7. P. 422–430. doi: 10.1016/j.tins.2012.02.003

Valenti O., Gill K. M., Grace A. A. Different stressors produce excitation or inhibition of mesolimbic dopamine neuron activity: response alteration by stress pre-exposure // European Journal of Neuroscience. 2012. Vol. 35. № 8. P. 1312–1321. doi: 10.1111/j.1460-9568.2012.08038.x

Wang D. V., Tsien J. Z. Convergent processing of both positive and negative motivational signals by the VTA dopamine neuronal populations // PLoS One. 2011. Vol. 6. № 2. P. e17047. doi: 10.1371/journal.pone.0017047

Wassum K. M., Ostlund S. B., Maidment N. T. Phasic mesolimbic dopamine signaling precedes and predicts performance of a self-initiated action sequence task // Biological Psychiatry. 2012. Vol. 71. P. 846–854. doi: 10.1016/j.biopsych.2011.12.019

Wise R. A., Bozarth M. A. Brain mechanisms of drug reward and euphoria // Psychiatric Medicine. 1985. Vol. 3. P. 445–460.

Wise R. A. Dual roles of dopamine in food and drug seeking: The drive-reward paradox // Biological Psychiatry. 2012. Vol. 73. № 9. P. 819–826. doi: 10.1016/j.biopsych.2012.09.001