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Features of Recognizing Images of Figures of Different Colors and Sizes by Children 3-4 Years Old Using a Noise Background

Tamara G. Kuznetsova
Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia
ORCID: https://orcid.org/0000-0002-0196-0519, e-mail: dr.tamara.kuznetsova@gmail.com

Maksim L. Struzhkin
Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia
ORCID: https://orcid.org/0000-0001-8846-7737, e-mail: mstruzhkin@gmail.com

Inna Y. Golubeva
Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia
ORCID: https://orcid.org/0000-0003-3698-9036, e-mail: Golubevaiu@infran.ru

The study is aimed at analyzing the training of early preschool children to recognize visual stimuli of different colors and sizes, based on a method we are developing, in an ordinary situation and with the introduction of acoustic interference, i.e., spoken noise presented through headphones. The materials of two empirical studies on a sample of 3–4-year-old children (3.5±0.43) from a kindergarten in St. Petersburg, of whom there were 13 girls and 17 boys, are presented. The study was conducted with an interval of 2 months. The findings showed that children took longer to recognize and select stimuli of different colors and made more perseverative errors, compared to recognizing and selecting stimuli of different sizes. The introduction of acoustic noise significantly impaired task success, which was particularly pronounced when identifying irritants from colored stimuli. It is suggested that difficulties in identifying colored stimuli may be due to the absence of a sensory reference marked by a word, and the acoustic noise slowed sensorimotor response.

Keywords: early preschool age; visual stimuli; color; size; errors; latent period; speech interference.

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Особенности опознавания изображений фигур разного цвета и размера детьми 3-4 лет с использованием шумового фона

Кузнецова Т.Г.
ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация
ORCID: https://orcid.org/0000-0002-0196-0519, e-mail: dr.tamara.kuznetsova@gmail.com

Стружкин М.Л.
ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация
ORCID: https://orcid.org/0000-0001-8846-7737, e-mail: mstruzhkin@gmail.com

Голубева И.Ю.
ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация
ORCID: https://orcid.org/0000-0003-3698-9036, e-mail: Golubevaiu@infran.ru

Работа направлена на анализ обучения детей раннего дошкольного возраста опознанию зрительных стимулов разного цвета и разного размера на основе разрабатываемой нами методики в обычной ситуации и при введении акустической помехи – речевого разговорного шума, подаваемого через наушники. Представлены материалы двух эмпирических исследований на выборке детей 3-4 лет (3,5±0,43) детского сада Санкт-Петербурга, из которых было 13 девочек и 17 мальчиков. Исследование проведено с интервалом в 2 месяца. Полученные данные показали, что для опознания и выбора стимулов разного цвета детям требуется больше времени, и они допускают больше персеверативных ошибок, в сравнении с опознанием и выбором стимулов разного размера. Введение акустического шума значительно ухудшило успешность выполнения задания, что особенно отчетливо проявилось при идентификации раздражителей из цветных стимулов. Высказывается предположение, что затруднения в опознании цветных стимулов могут быть обусловлены отсутствием сенсорного эталона, обозначенного словом, а акустическая помеха тормозила сенсомоторную реакцию.

Ключевые слова: ранний дошкольный возраст; зрительные стимулы; цвет; размер; ошибки; латентный период; речевые помехи.

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Introduction

The primary attributes of an object are shape, size, volume, and color. The rudiments of these concepts develop in ontogenesis as the brain matures and as the child gains experience in the process of developing the second signal system and interacting with real objects throughout the preschool years [5; 21]. Children with normal development of higher nervous activity recognize invariant visual images regardless of the modification of their parameters [1; 3; 10]. However, even children of 5-6 years old often have difficulty recognizing and selecting complex figures [14].

Children with intellectual disability, attention-deficit/hyperreactivity disorder (ADHD) face great difficulties in mastering incoming information due to unstable attention, weak inhibitory control over behavior, etc. [6; 11; 13; 16; 19], which requires cognitive training.

The development of learning technologies is associated with an increase in the number of child users of modern gadgets, when a child's incompletely formed brain has to perceive and process many competing streams of visual and auditory information, identify useful information and, comparing it with images (phenomena) stored in its long-term memory, make the right decision [17; 18; 22]. A serious problem becomes “noise pollution” leading to fatigue, decreased attention and performance.

In previous work [4; 9] it was shown that 3-4 year old children identify single-colored images of geometric figures of different sizes faster and with fewer errors compared to multicolored images of geometric figures of the same size.

At the moment we have not found any studies on the influence of acoustic noise on the perception of visual information by children of younger preschool age, which is relevant if children actively use computer training programs.

The following **task** was set: to find out how acoustic noise (spoken speech), put through headphones, affects the process of teaching 3-4 year old children to recognize visual stimuli of different colors of the same size and the same color of different sizes when working with this method.

Materials and Methods

Thirty children (13 girls and 17 boys) aged 3-4 years (3.5±0.43) with normal vision and hearing attending kindergarten No. 81 in St. Petersburg participated in the study with written parental permission. Classes were conducted in a separate room, where geometric figures of either the same size but different colors or different colors of the same size were presented sequentially on a touch screen monitor at its illumination of 475 lux, located at an arm's length of the child [4; 9].

In the first part of the study, 5 image blocks of 3 triangles of blue, red, or yellow color of different sizes (large 10*10 cm, medium 5*5 cm, and small 3*3 cm) were randomly presented each. The informative feature was the large triangle. Then five blocks of 3 equally sized (5*5 cm) images of circles, triangles, and squares of different colors were given. The informative feature was a stimulus of red color. Having recognized the image on the screen, the child touched it with a finger and “took” it to a conditional “house”.

It was preliminarily determined whether children knew the names of colors and geometric figures. The order in which the stimuli were presented did not affect the quality of learning. Learning was carried out by trial and error. The reinforcement was a smiling smiley face appearing on the monitor screen, which was accompanied by a sound signal (laughter). During one session 40 stimuli were presented to the child.

Two months later, the study was repeated with the same children, but the stimuli were presented against the background of “polyphony noise” of speakers (3 male and 3 female voices), presented through household headphones, with an average fundamental frequency of 164.7±53.5 Hz, with a temporal and spectral structure close to the speech signal (Fig. 1). The noise level corresponded to the average level of spoken speech (45 dB).

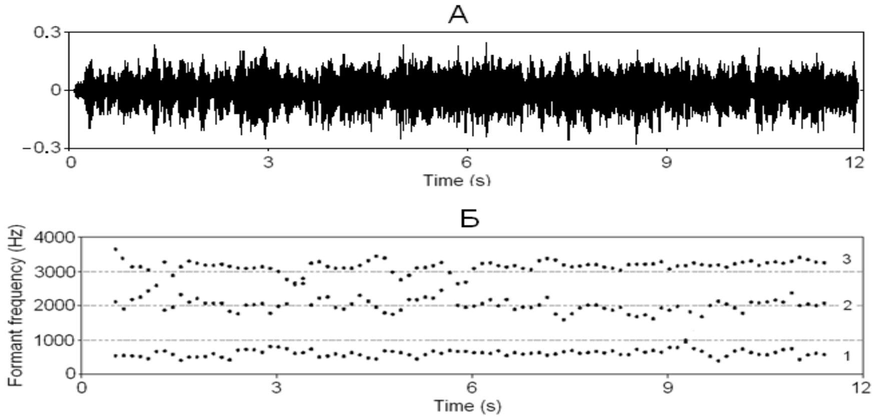

Fig. 1. Characteristics of acoustic interference - "speech noise": A - oscillogram of the signal; horizontally - time (in sec.), vertically - amplitude (in conventional units); B - dynamic spectrogram of the signal; contours of changes of three main spectral maxima (formants) throughout the signal are shown; horizontally - time (in sec.), vertically - frequency (in Hz)

The number of wrong choices (number of errors) and the latent period (LP) of the response (time from the moment the stimulus appeared on the monitor screen to the moment the child's finger touched it) were evaluated. Results were processed using two-factor analysis of variance (2-way ANOVA) for related samples.

Results

A two-factor analysis of variance (2-way ANOVA) was used to statistically analyze the obtained data (number of errors and latent response period in selecting geometric figures by 3-4 years old children) as a function of the "trait" and "noise" factors. The results are shown in Fig. 2 and 3.

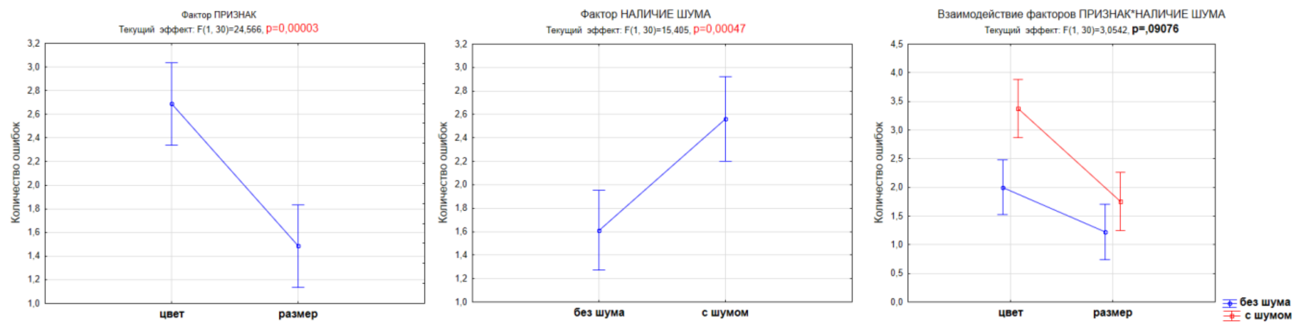

Fig. 2. Average number of errors depending on different attributes (color/size) and presence/absence of noise (vertical bars indicate 95% confidence interval)

For the number of errors, analysis of variance revealed a significant effect of the feature factor (color vs size) as well as the presence of noise factor (no noise vs with noise) on the number of training errors ($F(1,30)=24.57$, $p<0.001$; $F(1,30)=15.41$, $p<0.001$ respectively). There was no interaction of these factors ($F(1,30)=3.05$, $p=0.09$), but there was a tendency to increase the number of errors against noise when recognizing images of geometric figures of different colors of the same size compared to stimuli of figures of the same color of different sizes.

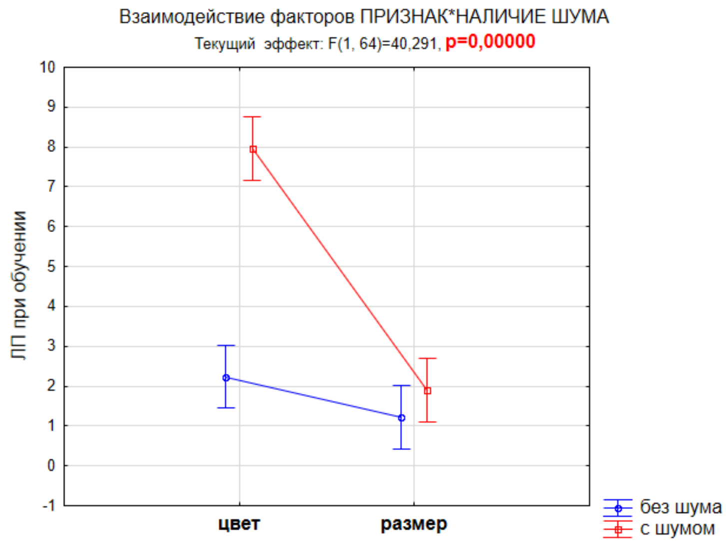

Fig. 3. Mean latent period (LP) of the response (sec.) depending on different features (color/size) and the presence/absence of noise (vertical bars indicate 95% confidence interval)

Time analysis of stimulus selection during training showed a statistically significant interaction between the factors “trait” and “noise” ($F(1,64)=40.29$, $p<0.001$). The introduction of acoustic (conversational) noise during stimulus selection for the feature “color” significantly increased LP ($p<0.001$, Tukey's post hoc test criterion), but had no effect on LP during stimulus selection for the feature “size” ($p=0.64$, Tukey's post hoc test).

Discussion

Thus, the study confirmed the results of the previous work [4], which showed that identification and selection of colored stimuli of the same size is more difficult for 3-4 years old children than selection of the same-colored stimuli of different sizes. The introduction of acoustic noise in the form of conversational speech made it even more difficult to recognize stimuli of different colors and had almost no effect on the choice of stimuli of different sizes.

The results of the two studies, from our point of view, can be explained by the fact that color recognition requires the presence of a sensory reference stored in long-term memory and a mental image denoted by a word. The presence of verbal standards reflects the maturity of the child's central nervous system. Color, unlike size and shape, is not perceived tactilely, and the formation of the image of color occurs throughout the preschool period as a result of learning [19; 20]. At the same time, red color, activating the system of emotions, reduces the selectivity of attention [12]. At the same time, due to the ontogenetic immaturity of the brain, the child's ability to concentrate and momentarily switch attention from one action or process to another is weak. The introduction of acoustic interference additionally slows it down, which can be considered the cause of perseverative errors. The obtained results are confirmed in the works of other authors [11; 21]. At the same time, a number of studies have established age differences in the development of auditory selective attention when detecting target speech signals in preschool children [2; 7; 8] and shown that “speech noise” affects the success of learning [15].

Thus, the reason for the increase in the number of errors and inhibition of the visual-motor response could be a combination of the above factors. Taking into account that the conducted work is a pilot one and is aimed at creating a game setup for training selective attention and formation of verbal images, it is supposed to continue the study with the introduction of musical noise.

Conclusions

As a result of this experiment, it was revealed that the introduction of acoustic conversational noise had a significantly greater effect on task performance when identifying different-colored geometric figures of the same size, significantly increasing the number of errors and the LP time of the motor response. However, noise had less effect when identifying and selecting geometric figures of the same color but different size, which is probably due to ontogenetic immaturity of the brain, weakness of attention switching processes, and lack of verbal images defining color.

The obtained data can be useful both for teaching younger preschoolers to recognize geometric figures and for creating optimal conditions in the group when conducting classes. The play method we are developing can be used for training the stability of attention and the formation of color sensory standards. This methodological approach, from our point of view, has great potential for a deeper interdisciplinary study of perceptual noise resistance, selectivity of attention.

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Информация об авторах

Кузнецова Тамара Георгиевна, доктор биологических наук, главный научный сотрудник лаборатории нейромодуляции двигательных и висцеральных функций, ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация, ORCID: https://orcid.org/0000-0002-0196-0519, e-mail: dr.tamara.kuznetsova@gmail.com
Стружкин Максим Леонидович, старший лаборант, лаборатория психофизиологии речи, ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация, ORCID: https://orcid.org/0000-0001-8846-7737, e-mail: mstruzhkin@gmail.com
Голубева Инна Юрьевна, кандидат биологических наук, научный сотрудник лаборатории нейромодуляции двигательных и висцеральных функций, ФГБУН «Институт физиологии им. И.П. Павлова РАН» (ФГБУН ИФ РАН), г. Санкт-Петербург, Российская Федерация, ORCID: https://orcid.org/0000-0003-3698-9036, e-mail: Golubevaiu@infran.ru

Information about the authors

Tamara G. Kuznetsova, Doctor of Sciences in Biological Sciences, Leading Researcher at the Laboratory of Neuromodulation of Motor and Visceral Functions, Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia, ORCID: https://orcid.org/0000-0002-0196-

0519, e-mail: dr.tamara.kuznetsova@gmail.com
Maxim L. Struzhkin, Senior Laboratory Assistant, Laboratory of Speech Psychophysiology, Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia, ORCID: https://orcid.org/0000-0001-8846-7737, e-mail: mstruzhkin@gmail.com
Inna Y. Golubeva, PhD in Biology, Researcher at the Laboratory of Neuromodulation of Motor and Visceral Functions, Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia, ORCID: https://orcid.org/0000-0003-3698-9036, e-mail: Golubevaiu@infran.ru

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