

ВРЪЗКА МЕЖДУ ЕЗИКОВАТА КОМПЕТЕНТНОСТ В 6-7 ГОДИШНИ ДЕЦА И ИМПЛИЦИТНОТО УСВОЯВАНЕ НА СТРУКТУРИРАНИ ПОРЕДИЦИ

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Резюме: Според имплицитно-експлицитния модел (Ullman, 2004), имплицитната памет има ключова роля за усвояването на езика, главно фонология, морфология и синтаксис, където доминират структурирани последователности. Смята се, че регулярните сензо-моторни патерни се вграждат имплицитно в езиковите функции. В рамките на тази концепция настоящето изследване оценява връзките между езиковата компетентност и индивидуалните способности за имплицитно усвояване на сензо-моторни регулярности при 6-7 годишни здрави и нормално развиващи се деца. Езиковата компетентност беше оценена чрез стандартизиран тест за фонологично осъзнаване (КТФО, Щерева, 2012). Индивидуалните способности за имплицитно обучение бяха измерени в слухова задача за серийно обучение (ЗСО) чрез представяне на структурирани и рандомизирани сензо-моторни последователности. Задачата беше тренирана имплицитно, т.е. без децата да бъдат информирани за наличието на регулярни последователности, отделно с дясна и лява ръка. Изчислен беше индекс за имплицитно усвояване на последователностите (Yordanova et al., 2015). Статистическата оценка беше проведена посредством стъпков мулти-регресионен анализ. Главните резултати показват, че (1) Съществува връзка между езиковата компетентност и индивидуалните способности за имплицитно усвояване на сензо-моторни последователности при здрави деца на 6-7 г.; (2) Тази връзка ключово се отразява от скалите за класификация на КТФО; (3) Имплицитното знание усвоено с дясна или лява ръка корелира по различен начин с езиковата компетентност, разкривайки специфични функции на лявата и дясната хемисфери при интегриране на имплицитните сензо-моторни паметни в езиковата функция. Резултатите подкрепят имплицитно-експлицитния модел за езика и предоставят нови факти за хемисферна специализация при използване на имплицитно и експлицитно знание за развитие на езика в детска възраст.

Ключови думи: езикова компетентност, имплицитно обучение, сензо-моторни регулярности, детско развитие

LANGUAGE COMPETENCE IN 6-7 YEAR-OLD CHILDREN IS ASSOCIATED WITH IMPLICIT LEARNING OF SENSORIMOTOR REGULARITIES

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Abstract: According to the implicit-explicit model of language (Ullman, 2004) implicit memory plays a critical role for language acquisition. The model focuses on phonological, morphological and syntactic aspects of language where structured patterns dominate by postulating that such regular patterns are implicitly incorporated in language functions. In the present research, the associations between language competence and individual abilities of implicit learning of sensorimotor regularities were evaluated in 6-7 year-old typically developing children with normal language function. Language competence was assessed using a standardized test for phonologic awareness (TPA, Shtereva, 2012). Individual abilities for implicit learning were evaluated in an auditory serial response time task (SRTT), in which structured and random auditory-motor sequences were presented to 16 children. Children trained the task implicitly without being informed about the presence of regular sequences. Training was performed with the right and the left hand.. An index of implicit acquisition of sequences (Yordanova et al., 2015) was computed for each training session and correlated with language competence scores using multiple regression analyses.

According to the results (1) Individual implicit learning abilities correlate with language competence in healthy children; (2) Major correlations include language abilities captured by the classification scale of the



TPA; (3) Implicit learning with the left and right hand reveal different associations with language competence indicating specific roles for the left and right hemisphere in integrating implicit sensorimotor memories in language competence. The results support the implicit-explicit model of language acquisition during development and provide original evidence for hemispheric specialization in this process.

Keywords: language competence, implicit learning, sensor-motor regularities, child development

1. Introduction

Language acquisition is a major achievement of cognitive development during childhood. Being of crucial relevance for communication, language competence has an enormous impact on all aspects of individual functioning - cognitive, social, and emotional [1]. Understanding brain mechanisms of language acquisition and, in particular, their neurophysiologic grounds, emerges as a target in neuroscience research.

According to the implicit-explicit model of language [2] implicit memory plays a critical role for language acquisition. Implicit memory is defined as a pool of automatic memory mechanisms which encode and retrieve information, with the individual remaining unaware of that something has been memorized [3-5]. Accordingly, implicit learning refers to automatic operationalized acquisition of knowledge. It has been demonstrated that structured information (patterns, sequences, regularities) is prone to being processed implicitly [5]. In contrast, explicit learning refers to the conscious comprehension of regularities and their memorizing through high-level and attentive control.

The model of Ullman [2,6] suggests that phonological, morphological and syntactic aspects of language which are dominated by structured patterns are learned to a large extent implicitly during language acquisition. It may be therefore hypothesized that the ability to acquire implicit knowledge about structured regularities in the environment would be associated with the development of language functions in children. The objective of the present study was to test the associations between language competence reflected by the level of phonological awareness and ability to learn implicitly auditory regularities in 6-7 year-old typically developing children with normal language function.

2. Method

2.1. Participants

Fourteen 6-7 year-old children (mean age 91.4 months, SD = 5.5, range 82-99 months, 6 males) were recruited from local schools in Sofia, Bulgaria. All children had normal and above scores of cognitive development as verified by Raven test scores, no working memory deficits as assessed by forward digit span test, and no attention deficits as reflected by continuous performance test results. All children were clinically healthy, had no psycho-emotional, behavioural or social problems assessed by Strengths and Difficulties Questionnaire (SDQ) for parents and teachers [7], did not receive any medication at the time of investigation, and reported no history of somatic, neurologic, or psychiatric diseases in the past. Low academic achievements, below-standard socio-demographic status, and language impairments were exclusion criteria. All children were right-handed (evaluated by the Edinburgh Handedness Inventory [8]). Informed written consent was obtained from parents and the study was approved by the Bulgarian Ministry of Education and Science.

2.2. Serial response time task

Stimuli. To evaluate implicit learning abilities, a serial response time task (SRTT) was used [9,10]. Following Yordanova, 1991 [11], two types of auditory stimuli (low tone, L, 800 Hz and high tone, H, 1200 Hz) were computer generated, filtered, amplified, and reproduced by a loudspeaker in a free-sound field. All stimuli were presented at 60 dB SPL, with a duration of 50 ms (rise/fall time 10 ms).

Task conditions. The stimuli were delivered with fixed inter-stimulus intervals of 2 s in two task conditions: (1) random, in which the L and H tones were presented randomly with



equal probability of 50% and required selective responding with the index or the middle fingers of one hand, and (2) regular, in which the two stimulus types were again equiprobable and required the same selective responses. However, in the regular condition, the two tones were presented in a structured sequence composed of six stimuli (H-H-L-H-L-L). This sequence was repeated 20 times during the regular condition (Fig. 1).

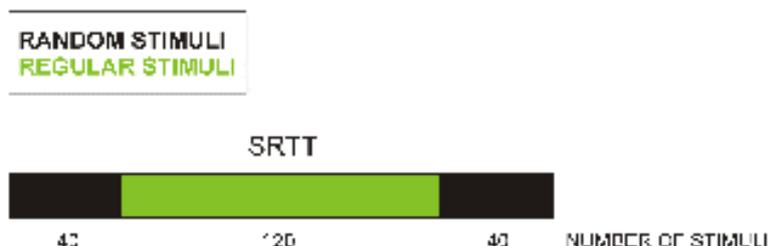


Fig. 1. Schematic presentation of block structure.

Task structure. Following Cohen et al. 2005 [12], each SRTT block consisted of three parts of 40, 120 and 40 trials, altogether 200 trials (Fig. 1). Unknown to the participants, each block was a "sandwich" where the outer trials (first 40 and last 40) followed a random series whereas the inner trials (120) repeated a fixed sequence of 6 stimuli as described above. From children's point of view, this was a choice reaction task where they had to respond by selecting the correct response to each tone type. There were short breaks between the sandwich sessions. During three consecutive days, SRTT was performed first with the right hand and then with the left hand.

2.3. Evaluation of implicit learning

Gain of implicit knowledge (ImK) was computed for each child as the difference in reaction times (RT) between the last random block and the preceding regular block in each sandwich. This subtraction represented an ImK coefficient reflecting RT speeding produced by the regularity [9,10].

2.4. Evaluation of language competence

Language competence was evaluated using the Test for Phonological awareness (TPA) validated for Bulgarian population [13]. The test comprises 18 scales grouped into 5 qualitative categories (rhyming, classification, manipulation, merging, segmenting) and one quantitative category (fast serial naming) and total scores for qualitative and quantitative categories. The test was applied by authorized experts before or after SRTT training.

2.5. Statistical analysis

To explore the association between language competence and abilities of implicit regularity learning, multiple step-wise regression analysis was employed where ImK coefficients were the dependent variables and the scores of each scale of the TPA were independent predictors. As additional predictors age and gender were included. The gain of awareness about the regularity also was included in the model to control for the possible contribution of explicit sequence comprehension to speeded reactions in regular blocks. To reflect overall implicit learning abilities, ImK coefficients were averaged across the three training days, separately for the right-hand and left-hand conditions.

3. Results

Gain of ImK in auditory right-hand condition was predicted by the total score of the Fast Serial Naming (FSN) scale ($F(1/13) = 20.3$, $p = 0.001$; $R = 0.793$): FSN was associated with enhanced implicit learning ($B = -1.23$, $Beta = -0.793$, $t = -4.5$, $p = 0.001$). The gain of ImK about auditory regularities associated with left-hand responses was predicted by the qualitative Classification scale of TPA ($F(1/13) = 5.72$, $p = 0.034$, $R = 0.569$), with high classification



achievement linked to enhanced implicit learning ($B = 110.0$, $\text{Beta} = 0.569$, $t = 2.4$, $p = 0.03$) – Fig. 2.

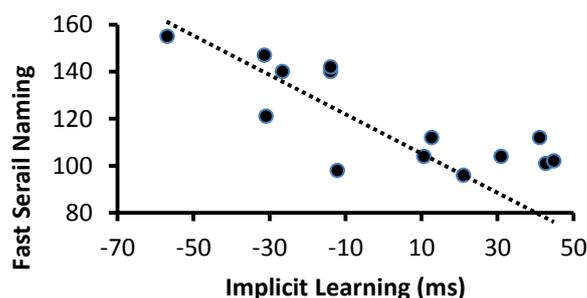


Fig. 2. Relationship between fast serial naming and the coefficient of implicit learning for the right hand condition.

4. Discussion

According to the results, (1) Individual implicit learning abilities correlate with language competence in phonological awareness in healthy 6-7 year-old children; (2) Implicit learning with the left and right hand reveal different associations with language competence indicating specific roles for the left and right hemisphere in integrating implicit sensorimotor memories in language competence. The results support the implicit-explicit model of language acquisition during development [6] and provide original evidence for hemispheric specialization in this process.

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