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FACE RECOGNITION PECULIARITIES OF DIFFERENT AGE PEOPLE IN A LITHUANIAN SAMPLE

Albina Saikauskienė[1], Aušra Daugirdienė
Lithuanian University of Educational Sciences

Abstract. ***Background.*** The paper presents empirical data and analyses biological and psychological face recognition aspects. The function of face recognition is particularly important in the process of social interaction. Despite the experience acquired in everyday face recognition, the ability to recognize faces weakens with aging. The issue of face recognition is not completely new on a worldwide scale, however, researchers present conflicting results and raise new questions about this phenomenon. What is more, in Lithuania, research on face recognition is developed not enough. It motivated us to initiate this study as well as data from researches carried out in other countries that found cultural differences in the processing of facial information (Blais et al., 2008). For example, adults from China showed a disposition to process information holistically, whereas individuals from Britain – to process information analytically (Kelly et al., 2011).

Purpose. The aims of the research were: 1) to determine at what age people recognize faces best and when this ability starts worsening; 2) to determine the differences in face recognition ability among different age groups.

Method. The experiment was carried out. The methodology of the research was based on the similar type of research (Germine, Duchaine, Nakayama, 2011; Hay, Cox, 2000; Tanaka, Farah, 1993). 80 black-and-white photographs depicting people of different ages were presented to the research participants for recognition.

Results and conclusions. The research results revealed that the ability to recognize faces reaches its optimal level in the interval of 20–35 years of age. The comparison between different age groups showed that young adults (20–35 years old) better than adolescents (11–18 years old) and senior adults (56–75 years old) memorized and recognized faces of different age people they had already seen.

Key words: face recognition, upright faces, inverted faces.

[1] Address for correspondence: Lithuanian University of Educational Sciences, Faculty of Education, Department of Psychology Didactics. Studentų 39, LT-08106 Vilnius. Phone: (85)273 08 95. E-mail: albina.saikauskiene@leu.lt.

INTRODUCTION

Face recognition is very important in the process of social interaction, therefore, the issues of development, improvement and weakening of face recognition function remain in the spotlight of various researchers around the world.

In everyday life, we do not analyse how the processing of face information goes on, what mechanisms are involved in face perception and recognition processes. Researchers studying face recognition peculiarities suggest different models to explain face perception and recognition.

Theoretical models of face perception and recognition. One of the most known is the cognitive face processing model proposed by Bruce and Young (1986), it analyses face recognition and recall of the knowledge one already has about the person. According to Bruce and Young, there are seven different kinds of information or codes that faces once seen provide: pictorial, structural, visually derived semantic, identity-specific semantic, name, expression, and facial speech codes. These components are not of equal significance in the process of face recognition. While recognizing faces in everyday life, people more frequently rely on structural, identity-specific semantic and visually derived semantic information.

Theoretical model suggested by Bruce and Young is a synthesis of several ideas and is regarded as the product of its time. Later on, cognitive psychology concentrated on the information processing operations presented in this model that are stable and common to all individuals, except for the cases when brain areas responsible for these operations are damaged (Young, Bruce, 2011).

Haxby, Hoffman, and Gobbini (2000) suggested an expanded face recognition model: a model of the distributed human neural system for face perception, revealing different representations of invariant and changeable aspects of the face (eye gaze, facial expression, lip movement) in human neural system. Invariant face aspects facilitate face recognition, whereas changeable aspects provide information necessary for social communication. Based on this model, face cognition system is divided into two parts: the core system, in which visual analysis of the face appearance is carried out, and the extended system related to the identification of additional information in faces.

Latter, Gobbini and Haxby (2007) modified and extended the aforementioned model by including additional areas of neural system that encode different aspects of information about the person, and structures that reflect emotional reactions arising with regard to how close acquainted the person is. The inclusion of additional structures into the extended face perception model allows for its wider application. For example, it can be used when studying neural puberty of adolescents when they begin to look for new social-emotional components in the faces of their peers due to the specific developmental challenges that arise (Scherf, Behrmann, Dahl, 2012).

The integrative model of face processing (Schwaninger, Carbon, Leder, 2003) combines different hypotheses about face recognition abilities of adults and is devised on the basis of holistic, schema, and component configural approaches. According to holistic approach, adults process upright faces as an inseparable unit (Farah, Tanaka, Drain, 1995; Tanaka, Farah, 1993), combining face components and configural information into a holistic representation (Tanaka, Sengco, 1997). According to component configural approach, component and configural information is processed separately. Information of both kinds is used in the recognition of upright faces, however, it is not proved that configural information is used in the cases of inverted face recognition. It is believed that by changing the position of a face, the processing of configural information declines more than the processing of component information (Sergent, 1984; Searcy, Bartlett, 1996). According to schema hypothesis (Goldstein, Chance, 1980), the ability to process face information (i.e. face schema) improves due to the acquired experience and flexibility.

The integrative model of face processing (Schwaninger, Carbon, Leader, 2003) serves as a theoretical background for the current study, because it is a comprehensive theory that comprises different hypotheses about face recognition abilities.

Changes in the face recognition ability. It is a recognized fact that adults have a well-developed ability to recognize faces, however, it is not completely clear what this ability depends on. A range of sometimes conflicting evidence and evaluations is presented as the contribution to experience or heredity to the human system of face recognition.

McKone et al. (2012) revealed the change in the attitudes that prevailed for several decades: traditionally face recognition ability was

viewed as the result of rich experience in infancy, childhood and adolescence, reaching adult-like levels relatively late in life. At the end of the 20th century, there dominated a variant of the late maturity approach, according to which, special face perception mechanisms do not fully qualitatively develop up to the age of ten, and face recognition experience is the driving force of this slow development (Carey, Diamond, 1977, 1994). Later this approach was modified and complemented by claims about the longer development of the ability to perceive certain aspects of face, especially when it comes to configural face information processing. For example, it is easier for children to recognize faces according to separate facial features than according to the overall image of a face. This indicates that configural information processing is more complex and develops more slowly than featural face processing (Hay, Cox, 2000; Mondloch, Le Grand, Maurer, 2002). Besides, the development of configural face information processing depends on child's early visual experience (Mondloch, Le Grand, Maurer, 2002). According to the research (McKone, Crookes, Kanwisher, 2009; McKone et al., 2012), the role of experience in the development of face recognition mechanisms has been overestimated. In order to achieve face recognition level that of an adult, the first five years of experience are mostly important for a child. It is likely that the effect of experience is stronger in the early period of development than later in life. Besides, genetic factors are also significant for the development of face recognition ability. Twin studies have shown that individual differences in face recognition have a heritable genetic component for the holistic processing of facial information (Wilmer et al., 2010; Zhu et al., 2010) as well as for the ways cortex reacts to faces: cortical response to faces in monozygotic twins is significantly more similar than that in dizygotic twins (Polk et al., 2007).

Considerable controversy arises when debating on the issue of the age at which people recognize faces the best. Germine, Duchaine, and Nakayama (2011) presented evidence that face recognition matures late relative to other abilities: face learning improves rapidly in adolescence (from 10 to 20 years of age) and reaches its peak around the age of 32. Later on, the face recognition ability begins to decline and at the age of 65 reaches the level acquired in adolescence (16 years of age). McKone et al. (2012) treated with caution those reports about the late maturity of the memory for faces. They argued that if the general cognitive functions

do not change after 20–32 years of age, it can be assumed that face recognition development is induced by experience.

Some researchers (Chung, Thomson, 1995; de Heering, Rossion, Maurer, 2012; Flin 1985; Lawrence et al., 2008; Mondloch, Maurer, Ahola, 2006; Schwarzer et al., 2010) presented research results indicating a rather early maturity of face recognition ability. Chung and Thomson (1995); Flin (1985); Lawrence et al. (2008) pointed out the weakening in face recognition ability in early adolescence (11–12 years old). It is hypothesized that hormonal changes during adolescence could affect the activity of brain structures involved in face recognition process. On the other hand, brain of children under 12 years is not asymmetric for face processing that is typical of adults. At this period, until the right-brain hemisphere advantage occurs for facial information processing (at the onset of adolescence), the ability to recognize faces weakens temporarily (Ellis, 1990).

The ability to recognize faces depends on various cognitive functions (memory, attention) as well as the choice of appropriate strategy. de Heering, Rossion, and Maurer (2012) claimed that both general cognitive mechanisms and specialised face recognition mechanisms contribute to the recognition of the upright faces. However, the speed of face recognition did not reveal any developmental changes specific to upright faces. Adults more rapidly than children recognize both upright and inverted faces. This can be attributed to the overall development of cognitive functions that manifests as the ability to choose deliberate strategies, concentrate on the completion of the task, avoid distractors, concentrate on minor stimuli as well as make rational decision (McKone et al., 2012).

On the one hand, age-dependent information processing strategies can reflect the level of maturity of the corresponding neural structures, on the other hand, advanced encoding strategies are possible only in the presence of appropriate maturity of neural structures (Chung, Thomson, 1995).

Specific changes in face recognition can be observed in adolescence: social refocusing on peers, tasks posed by this age are being solved (formation of friendships, establishment of romantic relationships). These tasks motivate to search for the new social-emotional components in faces, in other words, the existing face processing system undergoes

inner reorganisation. It is likely that this causes a short-term disturbance in the ability to recognize faces (Scherf, Behrmann, Dahl, 2012).

Face recognition, as other cognitive functions, is susceptible to negative aging-related changes. Face recognition quality depends a lot on a person's age, length of education, state of cognitive functions as well as vision acuity (Lott et al., 2005).

In the process of face recognition, a special role is performed by the ability to codify configural information. It has been observed that in the natural aging process the sensitivity to this type of information is slowly declining and holistic face processing, which has been improving since childhood until the age of a young adult, begins to decline (Schwarzer et al., 2010). This is revealed by the different manifestations of the so-called face inversion effect in the recognition of inverted faces between young and elderly people. Due to the face inversion, the processing of configural information gets worse and facial features are not readily perceived as interrelated elements. The elderly experience a weaker effect of inverted faces because of the decreasing sensitivity to configural information (Gao et al., 2009; Murray, Halberstadt, Ruffman, 2010).

It cannot be unequivocally stated that face recognition is declining with age in all cases. The outcomes of this process can depend on face recognition procedure (Bartlett, Leslie, 1986), different requirements posed by the task (Schwarzer et al., 2010), application of different strategies for facial information analysis (Firestone, Turk-Browne, Ryan, 2007).

Based on the reviewed studies, the following research hypotheses are put forward:

1. The ability to recognize faces reaches its optimal level around the age of 30.

2. Adolescents and young adults better memorize and easier recognize previously encountered both upright and inverted faces comparing to older people.

METHOD

Participants of the research. 93 subjects participated in the experiment (41 men, 52 women), they were divided into four age groups: 24 adolescents (11–18 years), 22 young adults (20–35 years), 24 middle-aged adults (36–55 years) and 23 senior adults (56–75 years). The difference

in the number of men and women who formed the groups was not significant (from 1 to 3 persons). Participants were initially selected using convenience sampling procedure and then divided into four age groups. Groups were formed in reference to the age group divisions presented by Крайг and Бокум (2007) with particular emphasis on the poorly investigated age period between 36 to 55 years.

The adult groups consisted of people with different educational background: 36 had university education, 5 – college education, and 28 – secondary education.

Materials and procedure. Black-and-white photographs of adolescents, adult men and women with neutral facial expressions were used for recognition. Participants were presented with 80 black-and-white photographs of the same size (10 x 12,5 cm) on the computer screen: 40 images in the upright position and 40 inverted (upside down) ones. There were only a face and neck discernible on the dark grey background panel (pantone Cool Gray 10EC), the hair and ears were masked. All models were photographed from a one meter distance using Panasonic DMC – TZ5 camera (optical zoom – 10x, focal length (width) – 28 mm, digital zoom – 4x, LCD display – 3 inches). The pictures were used in the research only with the agreement of the photographed people.

Researcher interacted with each participant individually. Participants were interviewed in their own homes, in a separate room where only the researcher and the participant were present. At the beginning, participants received a written instruction and were additionally informed about the course of the research orally.

The research was carried out in two stages consisting of two parts: introductory and the main.

In the introductory part of the first stage of the research, participants were presented with 20 photographs with the images of upright faces of different age adolescent, adult men and women faces. Participants had to memorize the presented faces. Faces on the screen were presented separately, one by one, each face being displayed for 5 seconds with the interval of 3 seconds between each photograph. Duration of the presentation of pictures was the same in the introductory and in the main parts, in both stages of the research.

The main part of the first stage of research proceeded after a 5 minute break. During it, participants were shown 40 pictures: 20 of which

they had already seen in the introductory part, and other 20 were new for them. All of the pictures were displayed one by one in a random order. Participants were asked to tell which faces they had already seen, i.e. which faces were familiar for them, and which faces they saw for the first time. Responses were recorded by the researcher in the protocol.

After a ten minute break, the second stage of the research followed in the same order as the first stage. The difference was that the participants were presented with the images of inverted faces. Those stimuli faces that were presented in the main part of the first stage as the new ones were given to memorize at this stage of the research (in the introductory stage). The faces displayed in the introductory part of the first research stage, in this case, were presented in the main part together with the memorized faces. The task for participants in the introductory part of this research stage was to memorize 20 inverted faces and to tell in the main part (40 pictures) which face they had seen before and which they had not.

During the research, the precision in which the participants of different age groups recognized already seen faces was recorded. Photographs of the faces of different age adolescents, men and women were presented for recognition. Faces were shown in two positions: vertical/upright and turned upside down/inverted. The participants' responses were codified as follows: "1" for correct answer (the participants indicated correctly which face they had already seen before and which had not), "0" for incorrect answer. The overall duration of the experiment including breaks was about 40 minutes.

Calculation of the research data. The distribution of variable estimates in groups is close to normal, therefore, one way ANOVA was applied for the comparison of means of four independent samples. For the comparison of means of two dependent samples (recognition of upright and inverted faces), paired t test was used.

RESULTS

The comparison of the results between different age groups.

To compare mean estimates of the four age groups, one way ANOVA was used. The descriptive face recognition statistics is presented in Table 1.

Table 1. *The descriptive statistics of face recognition (mean, standard deviation, minimum and maximum values)*

Stimuli faces (photographs)	Groups of participants*	N	M	SD	MIN	MAX
The upright position of faces	1	24	29,54	3,161	24	36
	2	22	32,91	3,264	25	37
	3	24	30,83	2,776	26	36
	4	23	27,91	3,161	23	35
	Overall:	93	30,27	3,539	23	37
The inverted position of faces	1	24	25,58	2,448	21	30
	2	22	27,50	3,112	22	37
	3	24	25,21	3,611	19	32
	4	23	22,61	3,085	18	28
	Overall:	93	25,20	3,497	18	37

Note: * 1 – adolescents; 2 – young adults; 3 – middle-aged adults; 4 – senior adults; N – number of participants; M – mean, SD – standard deviation, MIN – minimum value; MAX – maximum value.

Table 2. *The comparison of mean estimates of face recognition between different age groups*

Stimuli faces (photographs)	Groups of participants	Mean difference	p
The upright position of faces	Adolescents / Young adults	**–3,367**	**0,002**
	Adolescents / Middle-aged adults	–1,291	0,474
	Adolescents / Senior adults	1,628	0,278
	Young adults / Middle-aged adults	2,075	0,112
	Young adults / Senior adults	**4,996**	**0,000**
	Middle-aged adults / Senior adults	**2,920**	**0,009**
The inverted position of faces	Adolescents / Young adults	–1,916	0,161
	Adolescents / Middle-aged adults	0,375	0,975
	Adolescents / Senior adults	**2,974**	**0,008**
	Young adults / Middle-aged adults	2,291	0,065
	Young adults / Senior adults	**4,891**	**0,000**
	Middle-aged adults / Senior adults	**2,599**	**0,025**

Note: p value for significant difference between groups was < 0,05.

The comparison of mean estimates of face recognition between groups based on Tukey HSD criterion (Table 2) revealed that young adults recognized upright faces significantly more accurately compared to adolescents and senior adults. Statistically significant differences can be also observed between middle-aged and senior adults. It was found that the results of senior adults' ability to recognize inverted faces were significantly worse than those of other age groups.

The comparison of face recognition results between different age groups (Table 3) shows that the age differences determine data distribution of 26,2% ($\eta^2 = 0{,}262$) of upright face and 24,4% ($\eta^2 = 0{,}244$) of inverted face recognition. The remaining differences in the face recognition could be attributed to individual traits of participants (for example, educational background, the state of cognitive functions, experience).

Table 3. *The comparison of face recognition between different age groups*

Stimuli faces (photographs)	Description of comparisons		df	Mean square	F	p	η^2 *
The upright position of faces	Between age groups	301,344	3	100,448	10,506	0,000	0,262
	Within the group	850,936	89	9,561			
	The whole sample	1152,280	92				
The inverted p osition of faces	Between age groups	274,348	3	91,449	9,567	0,000	0,244
	Within the group	850,770	89	9,559			
	The whole sample	1125,118	92				

Note: * η^2 – variable dependency ratio; p value for significant difference between groups was < 0,05

The results show (Figure 1) that face recognition reaches its highest level at the age of a young adult and then begins to decline gradually.

The results of the present research indicate that young adults, in comparison to other age groups, best of all recognise faces in both positions (vertical and inverted), however, statistically significant differences can be observed in the recognition of upright and inverted faces with regard to the age of the faces presented as stimuli. Significant differences were found in other groups as well (Table 4).

Based on the presented data (paired t-test was applied), statistically significant differences can be noticed in the accuracy of upright and inverted faces' recognition in almost all age groups. No significant differences were found in the adolescent and young adult groups for recognizing faces of the elderly people.

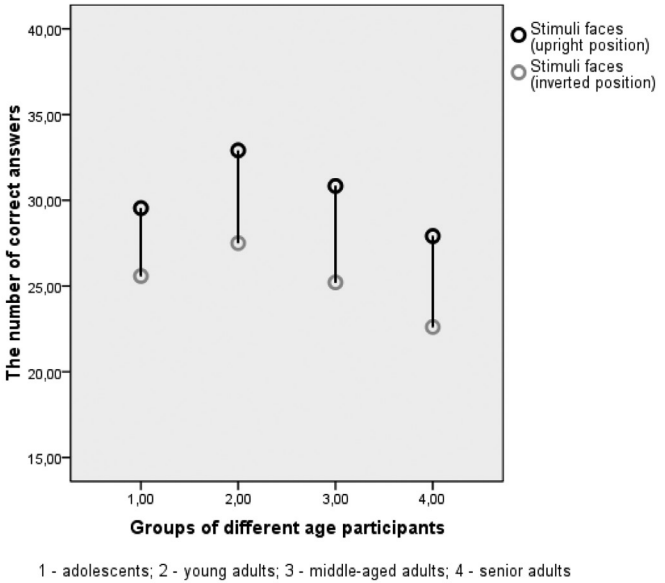

Figure 1. *Differences in face recognition in different age groups*

Table 4. *Upright and inverted face recognition in separate age groups*

Stimuli faces (photographs)	Groups of participants*	N	Mean (upright / inverted faces)	t	p
Adolescents	1	24	**8,33 / 6,83**	**4,628**	**0,000**
	2	22	**8,55 / 6,91**	**4,739**	**0,000**
	3	24	**8,13 / 6,71**	**5,146**	**0,000**
	4	23	**7,74 / 5,96**	**6,512**	**0,000**
Young adults	1	24	**7,00 / 6,25**	**2,642**	**0,015**
	2	22	**8,36 / 7,36**	**2,730**	**0,013**
	3	24	**7,38 / 6,17**	**3,550**	**0,002**
	4	23	**6,52 / 5,17**	**3,875**	**0,001**
Middle-aged adults	1	24	**6,67 / 5,42**	**3,315**	**0,003**
	2	22	**8,18 / 6,09**	**8,521**	**0,000**
	3	24	**8,21 / 6,00**	**6,033**	**0,000**
	4	23	**6,57 / 5,43**	**4,930**	**0,000**
Senior adults	1	24	7,54 / 7,08	1,306	0,204
	2	22	7,82 / 7,14	1,850	0,078
	3	24	**7,13 / 6,33**	**2,363**	**0,027**
	4	23	**7,09 / 6,04**	**4,521**	**0,000**

Note: * 1 – adolescents; 2 – young adults; 3 – middle-aged adults; 4 – senior adults; N – number of participants; p value for significant difference between groups was < 0,05

DISCUSSION

The aim of the research was to assess the difference in human ability to recognize faces in different age periods: from adolescence (11 years old) to an old age (75 years old). The analysis of the results showed that age related face recognition differences are reflected across different age groups. It has been observed that young adults (20–35 years) recognize faces best of all, followed by middle-aged adults (36–55 years), adolescents (11–18 years) and senior adults (56–75 years) (Figure 1). These results confirm that face recognition improves in adolescence, reaches its highest level at the age of a young adult, then begins to decline, and in old age reaches lower level than in adolescence.

Differences in face recognition between different age groups. The analysis of the research results revealed differences that exist across all age groups (Table 2). Most frequently statistically significant differences were found between young and senior adults as well as young adults and adolescents. Such results can be explained by the fact that there is an intense development in face recognition ability in adolescence (Carey, Diamond, 1994; Lawrence et al., 2008; Mondloch, Maurer, Ahola, 2006; Scherf, Behrmann, Dahl, 2012) which, however, does not match to the adults' ability to recognize faces. In the senior age group, especially after the age of 70, the ability to recognize faces weakens markedly (Bartlett, Leslie, 1986), whereas in the group of young adults, the ability to recognize faces reaches its peak (Germine, Duchaine, Nakayama, 2011).

Compared with other age groups, less significant differences were found between young and middle-aged adults. It can be claimed that in the middle-aged group no significant decline in face recognition exists. Middle-aged participants better than older ones recognized upright and inverted faces, although differences were not significant in all cases.

Few statistically significant differences in face recognition were found between adolescents and middle-aged adults as well as between adolescents and senior adults. The possible explanation for this phenomenon is that face recognition improves in adolescence and frequently coincides with middle-aged adults' level that has already begun to decline. A similar explanation could be given with regard to senior adults: people older than 70 keep the same face recognition level as

in the period of early adolescence, only later more pronounced differences begin to appear.

The research results show that young adults, in comparison to other age groups, better recognize upright and inverted faces. Nevertheless, for this age group, as for other participants, statistically significant differences were found in recognition of upright and inverted faces (Table 4). Significant differences were not observed only in adolescent and young adult groups for recognizing faces of elderly people. The inverted faces are not recognized as well because of the following reasons: face inversion worsens processing of the configural information (Gao et al., 2009; Murray, Halberstadt, Ruffman, 2010; Searcy, Bartlett, 1996; Sergent, 1984), people have greater experience in observaing upright more than inverted faces (Germine, Duchaine, Nakayama, 2011; Schwaninger, Carbon, Leder, 2003).

The task of inverted face recognition was included in the research aiming to find how participants of different age process facial information: rely more frequently on configural information or facial features. The comparison of face recognition results between groups showed that senior adults demonstrated the worst results when recognizing inverted faces. Statistically significant differences were found when comparing results of this age group and other groups. It is in line with the data found in academic literature, according to which, senior people are affected to a lesser extent by the inverted face effect because of the decreasing sensitivity to configural facial information (Gao et al., 2009; Schwarzer et al., 2010).

The analysis of the research data highlighted a number of limitations of the research:

1. The break (of 10 minutes) between research stages was too short. It was noted that towards the end of the research, several elderly participants had difficulty concentrating on task accomplishment. It is likely that the memory and attention load required from the participants during 40-minute research causes fatigue in older participants.

2. The fact that the same faces were used as stimuli in both stages of the research just changing their purpose – stimuli faces shown as new in the first stage of the research (the upright position of faces) were presented for memorizing in the second stage – was the limitation as well.

During the research, three participants hesitated about the position they saw one face in; however, while actually recognizing a face, only one participant made a mistake that is why this could not have affected research results significantly.

CONCLUSIONS

1. The ability to recognize upright and inverted faces is the best at the age of a young adult.

2. Adolescents, young adults and middle-aged adults better memorize and easier recognize the faces they had already seen compared to senior adults:

2.1. Young adults better than adolescents and senior adults memorize and recognize upright faces;

2.2. Middle-aged adults better than senior adults memorize and recognize upright faces;

2.3. Young adults, middle-aged adults and adolescents better than senior adults memorize and recognize inverted faces.

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SKIRTINGO AMŽIAUS ŽMONIŲ VEIDŲ ATPAŽINIMO YPATUMAI LIETUVOS POPULIACIJOJE

Albina Saikauskienė, Aušra Daugirdienė
Lietuvos Edukologijos universitetas, Lietuva

Santrauka. ***Problema*****.** Veidų atpažinimo funkcija socialinės sąveikos procese ypač svarbi. Nepaisant kasdien įgyjamos patirties, pastebimas senyvo amžiaus žmonių gebėjimo atpažinti veidus silpnėjimas. Pasaulyje veidų atpažinimo tema nėra visiškai nauja, tačiau tyrėjai pateikia prieštaringus rezultatus ir iškelia papildomus klausimus. ***Tikslas*****.** Tyrimu siekiama nustatyti, kokiame amžiuje žmonės geriausiai atpažįsta veidus, atskleisti šio gebėjimo silpnėjimo pradžią, nustatyti gebėjimo atpažinti veidus skirtumus tarp įvairaus amžiaus žmonių grupių. ***Metodika*****.** Tyrime naudotas eksperimento metodas. Tyrimo metodika parengta atsižvelgiant į panašaus pobūdžio tyrimus (Germine et al., 2011, Hay, Cox, 2000, Tanaka, Farah, 1993). Tiriamiesiems buvo pateikta 80 nespalvotų skirtingo amžiaus žmonių nuotraukų, kurias jie turėjo atpažinti. ***Rezultatai ir išvados*****.** Tyrimo rezultatai atskleidė, kad gebėjimas atpažinti veidus optimalus pasiekus jauno suaugusiojo amžių (20–35 m.). Palyginus skirtingas amžiaus grupes paaiškėjo, kad jauni suaugusieji (20–35 m.) anksčiau matytus įvairaus amžiaus žmonių veidus įsimena ir atpažįsta geriau nei paaugliai (11–18 m.) ir vyresnio amžiaus asmenys (56–75 m.).

Pagrindiniai žodžiai: veidų atpažinimas, vertikalioje padėtyje esančių veidų atpažinimas, apverstų veidų atpažinimas.

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