Mobile device-based childhood vision screening for detecting binocular vision disorders

PhD thesis

Zsófia Csizek MD

Supervisors:

Gábor Jandó MD, PhD

Eszter Mikó-Baráth MD, PhD

Program director: Prof. Zoltán Karádi MD, PhD, DSc

Doctoral School Director: Prof. Dóra Reglődi MD, PhD, DSc

University of Pécs, Medical School

Department of Physiology

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1. Introduction

Among pediatric ophthalmic disorders, amblyopia (lazy eye) holds significant importance as it is a disorder of early binocular vision development and can lead to irreversible monocular vision loss and unilateral blindness.

One of the main focuses of our research group is studying the basic physiological mechanisms of stereopsis development and its disorders, particularly early detection of amblyopia and the most common pathological conditions leading to it, such as strabismus, high hyperopia, and anisometropia in preschool and early school-aged children. In our work, we are developing a cost-effective, quick-to-perform stereotest (EuvisionTab®), which enables screening without requiring highly trained examiners and can reduce the prevalence of amblyopia.

The EuvisionTab stereopsis testing module is a digital stereotest that can be used on a mobile device with numerous freely adjustable test parameters, allowing us to create the most effective screening tests through artificial intelligence. The system can be continuously improved thanks to its IT background, with various parameters being modifiable at any time.

The application of artificial intelligence (AI) is increasingly gaining ground in various fields of medicine. By using appropriate methods and strict statistical evaluation of results, the application of AI and various mobile applications can contribute to improving the quality

of patient care, appropriately shaping different examination situations, screening protocols, and achieving more accurate results.

In my doctoral thesis, I intend to present the EuvisionTab stereopsis testing module with our results so far, comparing its effectiveness with already known international stereotests.

2. Methods

Different methods exist for testing stereopsis appropriate for various age groups. In preschool and older children, we primarily use psychophysical methods.

The traditional stereotests widely used in clinical practice worldwide include Lang I, II, TNO, Stereo Fly, and Frisby stereotests, with the Lang tests being the most well-known in Hungary.

The EuvisionTab stereotest (ETS) developed by our research group is an innovative method based on a mobile device for testing stereopsis and is also suitable for amblyopia screening. As a digital system, it has numerous modifiable parameters, such as dynamics, density, and visual noise, allowing the creation of tests of varying difficulty, thereby detecting different degrees of stereopsis disorders. Detailed stereotests will be discussed in the examination methods section.

3. Objectives

The main aim of our current research is to determine the sensitivity and specificity of the EuvisionTab stereopsis testing module for amblyopia and its leading causes, known as amblyogenic risk factors, and to compare it with known stereotests:

1.) Comparison of the effectiveness of static and dynamic ETS.
2.) Examination of the effectiveness of ETS with different densities (point density) and uncorrelated noise.
3.) Comparison of the diagnostic effectiveness of ETS with other currently used clinical stereotests: Lang II, TNO, Stereo Fly, and Frisby.
4.) Examination of the diagnostic effectiveness of each test beyond amblyopia for specific amblyogenic risk factors (anisometropia, strabismus, hypermetropia).
5.) Comparison of the usability of ETS with and without refractive correction.
6.) Enhancing the efficiency of ETS using artificial intelligence.

4. Examinations

4.1 Study design

In our cross-sectional study, we compared the results of the ETS with those of stereotests accepted by ophthalmologists in clinical practice. The goal was to identify the best stereotest for detecting amblyopia and amblyogenic conditions by considering the maximum specificity

and sensitivity through artificial intelligence using a combination of four classic tests and four new random dot stereogram tests (ETS).

The primary endpoints were sensitivity, specificity, and the area under the receiver operating characteristic (ROC) curve (AUC). Sensitivity was considered the most important metric, as delayed detection of amblyopia reduces the chances of fully developing visual functions.

4.2 Study participants

The examinations took place at the Vithas Medimar International Hospital in Alicante, Spain, and the Ophthalmology Clinic of the University of Pécs. A total of 194 control participants aged 3.8 to 14 years (mean age: 7.05 years, SD: 2.53) were emmetropic children without ophthalmic or neurological conditions and participated in age-appropriate ophthalmic examinations at the mentioned institutions. The study group (n = 229, 3.6-14 years, mean age: 7.45 SD: 2.72) included children with amblyopia or any type of strabismus or refractive error. The diagnosis of eye diseases was based on international guidelines and literature. The classification of children by disease was performed based on the diagnosis obtained during a comprehensive ophthalmic examination.

If the child had a known refractive error, examinations were performed with and without refractive correction. The refractive error-free condition simulated a real preschool/school screening situation: stereopsis of a newly diagnosed, untreated patient.

The studies were conducted with the approval of the Ethics Committee of the University of Alicante and the Regional and Institutional Research Ethics Committee of the University of Pécs (Alicante: UA-2017-03-20, Pécs: 6301/2016) and complied with the Helsinki Declaration.

4.3 Examination methods

First, a detailed pediatric ophthalmic examination was conducted, followed by stereotests: TNO, Frisby, Lang II, and Stereo Fly tests, in random order. Finally, the ETS measurement was performed. The first four stereotests were conducted in a well-lit room at a distance of 40 cm, while the ETS was performed at 25-30 cm in complete darkness. The different stimuli and matching criteria of the stereotests are detailed in Table 1.

Test name	Stimuli	Channel separation	Type of stereotest	Producer	Viewing distance (cm)	Possible results	Number of participants tested
Classic tests							
Lang II	star, elephant, car, moon	panographic	global; random dot	Lang Stereotest AG, Forch, langstereotest.com	40	>1000″* 600″ 400″ 200″	423
TNO	Plate V-VI, „pancake"	anaglyphic	global; random dot	Lameris Ootech BV, ootech.nl	40	>1000″ 480″ 240″ 120″ 60″	385
Frisby	circles	not needed	global; real depth	Frisby Stereotest™, frisbystereotest.co.uk	40	>1000″ 340″ 170″ 85″	265
Stereo Fly	circles	polarization method	local; contour stereogram	Stereo Optical Company, INC., stereooptical.com	40	>1000″ 800″ 400″ 200″ 140″ 100″ 80″ 60″ 50″ 40″	249
ETS	Snellen E	anaglyphic	global; random dot	Euvision Ltd., Pécs, Hungary	25-30		
SRDS 8						0-5/5	254
DRDS 1						0-5/5	130
DRSD 0.7						0-5/5	130
DRDS 1+noise						0-5/5	254
AI-ETS	Snellen E	anaglyphic	global; random dot	Euvision Ltd., Pécs, Hungary	25-30		
sum						0-20/20	130
w						0-20/20	130
aw						0-20/20	130

Table 1. Summary of Stereovision Tests

The ETS was performed using a tablet (Samsung Galaxy Tab A and bq Aquaris M10 tablet), which is essentially an anaglyph random dot stereogram (RDS) generator with numerous adjustable parameters, such as frame refresh rate, dot size, dot density, disparity, and visual noise level, regulating the difficulty of binocular perception. Our goal was to create an effective test for stereopsis examination that meets the criteria for an ideal screening method, including time efficiency,

reproducibility, sensitivity, specificity, statistically supported decision-making ability, and tolerance to common methodological errors.

In this study, we varied three properties of the tests: 1) whether the stimulus consisted of static (SRDS) or dynamically (DRDS) refreshing random dots. 2) We applied different density values, using three combinations in terms of dynamics and density: 8% static (SRDS 8), 1% dynamic (DRDS 1), and 0.7% dynamic (DRDS 0.7). 3) Finally, we varied the noise level, adding a proportion of binocularly uncorrelated dots to the RDS, in this case, 0.5% uncorrelated noise (DRDS 1 + noise).

During the measurement, children had to identify randomly oriented anaglyph Snellen E letters (up, down, right, left) while wearing red-green glasses.

To enhance the efficiency of the ETS, we applied a weighted combination (AI-ETS) of the four test results, creating a new indicator. We chose a simple model for AI: the perceptron model, a simple linear integrator.

5. Results

5.1 Area under the ROC curve (AUC)

We evaluated the effectiveness of various stereopsis tests by observing if they distinguish children with ophthalmic diagnoses from the emmetropic control group. This assessment was performed by calculating the AUCs and DeLong pairwise comparisons. All tests performed better in identifying individuals with amblyopia and amblyogenic risk factors. However, pairwise comparisons showed that for the amblyogenic and combined amblyopic + amblyogenic group, the optimized AI-ETS versions (i.e., AI-w WC, AI-aw WC) produced higher AUCs than the classic tests, except for the TNO (Table 2). These differences were statistically significant for all mentioned pairs.

Stereotest	Amblyopia	Amblyogenic conditions	Non amblyogenic conditions	Amblyopia+ Amblyogenic conditions
SRDS 8 NC	0.910 (0.852-0.950)	0.693 (0.615-0.763)	0.508 (0.435-0.581)	0.788 (0.722-0.844)
DRDS 1 NC	0.918 (0.862-0.956)	0.685 (0.607-0.756)	0.525 (0.452-0.598)	0.787 (0.721-0.843)
DRDS 0.7 NC	0.976 (0.906-0.998)	0.856 (0.749-0.929)	0.558 (0.445-0.666)	0.916 (0.839-0.964)
DRDS 1+zaj NC	0.914 (0.821-0.969)	0.829 (0.718-0.909)	0.599 (0.486-0.705)	0.872 (0.785-0.933)
AI-sum NC	0.995 (0.937-1)	0.876 (0.774-0.944)	0.606 (0.494-0.711)	0.936 (0.864-0.976)
AI-w NC	0.996 (0.940-1)	0.867 (0.762-0.937)	0.604 (0.491-0.709)	0.931 (0.859-0.974)
AI-aw NC	0.996 (0.940-1)	0.865 (0.760-0.936)	0.614 (0.501-0.718)	0.930 (0.857-0.973)
SRDS 8 WC	0.889 (0.830-0.933)	0.641 (0.563-0.715)	0.513 (0.447-0.580)	0.759 (0.693-0.816)
DRDS 1 WC	0.853 (0.788-0.904)	0.629 (0.550-0.703)	0.511 (0.445-0.578)	0.735 (0.667-0.795)
DRDS 0.7 WC	0.934 (0.846-0.980)	0.689 (0.566-0.796)	0.576 (0.464-0.684)	0.812 (0.716-0.886)
DRDS 1+zaj WC	0.919 (0.827-0.971)	0.671 (0.547-0.781)	0.536 (0.423-0.645)	0.795 (0.698-0.873)
AI-sum WC	0.972 (0.901-0.997)	0.805 (0.718-0.909)	0.596 (0.483-0.702)	0.889 (0.806-0.945)
AI-w WC	0.971 (0.898-0.996)	0.830 (0.719-0.910)	0.613 (0.501-0.718)	0.900 (0.819-0.953)
AI-aw WC	0.976 (0.906-0.998)	0.840 (0.731-0.917)	0.611 (0.499-0.716)	0.908 (0.829-0.958)
Lang II	0.822 (0.768-0.869)	0.604 (0.541-0.666)	0.522 (0.466-0.578)	0.704 (0.648-0.755)
TNO	0.953 (0.916-0.977)	0.742 (0.680-0.797)	0.603 (0.544-0.659)	0.840 (0.791-0.882)
Stereo Fly	0.926 (0.871-0.962)	0.656 (0.576-0.731)	0.585 (0.508-0.659)	0.780 (0.714-0.837)
Frisby	0.852 (0.786-0.903)	0.668 (0.590-0.740)	0.528 (0.453-0.603)	0.754 (0.688-0.812)

Table 2. Analysis of the Receiver Operating Characteristic (ROC) Curves for Stereotests: AUC Values with 95% Confidence Intervals.

5.2 Sensitivity and specificity studies at the optimal ROC point

In the next phase of the statistical analysis, we performed binary classification (pathological vs. normal) at the optimal ROC point. Sensitivity and specificity were calculated for each stereotest across different groups, including the control group. All tests evaluated in the study demonstrated at least 86% specificity. However, sensitivity varied widely. Based on the average sensitivity values, AI tests surpassed both the individual ETS tests and traditional stereotests, which is consistent with the AUC data. Notably, the AI-aw test exhibited the highest sensitivity for both amblyopia and amblyogenic conditions. In contrast, the sensitivity of all tests was low for non-amblyogenic conditions. Additionally, it was observed that examinations with refractive correction improved children's performance for amblyogenic conditions, resulting in lower sensitivity values for the WC group tests compared to the NC group.

5.3 Comparison of results from binary classification

As the next step, we investigated whether the significant differences observed in AUC values led to substantial changes in sensitivity measured during binary classification. To test if the performance of classic tests differed significantly from that of the AI-aw WC, we used McNemar's paired comparison test. Our analysis indicated that for the combined amblyopic and amblyogenic group, the AI-aw WC consistently outperformed all classic tests except the TNO. The

comparison of AI-aw WC with the Frisby, Lang II, Stereo Fly, and TNO tests revealed differences, with the corresponding p-values being 0.0117, 0.0129, 0.0129, and 0.508, respectively (n = 46).

6. Discussion

In our research, we examined the performance of an innovative stereopsis testing method, the EuvisionTab stereotest (ETS), in detecting amblyopia, amblyogenic, and non-amblyogenic conditions in children. The ETS was also compared with four traditional clinical stereotests commonly used internationally (Lang II, TNO, Stereo Fly, Frisby). Key differences of the ETS tests include: 1) they do not rely on measuring stereoacuity; 2) they can be static or dynamic; 3) they have low point density (disparity); 4) they may include non-correlated noise, and 5) they can utilize artificial intelligence technology. Our findings were supported by various statistical models, including the determination of AUC (DeLong method), McNemar, and Fisher-exact tests.

Main findings of the research

1.) Static and Dynamic ETS Tests: Proved effective in screening for amblyopia and amblyogenic risk factors. Static tests were highlighted for their excellent specificity, while dynamic tests were notable for their sensitivity.
2.) Density of Tests: It was observed that the lower the density of the test, the more sensitive it becomes.

3.) Visual Noise Addition: Adding visual noise also increased test sensitivity.
4.) Diagnostic Efficiency of ETS: The ETS showed higher or equally good diagnostic efficiency compared to the traditional tests (Lang II, TNO, Stereo Fly, and Frisby) examined in our research.
5.) Detection of Amblyogenic Risk Conditions: Beyond amblyopia, the ETS is suitable for detecting and screening amblyogenic risk conditions (anisometropia, strabismus, hypermetropia).
6.) Refractive Correction: Without refractive correction, the ETS proved to be more sensitive, representing a screening situation.
7.) Artificial Intelligence: By using artificial intelligence, the effectiveness of the ETS can be enhanced, as it combines the advantages of high-specificity static and high-sensitivity dynamic tests.

Our digital stereotest, the ETS, proved effective in detecting amblyopia and amblyogenic risk conditions. With the aid of artificial intelligence, it surpassed the efficiency of traditional tests used in clinical settings worldwide.

We hope that our stereotest will soon become part of the most modern vision screening protocols, thanks to digital data storage (no need for paper documentation, existing results can be easily and quickly retrieved), flexible parameter settings, random image sequences, and artificial intelligence. The ETS is a simple, efficient, and quick stereotest, making it teachable to laypersons to assist

ophthalmologists, general practitioners, and health visitors. This could be a significant advancement in primary care, helping to avoid further burdens on health visitors and ophthalmic specialists, which is much needed in Hungary.

The application of ETS could represent a major step forward in children's vision screening, surpassing the limitations of traditional methods by using an artificial intelligence model that integrates the advantages of different types of stereograms (SRDS 8, DRDS 1, DRDS 1+noise, DRDS 0.7), exceeding the efficiency of clinical stereoacuity-based tests in identifying childhood vision problems. Additionally, it offers a more economical solution for vision screening, which is an important factor given the limited availability of resources.

The use of artificial intelligence and the introduction of further AI models in future research could further optimize the detection of amblyopia and amblyogenic conditions. We plan to continue our research with further multicentric studies using our ETS test.

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7. Publications

7.1 Articles related to this thesis

Csizek Z, Mikó-Baráth E, Budai A, et al. Artificial Intelligence-Based Screening for Amblyopia and its Risk Factors: Comparison with four Classic Stereovision Tests. (Frontiers in Medicine. 10: 1294559, 2023) **IF: 3.9**

Csizek Z, Budai A, Nemes VÁ, Hegyi P, Szabó I, Pusztai Á, Piñero D P, D, Jandó G, Mikó-Baráth E: Mobileszköz alapú gyermekkori látásszűrés a tompalátás korai felismerésére (Orvosi Hetilap, 165.16: 620-628, 2024) **IF: 0.6**

Cumulative impact factor: 4,5

7.2 Abstracts related to this thesis (citable)

1. Szabó, I ; **Csizek, Zs** ; Mikó-Baráth, E ; Budai, A ; Frigyik, A ; Pusztai, Á ; Nemes, VÁ ; Závori, L ; Fülöp, D ; Czigler, A et al. Optimizing Stereovision Test Combinations for Amblyopia Screening in Children: A Perceptron Model Approach.In: International Neuroscience Conference, Pécs 2024 : Abstract book (2024) p. 121 Paper: P2.16
2. **Zsófia Csizek**, Eszter Mikó-Baráth, Anna Budai, Kitti Szabó-Guth, Ágota Pusztai, Adrienne Csutak, David P Piñero, Gábor

Jandó: Innovative medical diagnostic device: detection of amblyopia. FENS Virtual Forum (2020)

3. **Zsófia Csizek,** Eszter Mikó-Baráth, David P Piñero, Anna Budai, Kitti Szabó-Guth, Péter Hegyi, Ágota Pusztai, Adrienne Csutak, Gábor Jandó: Mobile devices in vision screening: examination of stereovision. V-VSS Florida (2020)
4. **Zsófia Csizek**, David P. Piñero, Eszter Mikó-Baráth, Anna Budai, Pedro Ruiz Fortes, Carlos Javier Hernández Rodríguez, Roberto Soto Negro, Gábor Jandó: New stereotest – sensitivity and specificity. *42st European Conference on Visual Perception (ECVP)* 2019 Leuven. Perception, 48 (2_suppl), 1–236. DOI: 10.1177/0301006619863862
5. **Csizek Zs,** Fülöp D, Nemes V, Budai A, Mikó-Baráth E, D'Orlando F, Caporusso G; Agostini T, Jandó G: Feasibility of dynamic stereovision tests in amblyopia screening. *IBRO Workshop:* Debrecen, Magyarország, 2014.01.16 -2014.01.17. Paper P186.

7.3 Oral presentations related to this thesis

1. **Csizek Zsófia**, Mikó-Baráth Eszter, Budai Anna, David P Piñero, Pedro Ruiz Fortes, Carlos Javier Hernández Rodríguez, Roberto Soto Negro, Jandó Gábor: Új sztereoteszt alkalmazhatósága – szenzitivitás és specificitás. XXI. Látásszimpózium, Pécs (2019)
2. Mikó-Baráth Eszter, Fülöp Diána, Nemes Vanda Ágnes**, Csizek Zsófia,** Radó János, Guth Kitti, Buzás Péter, Jandó Gábor: A

látásélesség érésének elektrofiziológiai meghatározása érett és koraszülött csecsemőkben, FAMÉ Budapest (2019)

3. David Pablo Piñero, Eszter Mikó, Pedro Ruiz, Anna Budai, Carlos Javier Hernández , **Zsofia Csizek** , Roberto Soto , Gabor Jandó: Sensibilidad y especificidad de un nuevo test de estereopsis en tablet para el screening de la ambliopía. OPTOM Meeting Valladolid, Spanyolország (2019)
4. Eszter Mikó –Baráth, Diána Fülöp, Vanda Ágnes Nemes, **Zsófia Csizek**, János Radó and Gábor Jandó: The electrophysiological estimation of visual acuity in preterm and full-term infants, BrISCEV London (2019)
5. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Statikus és dinamikus sztereotesztek alkalmazása óvodáskorú gyerekek látásszűrésében. I. helyezés, XXXII. Országos Tudományos Diákköri Konferencia Orvos-és Egészségtudományi Szekció, Budapest (2015)
6. Harmouche Ahmed, Czigler András, Fülöp Diána, **Csizek Zsófia**, Juhász Petra: Mobiltechnológia használata a prevencióban- visus vizsgálat android eszközökön - XXXII. Országos Tudományos Diákköri Konferencia, Budapest (2015)
7. Czigler András, Harmouche Ahmed, Fülöp Diána, **Csizek Zsófia**, Juhász Petra: Mobil számítástechnikai eszközök használata gyermekek amblyopia szűrésében - XXXII. Országos Tudományos Diákköri Konferencia, Budapest (2015)
8. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Statikus és dinamikus sztereotesztek alkalmazása óvodáskorú gyerekek

látásszűrésében - Marosvásárhely, Tudományos Diákköri Konferencia (2015)

9. Budai Anna, Juhász Petra, **Csizek Zsófia**, Dr. Mikó-Baráth Eszter, Dr. Nemes Vanda, Dr. Jandó Gábor: A dinamikus random pont sztereoteszt szerepe óvodáskorú gyermekek amblyopia-szűrésében. Magyar-Amerikai Orvosszövetség Konferenciája, Balatonfüred (2015)
10. Anna Budai, **Zsófia Csizek**, Diána Fülöp: Visual screening of preschool children- case presentation, 46th Annual Meeting of HMAA, Sarasota, Florida, USA (2014)
11. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Statikus és dinamikus sztereotesztek alkalmazása óvodáskorú gyerekek látásszűrésében –Idegtudományi Konferencia, Pécs: 1. helyezett (2014)
12. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Statikus és dinamikus sztereotesztek alkalmazása óvodáskorú gyerekek látásszűrésében - Balatonfüred, HMAA Hungary Chapter (2014)
13. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Statikus és dinamikus sztereotesztek alkalmazása óvodáskorú gyerekek látásszűrésében, Pécsi Tudományegyetem ÁOK házi TDK konferencia, I. helyezett Pécs (2014)
14. Czigler András, Harmouche Ahmed, Fülöp Diána, **Csizek Zsófia**, Juhász Petra: Mobil számítástechnikai eszközök használata gyermekek amblyopia szűrésében, Pécsi Tudományegyetem ÁOK házi TDK konferencia, I. helyezett Pécs (2014)

15. Harmouche Ahmed, Czigler András, Fülöp Diána, **Csizek Zsófia**, Juhász Petra: Mobiltechnológia használata a prevencióban- visus vizsgálat android eszközökön, Pécsi Tudományegyetem ÁOK házi TDK konferencia, I. helyezett Pécs (2014)
16. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Vizuális kiváltott válasszal előre jelezhető a tompalátás? II. helyezett, XXXI Országos Tudományos Diákköri Konferencia, Szeged (2013)
17. **Fülöp Diána**, Csizek Zsófia, Budai Anna: A binocularitás érésének összehasonlítása koraszülötteknél és érett újszülötteknél; XXXI Országos Tudományos Diákköri Konferencia, Szeged (2013)
18. Budai Anna, **Csizek Zsófia**, Fülöp Diána: Vizuális kiváltott válasszal előre jelezhető a tompalátás? Legjobb magyar nyelvű előadás díja (Istvan Mechtler Award) Magyar-Amerikai Orvosszövetség Konferenciája, Balatonfüred (2013)
19. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Vizuális kiváltott válasszal előre jelezhető a tompalátás?, Pécsi Tudományegyetem ÁOK házi TDK konferencia (2013)
20. Fülöp Diána, **Csizek Zsófia**, Budai Anna: A binocularitás érésének összehasonlítása koraszülötteknél és érett újszülötteknél Pécsi Tudományegyetem ÁOK házi TDK konferencia, II. helyezett (2013)
21. Anna Budai, **Zsófia Csizek**, Diána Fülöp: Can visual evoked potential predict amblyopia? 45th Annual Meeting of HMAA, Sarasota, Florida,USA (2013)

22. Budai Anna, **Csizek Zsófia**, Fülöp Diána: DRDS-E, mint új típusú gyermekkori látásszűrő vizsgálat: monokuláris artefaktok kiküszöbölése. I. helyezés, *Házi TDK Konferencia*, Pécs (2012)

7.4 Poster presentations related to this thesis

1. Szabó, I ; **Csizek, Zs** ; Mikó-Baráth, E ; Budai, A ; Frigyik, A ; Pusztai, Á ; Nemes, VÁ ; Závori, L ; Fülöp, D ; Czigler, A et al. Optimizing Stereovision Test Combinations for Amblyopia Screening in Children: A Perceptron Model Approach.In: International Neuroscience Conference, Pécs 2024 : Abstract book (2024) p. 121 Paper: P2.16
2. **Zsófia Csizek**, Eszter Mikó-Baráth, Anna Budai, Kitti Szabó-Guth, Ágota Pusztai, Adrienne Csutak, David P Piñero, Gábor Jandó: Innovative medical diagnostic device: detection of amblyopia. FENS Virtual Forum (2020)
3. **Zsófia Csizek,** Eszter Mikó-Baráth, David P Piñero, Anna Budai, Kitti Szabó-Guth, Péter Hegyi, Ágota Pusztai, Adrienne Csutak, Gábor Jandó: Mobile devices in vision screening: examination of stereovision. V-VSS Florida (2020)
4. **Zsófia Csizek**, E. Mikó Baráth, K. Szabó Guth, P. Hegyi, D. P. Pinero, Á. Pusztai, A. Csutak, G. Jandó: New stereotest compared with other stereotests – sensitivity and specificity. Szeged HUNDOC meeting (2020)
5. **Zsófia Csizek**, E. Mikó Baráth, K. Szabó Guth, P. Hegyi, D. P. Pinero, Á. Pusztai, A. Csutak, G. Jandó: Mobile vision screening

system detects amblyopia with high sensitivity. Szeged IBRO Workshop (2020)

6. **Zsófia Csizek**, David P. Piñero, Eszter Mikó-Baráth, Anna Budai, Pedro Ruiz Fortes, Carlos Javier Hernández Rodríguez, Roberto Soto Negro, Gábor Jandó: New stereotest – sensitivity and specificity. *42st European Conference on Visual Perception (ECVP)* Leuven (2019)
7. **Zsófia Csizek**, David P. Piñero, Eszter Mikó-Baráth, Anna Budai, Pedro Ruiz Fortes , Carlos Javier Hernández Rodríguez, Roberto Soto Negro, Gábor Jandó: New stereotest – sensitivity and specificity. Pécs MEDPECS Konferencia (2019)
8. Anna Budai, András Czigler, Petra Juhász, **Zsófia Csizek**, Vanda A. Nemes, Gábor Jandó: *Screening of amblyopia in preschool children – first results of a clinical study.* IBRO Workshop, Budapest (2016)
9. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Binokuláris VEP vizsgálaton átesett csecsemők utánkövetése – Pécs Doctoral Workshop (2015)
10. **Csizek Zsófia**, Fülöp Diána, Budai Anna: Binokuláris VEP vizsgálaton átesett csecsemők utánkövetése 2015 Balatonfüred HMAA Hungary Chapter: - Excellence in Clinical sciences: Ophthalmology-Pulmonology-Internal medicine-Behaviour medicine Poster award

11. Budai Anna, Juhász Petra, **Csizek Zsófia**, Dr. Mikó-Baráth Eszter, Dr. Nemes Vanda, Dr. Jandó Gábor: A dinamikus random pont sztereoteszt szerepe óvodáskorú gyermekek amblyopia-

szűrésében. *Magyar-Amerikai Orvosszövetség Konferenciája*, Balatonfüred, (2015)

12. **Zsófia Csizek**, Diána Fülöp, Vanda Nemes, Anna Budai, Eszter Mikó-Baráth, Francesca D'Orlando, Grazia Caporusso, Tiziano Agostini, Gábor Jandó: Feasibility of dynamic stereovision tests in amblyopia screening – IBRO Workshop, Debrecen (2014)
13. A.Budai, **Zs.Csizek**, D.Fülöp, E.Mikó-Baráth, V. Nemes, F.D'Orlando, G. Caporusso, T. Agostini, G.Jandó: Feasibility of dynamic stereovision tests in amblyopia screening. *1st Innovation in Science 2014 – Doctoral Student Conference*, Szeged (2014)
14. A.Budai, **Zs.Csizek**, D.Fülöp, E.Mikó-Baráth, V. Nemes, F.D'Orlando, G. Caporusso, T. Agostini, G.Jandó: Psychophysical dynamic stereovision tests in amblyopia screening. *Trieste Symposium on Perception & Cognition*, Trieszt, Olaszország (2014)

7.5 Theses, grants

1. **Csizek Zsófia:** Predictive Factors in the Forecasting of Amblyopia, Dean's Thesis (2015)

2. **Csizek Zsófia:** Új Nemzeti Kiválóság Program pályázat elnyerése, Research Title: Validation of a New Stereopsis Testing Method Involving Healthy Children and Those with Various Ophthalmological Conditions, Grant Identifier: ÚNKP-19-3-I-PTE-110