Validation of the Functional Vision Evaluation for Children (FVEC) Battery

Marcia Caires Bestileiro Lopes
Universidade Federal de São Paulo
Marcela Aparecida Santos
Universidade Federal de São Paulo
Célia Regina Nakanami
Universidade Federal de São Paulo
Marcelo Fernandes Costa (costamf@usp.br)
Universidade de São Paulo

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Abstract

Background

we validated the recently developed Functional Vision Evaluation for Children (FVEC) Battery, which quantitatively measures major eye and visual function for rehabilitation.

Methods

The protocol for this test comprises 12 items involving unique abilities of the functional vision evaluated for 3 subsequent periods. Validation procedure includes analysis of difficulty of the examiner performance, the reliability and symmetry evaluation of the battery items and the prediction of the children in low vision category on a 0-100 ranking scale of visual behaviors. Factor analysis evaluates the contribution of the items to functions of Ventral and Dorsal visual streams.

Results

consistency was similar between the 3 examiners and the reliability intra-subjects was also significantly high for examiner 1 ($\alpha = 0.86$), examiner 2 ($\alpha = 0.85$) and examiner 3 ($\alpha = 0.87$). A Factor Analysis confirms that we arranged our data in two major factors expressing Ventral and Dorsal-related visual functions.

Conclusions

we validate the FVEC battery with high robustness, internal consistency and an outcome regarding the functional performances for the visual Ventral and Dorsal-related functions.

Key Messages

1. Our scoring procedure allows us to identify asymmetries between the functions of the Dorsal and Ventral pathways.
2. Strong reliability and internal consistency values demonstrate great stability for clinical application.
3. Stimuli and procedure are based on the Minimal Angle of Resolution of 1° for direct relation with patient’s visual acuity

Background

Vision is a sophisticated sense and provides information from the external environment related to the size, position, distance, color and shapes of the environment around (Gagliardo, HGRG, 2003; Kandel, ER, 1997). In addition, the visual system plays an important role in the early months of a child’s life in the development of communication, self-orientation, movement control, and many other behaviors (Gagliardo, 2003; Lindstedt, E, 2000; Kara-José, N., 2004).

The interest of researchers easily observed the importance of vision to be dedicated to the study of visual functions (Costa et al., 2017, Salomão & Ventura, 1995; Mayer et al., 1995). However, vision-guided functional demands in patients with developmental disorders have few descriptions (Barca et al., 2010).

When the visual affections occur early in life, they might affect overall development, compromising their cognitive and social development (Gieser, 2004). Assessing the child's visual behavior can favor the early detection of visual impairments (Gagliardo and Nobre, 2001), and configure a forward measure against later detection and intervention, leading to a negative impact on neurodevelopment (Perez Ramos & Perez Ramos, 1992; Guralnick, 1993).

The significant discovery for professionals who are dedicated to visual rehabilitation - early visual stimulation — was to identify the visual skills affected when there is a situation that disturbs the normal course of visual development. In this sense, there are some assessments of functional vision for children, but most of those instruments have no support from psychophysical and psychophysiological studies.

Based on this concern, we developed a battery of visual tests to assess functional performance of infants and children (Lopes et al., 2020). Thus, in this study, we aimed to validate the FVEC battery and we evaluate if functions dominated by the major ventral and dorsal visual streams could be assessed considering the possibility of evaluating the visual function of patients considering these two visual pathways independently. The possibility of obtaining information about these visual pathways will be an important and innovative improvement for the visual assessment of children.

Methods

Subjects

One hundred children with visual impairment, with a mean age of 24.57 months (SD = 17.37–51 females) took part in the present study. All children were evaluated, and are being monitored, at the Early Visual Stimulation Clinic of the Low Vision and Visual Rehabilitation Sector of the Department of Ophthalmology and Visual Sciences, at the Federal University of São Paulo / Hospital São Paulo, Brazil.

The evaluators were composed of physiotherapists and occupational therapists, 2 professionals with great experience in the area and knowledge of the FEVC instrument test application, and 2 professionals with less experience in visual impairment and without previous experience with the FEVC instrument. Those nine professionals underwent an observational familiarization and pre-application training. They performed all applications on the same day, with an interval of approximately 1 hour.

Equipment

The instruments used in this research come from the FEVC battery for the assessment of functional vision for children (Lopes et al. 2020) (Fig. 1). The instruments were: checkered racket, face racket, checkered cube and striped band.

Procedure

We performed the evaluation at the Early Visual Stimulation Clinic of the Low Vision and Visual Rehabilitation Sector of the Department of Ophthalmology, Federal University of São Paulo–São Paulo, Brazil. In an environment free from clusters and visual distractions, with white walls and an interval of approximately 30 seconds between each successive presentation, at a distance of 20cm from the stimulus, the child's face, in midline, from the child's face, these being positioned according to chronological age, corrected, in relation to neurodevelopment, therefore, from 0 to 6 months of age were tested in semi-seated, while from 6 to 24 months in seated, while the position of the evaluator varied, but always remaining outside the functional visual field of child.

The protocol for this test comprises 12 items involving different abilities in the functional vision. Table 1 shows those skills that are assessed in the battery of 3 presentations of this test and they should observe which answers should be noted.

Table 1
systematic description of the test battery of the 12 skills for the assessment of functional vision for children.

Functional Vision Skills	**Stimulus response** **First presentation**	**Stimulus response** **Second presentation**	**Stimulus response** **Third presentation**
1. Visual fixation	( )present ( )absent	( )present ( )absent	( )present ( )absent
	time : __________	time : __________	time : __________
2. Eye contact with face	( )present ( )absent	( )present ( )absent	( )present ( )absent
	time : __________	time : __________	time : __________
3. Optokinetic nystagmus	( )present ( )absent	( )present ( )absent	( )present ( )absent
	( ) Present – symmetric ( ) Present - asymmetric	( ) Present – symmetric ( ) Present - asymmetric	( ) Present – symmetric ( ) Present – asymmetric
4. Saccadics moviments	( )present ( )absent	( )present ( )absent	( )present ( )absent
	( )right ( )left	( )right ( )left	( )right ( )left
6. Ocular vestibule reflex	( )present ( )absent	( )present ( )absent	( )present ( )absent
7. Vergence	( )present ( )absent	( )present ( )absent	( )present ( )absent
8. Horizontal visual tracking	( )present ( )absent	( )present ( )absent	( )present ( )absent
9. Vertical visual tracking	( )present ( )absent	( )present ( )absent	( )present ( )absent
10. Smile in response to eye contact	( )present ( )absent	( )present ( )absent	( )present ( )absent
11. Increased global movement in stimulus presentation	( )present ( )absent	( )present ( )absent	( )present ( )absent
12. Attempt to reach the visualized stimulus	( )present ( )absent	( )present ( )absent	( )present ( )absent

Functional Vision Skills	Stimulus response First presentation	Stimulus response Second presentation	Stimulus response Third presentation
13. Functional visual field of confrontation	( )present ( )absent	( )present ( )absent	( )present ( )absent
	( )right ( )left ( ) higher ( )lower	( )right ( )left ( ) higher ( )lower	( )right ( )left ( ) higher ( )lower

The detailing of the application procedure comprises three items: 1. instrument, which defines which of the battery materials will be used for the respective testing; 2. activity, which describes how the evaluator must present the stimulus and the dynamics involved in this presentation; and 3. the expected response, for response score, presenting the expected behavior for the respective stimulation and dynamics of presentation of the activity.

1. Visual fixation

Visual fixation is the ability to maintain the eyes aligned, focused, and attended with the stimulus of interest. This maintenance of the ocular position causes the image of objects placed on the fovea, a region of the retina, with the possibility of better visual acuity.

1.1. Instrument used for this test: chess racket.

1.2. Activity: the racket should be presented in midline and time taken from fixation maintenance; there will be 3 presentations of 30 seconds each. The measure consists of the sum of the total fixation time of the 3 presentations.

1.3. Expected answer: fixation on the chess racket for 2/3 of the time.

2. Eye contact with face

The face, the human face, is an extremely important visual stimulus for social interaction and environmental reading, especially for babies. The preference for complex patterns is innate, as is the preference for face.

2.1. Instrument for this test: face racket.

2.2. Activity: presentation of the face racket must be done in midline and the time of fixation maintenance must be measured; there will be 3 presentations of 30 seconds each. The measure comprises the sum of the total fixation time of the 3 presentations.

2.3. Expected answer: fixation of the gaze on the face racket for 2/3 of the time.

3. Optokinetic Nystagmus

This is an involuntary and complex eye movement for moving stimuli, comprising three phases: fixation, tracking, and corrective saccade. This movement is more easily elicited by periodic stimuli. When the stimulus is fixed, a follow-up movement to the edge of the visual field is started. Reaching this limit, the eyes perform a saccadic movement in the opposite direction, seeking another fixation point.

3.1. Instrument for this test: striped band.

3.2. Activity: present the moving range from right to left, crossing the midline, and vice versa; 2 presentations were made for each direction at a speed of approximately 0.5m/s.

3.3. Expected response: presence of nystagmus with slow follow-up and rapid return to both sides and symmetrically.

4. Saccadic movements

They are ballistic movements, with great amplitude and high speed, aiming to direct the eyes to a point in the visual field. There are two types of saccadic movements, in relation to their generation: voluntary, when the eyes are directed to some object in a motivated or intentional way; and involuntary, when some stimulus abruptly enters the visual field, captures our attention and elicits a saccadic movement in its direction.

4.1. Instrument for this test: chess racket and face racket.

4.2. Activity: present the front to the children, in midline, after achieving the central fixation for the checkered racket, perform the sequential presentation of the racket facing the 30° visual angle to the right, and immediately after, present it at the 30° angle visual on the left, of the checkered racket.

4.3. Expected response: presence of fixation on the central racket and change of gaze because of abrupt eye movement (presence of saccade movement) to the racket that appears in the sequence laterally, to the left and right.

5. Vestibulo-ocular reflex

It is an important eye movement that is related to maintaining eye fixation on stimulus of interest, regardless of head or body movement. Vestibular stimuli reach the nervous centers of eye movements, correcting their position in relation to head and neck movement or displacement of the body in space.

5.1. Instrument for this test: no instrument required.

5.2. Activity: with the child suspended and supported at a 45° backward inclination, drawing visual attention to the experimenter's face, move the child's head to the right and then to the left, starting from the midline.

5.3. Expected answer: observing the triggering of eye movements at the same speed and in the opposite direction as head movements.

6. Vergence

It is the eye movement aimed at maintaining image fixation in the foveal region when the stimulus moves in the proximal or distal direction of the eyes.

6.1. Instrument for this test: chess cube.

6.2. Activity: make the presentation of the chess cube in a midline, followed by approaching, slowly (1cm/s), the midpoint of the base of the nose, between the eyes.

6.3. Expected response: presence of eye convergence because of the midline stimulus approximation and convergence break at a distance of less than 10cm.

7. Horizontal Visual Tracking

Also called by some authors as slow pursuit movement, this eye movement has the function of keeping the fovea fixed on the object of interest, while it moves horizontally in space.

7.1. Instrument for this test: chess racket.

7.2. Activity: make the presentation of the chess racket in midline, and after visual fixation and support to avoid head movement, move the racket slowly, to the right and left sides at a speed of 1° of visual angle per second.

7.3. Expected response: visually follow the stimulus with eye or head movement along the entire trajectory, without losses during the course, or with the appearance of eye deviations.

8. Vertical Visual Tracking

Also called by some authors as slow pursuit movement, this eye movement has the function of keeping the fovea fixed on the object of interest, while it moves vertically into space.

8.1. Instrument for this test: chess racket.

8.2. Activity: make the presentation of the chess racket in midline, and after visual fixation and support to avoid head movement, move the racket slowly, to the up and down position at a speed of 1° of visual angle per second.

8.3. Expected response: visually follow the stimulus with eye or head movement along the entire trajectory, without losses during the course, or with the appearance of eye deviations.

9. Smile in response to eye contact

This is a social interaction and imitation response, based on real visual stimuli. Most babies, from four months of age onwards, have a smile as a social contact.

9.1. Instrument: face racket.

9.2. Activity: Make the midline face racket presentation.

9.3. Expected answer: fix the racket on the face and smile spontaneously. We expect this response for babies between four and five months old.

10. Increased global movement when viewing an object

This ability starts around two / three months of age and is related to greater neurological maturation, with increased intentional movement and decreased reflexes.

10.1. Instrument for this test: chess cube.

10.2. Activity: make the presentation of the chess cube in the middle line of the tested child.

10.3. Expected answer: observe variation in the child's motor behavior, such as body extension, agitation of upper limbs and/or lower limbs, global movement, while maintaining visual attention. We expect this response for babies from two / three months.

11. Attempting to reach the visualized object

This skill starts around two / three months of age and consolidates at four months. At this stage, babies flex and extend their upper limbs to the object of interest viewed in the midline, to apprehend it.

11.1. Instrument for this test: chess cube.

11. 2. Activity: make the presentation of the chess cube in the middle line.

11.3. Expected answer: observe the intention or movement of at least one of the upper limbs towards the chess cube while maintaining visual attention. We expect this response for babies between two-three and four months.

12. Functional visual field of confrontation

Our field of vision comprises the full extent to which visual stimuli are perceived and elicit saccadic behavior towards them, in the perception of this stimulus in my space / visible field.

12.1. Instrument for this test: chess cube.

12.2. Activity: make a presentation of one of the chess cubes in a midline, being necessary to maintain its fixation. Then start approaching the other cube from the right, left, top and bottom towards the midline, at a speed of 1° of visual angle per second.

12.3. Expected response: observe the awakening of attention to the tested side, indicating vision in that perimetric visual quadrant.

Statistical Analysis

The Cochran Q test was used to evaluate whether the detection of presence or absence of the variables differ significantly among themselves. In our study, a significant Q test shows the items are of different difficulty, since the participants answered different items correctly. McNemar's Chi-square test for significant changes in proportions of dependent variables was used. The reliability of the battery was accessed using Cronbach's alpha, and the attenuated split-half correlations were used to verify the reliability symmetry between items related to local aspects of vision and items related to global aspects of vision. Pearson Correlation was used to evaluating the time fixating the grating and the Fantz's face stimuli. Classification trees were used to predict membership of patients in the classes of a categorical dependent variable from their measurements on predictor variables. Predictor importance was used to calculate the importance ranking on a 0–100 scale for each predictor variable in the analysis for the more complex behaviors evaluated, smile in facial contact, and manual reaching movement. A Factor Analysis considering varimax rotation extracting factor was used to detect the structure in the relationships between variables to classify variables in local visual stream and global visual stream.

Results

100 children were evaluated and consistent results were obtained from all children aging from 03 to 99 months (Mean = 24.3, SD = 17.3 mos; Median = 22.5 mos; 47 males). We show demographic data of the children in Table 2.

Table 2 – demographic description of the diseases present in this study.

Diseases	Children (n)
Albinism	3
Retinal changes	3
Low visual acuity	4
Congenital cataract	7
Colobomas	3
Cortical visual impairment	19
Scotomas	7
Congenital strabismus	6
Congenital glaucoma	6
Eye malformation	5
Congenital nystagmus	5
Retinoblastoma	6
Retinopathy of prematurity	10
Peters syndrome	6
Diagnostics under investigation	10

We first evaluate the item difficulty using the Cochran Q test, considering the overall data and for each examiner. For the overall measurement, we obtained a significant difference ($Q = 435{,}16$; $p < 0.001$) showing that Saccadic movement to the right side, Saccadic movement to the left side, vestibule-ocular reflex, manual reaching movements had a higher difficult level of execution when compared with all other scale items.

The consistency between examiners was measured, and we found no statistical differences, showing a good consistency of evaluation suggesting robustness of our protocol. These results are presenting in Table 3.

Table 3- Item difficulty analysis and intrasubject evaluation.

Item	Present	Absent	Present	Absent	Present	Absent	Present	Absent
	Overall*		Examiner 1		Examiner 2		Examiner 3	
Grating Fixation	5,8	94,2	6,3	93,7	6,7	93,3	3,1	96,9
Face Fixation	17,4	82,6	17,5	82,5	20,0	80,0	12,5	87,5
OKN	39,4	60,6	**41,3**	**58,7**	**43,3**	**56,7**	28,1	71,9
OKN Simetric	71,0	29,0	71,4	28,6	75,0	25,0	62,5	37,5
OKN Asymmetric	68,4	31,6	69,8	30,2	68,3	31,7	65,6	34,4
Saccade Right	**45,2**	**54,8**	**49,2**	**50,8**	**48,3**	**51,7**	**31,3**	**68,8**
Saccade Left	**45,8**	**54,2**	**47,6**	**52,4**	**46,7**	**53,3**	**40,6**	**59,4**
VOR	**44,5**	**55,5**	**44,4**	**55,6**	**46,7**	**53,3**	**25,0**	**75,0**
Vergency	62,6	37,4	17,5	82,5	18,3	81,7	12,5	87,5
Horizontal SPM	**24,5**	**75,5**	**58,7**	**41,3**	**61,7**	**38,3**	**50,0**	**50,0**
Vertical SPM	**46,5**	**53,5**	**49,2**	**50,8**	**48,3**	**51,7**	**37,5**	**62,5**
Smile for Face	**58,1**	**41,9**	20,6	79,4	25,0	75,0	31,3	68,8
IGM	16,8	83,2	63,5	36,5	68,3	31,7	**50,0**	**50,0**
Manual Reach	**41,3**	**58,7**	**44,4**	**55,6**	**46,7**	**53,3**	**40,6**	**59,4**

Bold Values - non significant differences; * - values in percentage; OKN - opto-kinetic nystagmus; VOR - vestibulo-ocular reflex; IGM - Improvement in General Movimentation

The battery reliability using Cronbach's alpha showed high internal consistency in judgments for examiner 1 (α = 0.86), examiner 2 (α = 0.85) and examiner 3 (α = 0.87). It was also important to evaluate the consistency between stimuli with clear local aspects as fixation to grating and face, OKN, convergence movement and smile to face contact, and stimuli with global aspects of vision as saccadic movements, VOR, smooth pursuit movement and manual reach attempting. Split-half correlations were also highly significant for examiner 1 (r_a= 0.81), examiner 2 (r_a= 0.83), and examiner 3 (r_a= 0.82), with a high reliability level, respectively, r_{sb}= 0.76, r_{sb}= 0.75, and r_{sb}= 0.75.

Correlations between time of fixation to the grating stimulus and to the Fantz's face stimulus were highly significant for the overall results (r = 0.84; p < 0.001) and considering examiner 1 (r = 0.84; p < 0.001), examiner 2 (r = 0.84; p < 0.001), and examiner 3 (r = 0.84; p < 0.001), showing high concordance between their measurements (Fig. 2).

We consider the smile to facial contact and the manual reaching movements the more significant functional responses to complex visual stimuli and interactive behavior with the environment. We ranked the predictive evaluations regarding the visual functions in importance (Fig. 3). For the smile for facial contact, the more predictive visual functions were face perception, saccadic movements and opto-kinetic nystagmus, visual functions related to maintain and control fixation behaviors improving detailed and stable perceptions. For the manual reaching movement, the predictors were vestibule-ocular reflex, smooth pursuit movement, and convergence movement present, which are important to spatial organization, localization, and motor planning.

A Factor Analysis confirms that we could arrange our data in two major factors after the two-factors rotating solutions. Factor 1 shows the highest loadings for the items pertaining to local visual processing stream. Factor 2 shows the highest loadings for the global visual processing stream related items.

Table 4- Factor analysis of two factor after varimax rotation.

	Factor 1	Factor 2
Grating Fixation	0,321	**0,634**
Face Fixation	0,341	**0,637**
OKN	0,196	**0,700**
OKN Simetric	**0,454**	-0,011
OKN Asymmetric	-0,279	**0,717**
Saccade Right	**0,716**	0,191
Saccade Left	**0,658**	0,142
VOR	**0,580**	0,329
Vergency	**0,694**	-0,112
Horizontal SPM	0,398	**0,506**
Vertical SPM	**0,545**	0,443
IGM	-0,225	**0,283**

As we can see in Table 4, saccadic movements, vestibule-ocular reflex, convergence vertical, smooth pursuit are strongly related to global visual processing stream, whereas the looking to grating, face, OKN and the horizontal smooth pursuit and the increase of body movements are related to local visual processing.

Discussion

The Functional Vision Evaluation for Children (FVEC) Battery presented robust results of internal validity and reliability considering 4 different examiners for the functional evaluation of vision in children with varied diagnoses of ophthalmological diseases and that have low vision as a functional result. Statistical analyzes show that our evaluation battery allows access to visual functions related to the ventral and dorsal visual pathways, responsible for processing local and global aspects of vision, respectively. This is an innovative feature of our assessment and, so far, we have not identified other evaluation that present these functional characteristics of relating the visual performances measured with the visual processing of the large visual cortical pathways. In this way, our work is innovative and has great potential to move forward the systematic planning of visual rehabilitation actions in children.

The multiplicity of visual changes to be tested often hinder the systematic organization of the findings and hinder the development of a therapeutic plan seeking a more global development and often remain in stimulations of isolated visual functions, leaving a more integrative approach to the main axes functional. Studies as those of Anderson & Rizzo, (1995) and Dundon, Bertini, Ladavas, Sabel & Gall (2015) have represented this great concern in visual rehabilitation, pointing to the need to evaluate themselves in an appropriate and integrative way, seeking elements that allow clarity for the therapeutic decision of restorative or compensatory treatment. Our evaluation battery, allowing the identification of local and global losses, presents itself as a robust alternative to support this decision of fundamental therapeutic importance.

Assessment methods for children with low vision, especially with cortical visual impairment, are aimed at improving the quality of measures of basic visual functions such as grating acuity using electrophysiological methods (Birch & Bane, 1991; W.V. Good, 2001), Vernier's acuity (Skoczenski & Good, 2004), spatial luminance contrast sensitivity (W. V. Good, Hou, & Norcia, 2012), and even attention (Atkinson & Braddick, 2012) and behavioral measures that can help understand the functional use of vision (Riazi, 2018). Assessment methods for children with low vision, especially with cortical visual impairment, aiming to improving the quality of measures of basic visual functions such as visual acuity, and even behavioral measures that can help understand the functional use of vision. We know that part of the difficulty in relating the measurements of visual functions to visual behaviors in children with low vision is the difference in the methods used to evaluate these functions, while electrophysiological methods present an estimate of the function generated in V1, behavioral measures reflect not only the sensory-perceptual aspects but also the integrative processing with cognitive areas such as language and motor structures (Dobson & Teller, 1978). This is especially true in children with severe cortical vision impairment.

The most recently developed visual assessment battery used in children with low vision and severe neurological impairments is the Bradford visual function box (Pilling, Outhwaite, & Bruce, 2016). It was conceptually developed to answer basic information, comprising the tasks of light perception using bright light in dark room, blink reflex to windmill, the look and following a real face, if the child return to a silent smile, fixation to a forced-choice cards and the duration that they hold fixation. Also, visual attention is assessed by recording the time and duration of fixation on toys of different sizes in different distances. In comparison with Bradford's battery, our FCVE battery has many functional advantages considering we evaluate not only the detection of stimulus but also the status of the voluntary and involuntary eyes movements, and allows for a more systematic diagnosis with standard visual stimuli, since we use 1° angle of visual stimuli as a criterion for all stimuli, as well as the measurements made allow us to separate compromise of local and global visual functions.

The possibility of evaluating the visual pathways of local and global processing is fundamental, since they handle integrating the sensory information processed in areas V1 and V2 with areas of superior processing. The processing of local visual information is important for the discrimination of figures and objects, face perception and other functions that are used for categorization, classification, naming and other cognitive functions related to language. Stimuli processed globally are of great importance for functions such as visual attention, location and spatial orientation, perception of texture and distance, and for planning and other executive functions (Angelucci et al., 2002; Han et al., 2002; Solomon, Chen, Morley, & Solomon, 2015; Yoshida, Yoshino, Takahashi, & Nomura, 2007; Zeki, 2001). As evidenced by factor analysis, our battery of visual assessment allows grouping the various tasks and stimuli used so that their contribution is more relevant to one or the other of these pathways. Certainly, this level of information has not been reported in the literature and, therefore, we consider being contributing importantly to the area of visual rehabilitation.

The attention to ease of application is relevant, since we had applicators with less experience in the area. However, it is important to emphasize that there is a need for familiarization with the instruments and training with qualified professionals to provide the correct instructions for this application to be successful.

Conclusion

We validated the Functional Vision Evaluation for Children (FVEC) battery, showing high reliability and internal consistency of the items evaluated. Difficult analysis showed that our battery is moderately easy to apply, but it could require some training for some examiners. We base the major contribution of our FVEC battery on the possibility of separate local from global visual functions, which improves the information regarding these two main visual streams.

Declarations

This study followed the principles of the Declaration of Helsinki, and was approved by the Research Ethics Committee of the Federal University of São Paulo. The informed assents were obtained from all the participant parents.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization: MFC and MCBL; Funding acquisition: MFC; Investigation: MFC, MCBL, MAS and RCN; Data analysis: MFC, MCBL, and MAS; Writing - original draft: MCBL, MAS and RCN; Writing - review & editing: all authors edited, revised, and approved the final version.

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Figures

Image not available with this version

Figure 1

Photo of the instruments - Functional vision assessment kit for children, used in the assessment of functional vision from the study by Lopes et al in 2020.

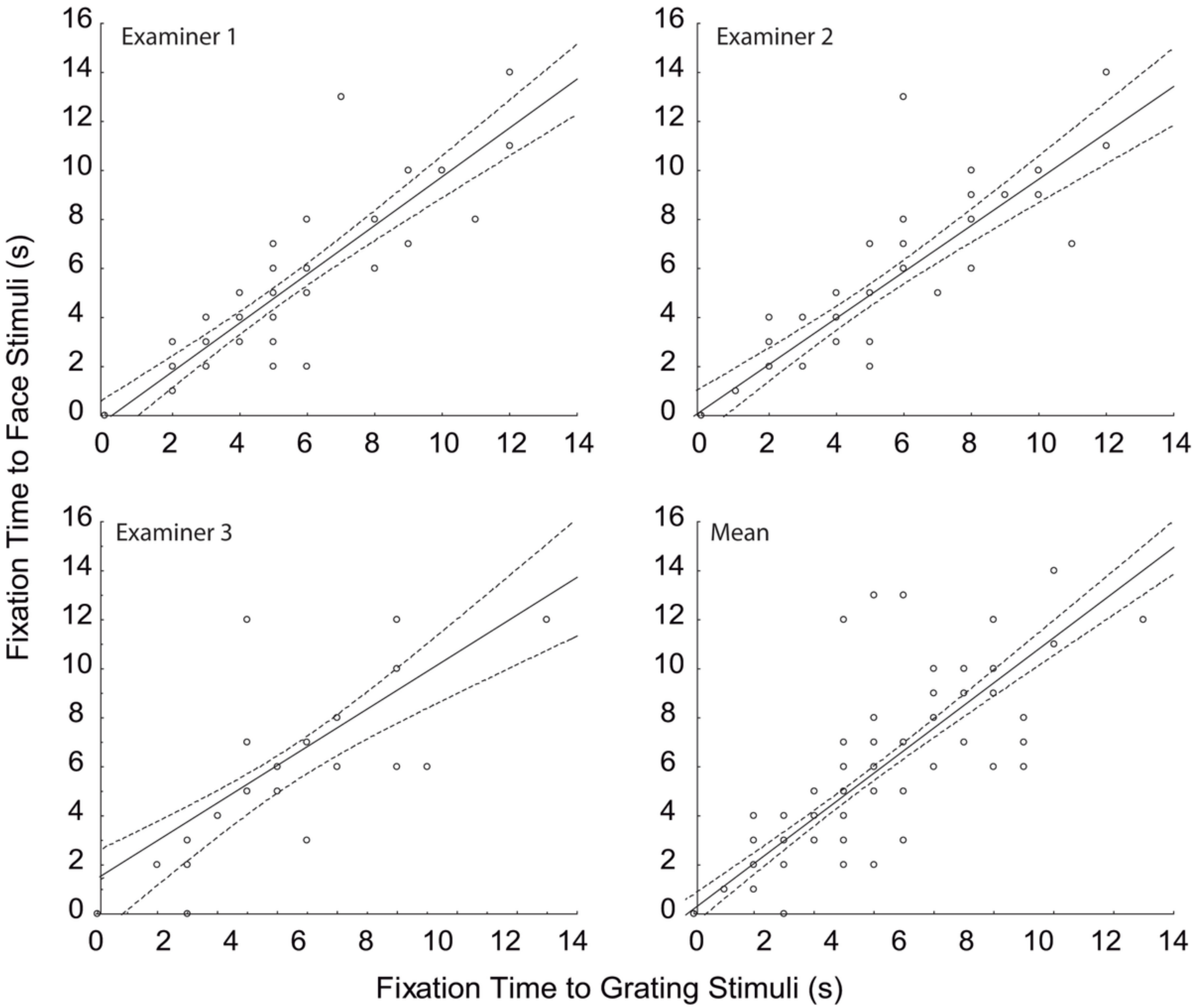

Figure 2

High correlations between time fixating face stimuli and time fixating grating stimuli for all subjects measured in seconds for a total of 3 trials of 5 minutes. Individual correlations were found for all three examiners and for the mean of the examiners. The dotted lines show the confidence interval for the mean calculated for 95% of data.

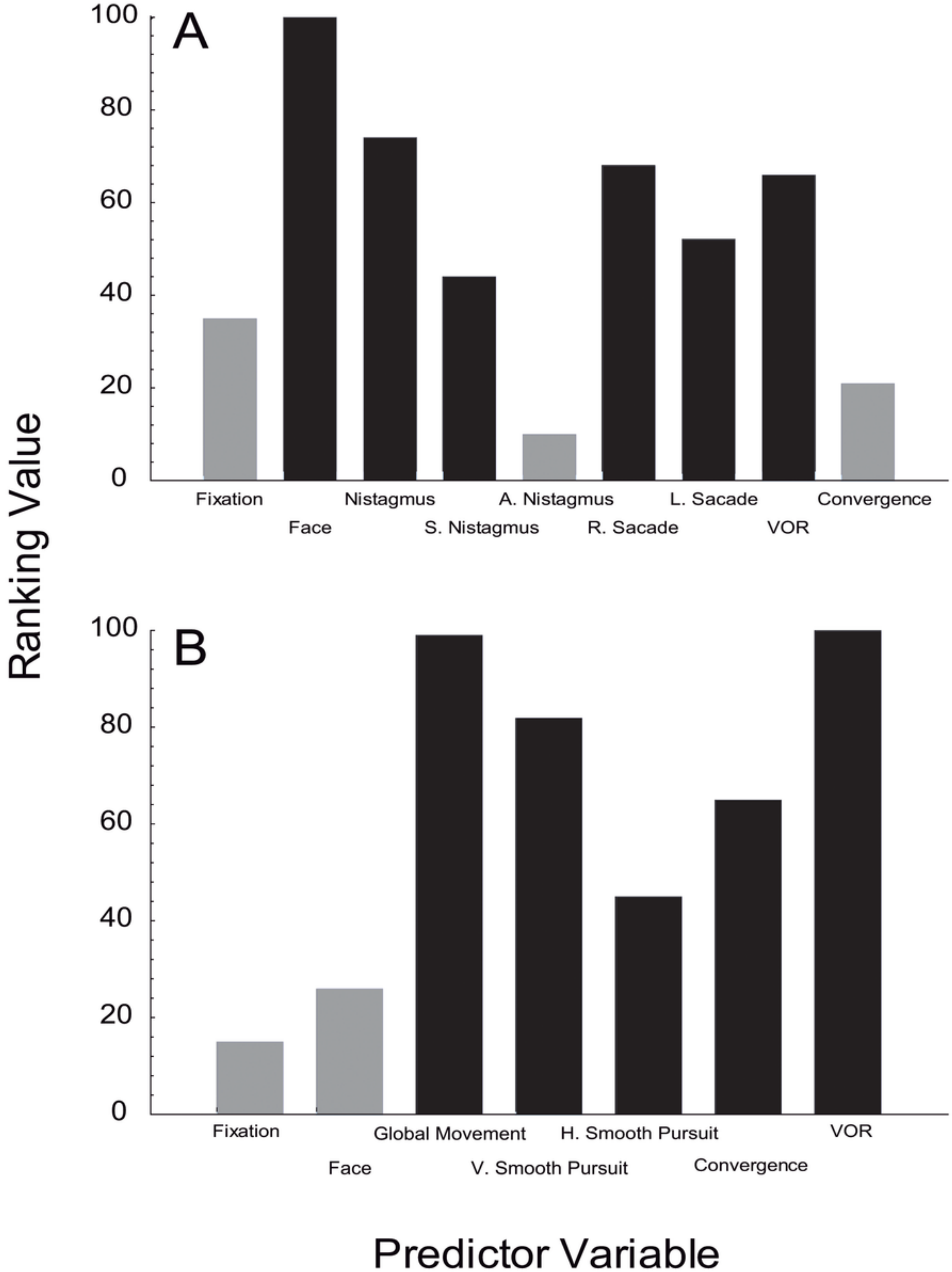

Figure 3

The predictor importance calculated for smile in facial contact and manual reaching movements. A. For the smile for facial contact, the more predictive visual functions were face perception, saccadic movements and opto-kinetic nystagmus. B. For the manual reaching movement the predictors were vestibule-ocular reflex, smooth pursuit movement, and convergence movement. Legends: Fixation: fixation to grating Stimuli; Face: fixation to face stimuli; VOR: vestibule-ocular reflex; R. and L Saccades:

saccade to right and to left gaze; H and V Smooth Pursuit: horizontal and vertical smooth pursuit movements; S. and A. Nystagmus: symmetric and asymmetric optokinetic nystagmus.