Research in Developmental Disabilities xxx (2010) xxx–xxx

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population

Céline Cavézian [a,b,c], Marc Vilayphonh [a,b], Maria de Agostini [d], Vivien Vasseur [e], Laurence Watier [f], Seta Kazandjian [a,b], Laurent Laloum [g], Sylvie Chokron [a,b,c,*]

[a] Laboratoire de Psychologie et NeuroCognition, CNRS, UMR5105, Université Pierre Mendès France, 1251 Avenue Centrale, Domaine Universitaire, BP 47, 38040 Grenoble Cedex 9, France
[b] ERT TREAT Vision, Fondation Ophtalmologique Rothschild, 25 rue Manin, 75019 Paris, France
[c] Service de Neurologie, Fondation Ophtalmologique Rothschild, 25 rue Manin, 75019 Paris, France
[d] CESP – U 1018, Equipe 10, 16 Avenue Paul Vaillant-Couturier, 94807 Villejuif, France
[e] Service d'Ophtalmologie, Fondation Ophtalmologique Rothschild, 25 rue Manin, 75019 Paris, France
[f] INSERM U657/PhEMI, Institut Pasteur (Pharmacoepidemiology and Infectious Diseases, Pasteur Institute), Bâtiment Laveran, 25 rue du Docteur Roux, 75724 Paris Cedex 15, France
[g] Service d'Ophtalmologie, Centre Hospitalier National des Quinze-Vingts, 28 rue de Charenton, 75571 Paris Cedex 12, France

ARTICLE INFO

Article history:
Received 4 March 2010
Accepted 22 March 2010

Keywords:
Children
Screening
Neurovisual disorders
Ophthalmological disease

ABSTRACT

In young children, visual attention, analysis or memory is only rarely evaluated. Moreover, tools to test for such higher-order visual capacities in children are limited. In an attempt to develop and refine such tools, we selected nine tests to assess visuo-attentional abilities before formal reading education (grade 1). The battery consisted of gaze fixation, visual field, visual extinction, binocular visual pursuit, visual memory, "A" cancellation, Teddy bears cancellation, embedded figures, and matching tasks. This battery was used in the general population ($n = 110$) to calculate cut-off scores identifying the lower 5% of the general population to obtain a screening measure for neurovisual disabilities in children. To evaluate our battery's sensitivity and specificity to neurovisual disorders over ophthalmological diseases, a neurovisual group ($n = 9$) and an ophthalmologic group ($n = 13$) also completed the tests. Overall, all but three tests of the battery could be used to discriminate between neurovisual and ophthalmologic children. The ophthalmologic children failed the visual field extent examination and the cancellation tasks, consistent with deleterious effects of ophthalmologic disease on visual perception as well as higher-order vision. Using the cut-off scores, the battery identified only 2 out of 13 ophthalmologic patients, but 5 out of 9 neurovisual patients. In the general population, these cut-off scores identified seven children. These children were previously undiagnosed with any disability (i.e., no diagnosis of ophthalmological, neurological, or psychiatric disease) and thus did not receive any rehabilitation. This preliminary study highlights the necessity for a neurovisual disorder screening tool for young children.

* Corresponding author at: ERT TREAT Vision, Fondation Ophtalmologique Rothschild, 25 rue Manin, 75019 Paris, France. Tel.: +33 01 48 03 66 72; fax: +33 01 48 03 68 59.
E-mail address: sylvie.chokron@gmail.com (S. Chokron).

0891-4222/$ – see front matter © 2010 Published by Elsevier Ltd.
doi:10.1016/j.ridd.2010.03.006

1. Introduction

It is common knowledge that a child cannot learn to read text if he/she is unable to correctly see the words or letters. In light of this, several countries (including France) developed a systematic screening method for ophthalmologic disorders in young children (around grade 1) to avoid the deleterious effects of such impairments on academic performance and learning. Nevertheless, this assessment tests almost only for visual acuity. Despite the fact that 'seeing' implies more than just the eye, testing of higher-order visual functions (i.e., visual cognition) is often limited to young patients known to be at risk for a neurovisual disorder (e.g., following brain damage or in very pre-term infants) (Dutton et al., 2004). Higher-order visual functioning is rarely assessed in young children in the general population or in children with learning difficulties. Yet, such an assessment may be of interest. First, improvements in general medical care have led to an increase in the survival rate of pre-term and/or children who have survived a perinatal asphyxia. Second, neurological abnormalities are often observed in these populations. In particular, periventricular leukomalacia is the most common neurological "lesion" in pre-term children with neurovisual disorders and often concerns posterior areas (occipital and parietal lobes) (Eken, de Vries, van der Graaf, Meiners, & van Nieuwenhuizen, 1995; Jacobson, Lundin, Flodmark, & Ellström, 1998). Additionally, it has been shown that visually impaired, full-term children displayed signs of cerebral dysfunction and/or anatomical abnormalities (Grönqvist, Flodmark, Tornqvist, Edlund, & Hellström, 2001). Overall, current opinion holds that numerous visual disorders in children might be related to neurological abnormalities (Blohmé & Törnqvist, 1997; Rosenberg et al., 1996) instead of ocular disease (which was predominant in the past; Lindstedt, 1972). Moreover, it has been shown that neurovisual disorders can delay or even prevent several academic skills, such as reading or arithmetic skills (Bull, Espy, & Wiebe, 2008). Indeed, some studies introduced the possibility that visual cognition (Watson et al., 2003), and not only visual perception (Helveston et al., 1985), is strongly related to reading and arithmetic skills in elementary school children. Altogether, this data suggests that the general population likely includes children (born pre-term or full-term, with or without known visual impairment or learning difficulties) with an abnormal cerebral functioning responsible for neurovisual impairment. Yet, it is likely that these children are left undetected in the general population.

The lack of standardized tools validated and adapted for young children largely contributes to this absence of systematic evaluation of visuo-attentional functions. To try to fill in this gap, we selected nine simple tests to develop a battery assessing for the main neurovisual functions and screening for children with a possible neurovisual disorder. Cut-off scores were determined from the performance of a large group of control children, and the specificity and sensitivity of our test battery was investigated through the performance of two groups of patients (children suffering from an ophthalmological disease or a neurovisual disorder).

2. Methods

2.1. Participants

The control group included 110 right-handed children (49 girls, 61 boys; mean age ± Standard Deviation (SD) = 5.36 ± .56 years) from the general population and recruited in schools in Paris (France) and its surroundings. Six showed refraction ophthalmological disorders (i.e., hypermetropia, myopia). Right-handed children of the ophthalmologic group (n = 13; 7 girls, 6 boys; mean age ± SD = 5.29 ± .46 years) were recruited in the Ophthalmology Department of the Fondation Ophtalmologique de Rothschild (Paris, France). They suffered from a convergent or divergent strabismus, amblyopia, cataract, treated macular exudation or retinal detachment (in the context of Coats' disease), with or without a refraction disease (myopia, astigmatism, or hypermetropia). Moreover, seven of them received orthoptic therapy. Finally, a neurovisual group composed of 9 right-handed patients (6 girls, 3 boys; mean age ± SD = 5.40 ± .78 years) with visual cognitive impairment (e.g., visual field defect, impaired gaze orientation, altered selective attention, visual agnosia, or optic ataxia) was recruited in the Neurology Department of the Fondation Ophtalmologique de Rothschild (Paris, France). The three groups (summarized in Table 1) were matched for age ($F(2,129) = .13$; $p = .87$). No child suffered from severe auditory or comprehensive difficulties, mental retardation, diplopia, psychiatric disease, or received treatments interfering with attentional skills (e.g., benzodiazepines, antipsychotics, soporifics, etc.), and all were able to read the R1/2 or R1/3 line on the Rossano Weiss R2 chart with at least one eye. All children participated in this study only after informed consent was obtained from their parents and after administrative authorizations (from schools) were obtained.

2.2. The neurovisual battery

Nine simple tests, with no time restrictions, were proposed to assess gaze fixation, visual field extent, visual extinction, visual pursuit, working memory, selective attention and visual exploration (cancellation tasks), fine visual analysis,

Table 1
Demographic characteristics of the control, ophthalmologic and neurovisual groups.

	Controls (n = 110)	Ophthalmologic (n = 13)	Neurovisual (n = 9)	p
Age (years)	5.36 ± .56	5.29 ± .46	5.40 ± .78	n.s.
Male/female ratio	61/49	6/7	4/5	n.s.

n.s.: non-significant difference between groups.

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006

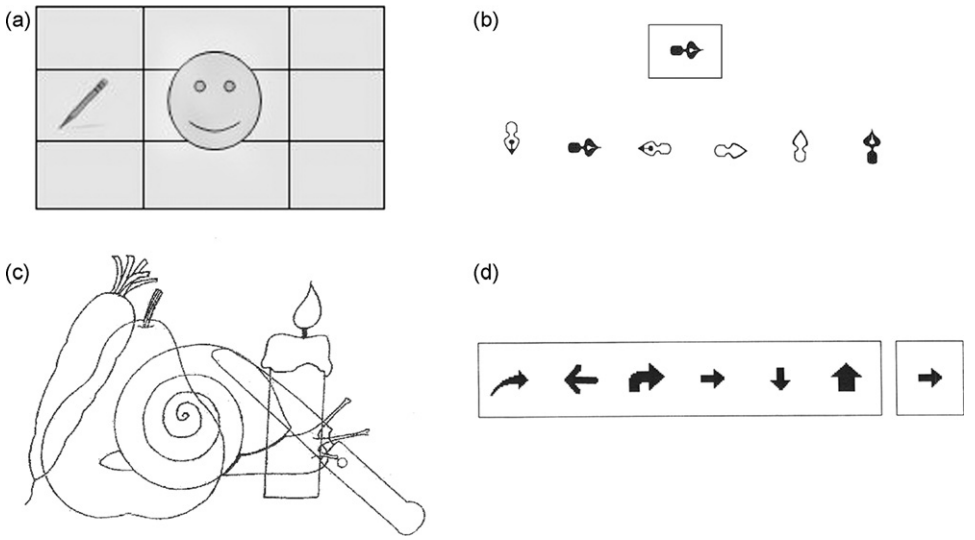

Fig. 1. Illustration of the procedure in visual field test (a), and examples of items used in the visual memory (b) with the target to be memorized at the top, in the embedded figures (c), and in the matching (d) tasks.

simultagnosia (i.e., the inability to recognize objects when presented simultaneously although the ability to recognize individual object is preserved), local and global attention (embedded figures test), and simple perception (shape matching task). The different tasks were completed individually, in a quiet room either at school (for the control group) or at the Fondation Ophtalmologique Rothschild, Paris, France (for patients) and in the following order:

1. Gaze fixation: The child is asked to look at the experimenter's eyes and to maintain his/her gaze (i.e., without moving his/her eyes or head) for 10 s. One point was attributed when no saccade was observed.
2. Visual field test: The child is asked to close his/her eyes and, when requested by the experimenter, to open his/her eyes, to fixate on the experimenter's nose, and to catch the target (a pen held in the experimenter's hand) *without* moving his/her head or eyes. The target is presented at a distance of 30–40 cm from the child, either in the right or left visual field. Presentation is made in the upper, the middle, or the lower part of the lateral visual field. Each position is tested twice for a total of 12 trials (Fig. 1a). One practice trial is conducted to ensure the child understand the instructions. The number of correct catches *without* head or eye movements determines the score.
3. Visual extinction: As in the previous task, the child is asked to close his/her eyes, then to open them and to fixate his/her gaze on the experimenter's nose. This time he/she is required to catch two pens, each one being presented in one visual field. If the child is able to do so, one point is attributed. Note that compared to the previous task, eye and head movements are tolerated here.
4. Binocular visual pursuit: The participant is asked to fixate on a target (a pencil) and to follow its displacement with his/her gaze, without moving his/her head. The target is moved such as to form the infinite symbol ("∞") crossing at the mid-sagittal plane of the child and extending until the child's shoulders, and at a speed of 10 cm/s. One point is attributed for each of the following abilities when present (for a total score of 3): (i) the child's eyes are always on the target; (ii) no head movement; and (iii) smooth pursuit (i.e., no nystagmus).
5. Visual memory (Fig. 1b): Sixteen pages (21 cm $\times$ 29.7 cm, landscape orientation), organized by pairs, are successively presented in front of the child. The first page of the pair is presented for 7 s during which the child has to memorize a target stimulus (a black geometric shape) on the centre of the page. After this delay, a second page, which presents the target among five distractors close in shape, is placed in front of the child. He/she is asked to find the previously memorized stimulus. One point is attributed for each target correctly recognized for a maximum score of 8 points.
6. Teddy bears cancellation test (Laurent-Vannier, Chevignard, Pradat-Diehl, Abada, & de Agostini, 2006): the participant is asked to cross out, with the pencil in his/her dominant hand, all the teddy bears ($n = 15$) distributed on the page (21 cm $\times$ 29.7 cm, landscape orientation) among 60 distractors (simple drawings such as a shoe). The number of correctly cancelled targets constitutes the score.
7. "A" cancellation task (Corkum, Byrne, & Ellsworth, 1995): the child is required to cross out all the "A" letters in upper case ($n = 15$) presented among 45 distractors ("A" letter in a different orientation). As in the previous task, the number of correctly cancelled targets determines the score.
8. Embedded Figures Test (Fig. 1c): Seven boards (21 cm $\times$ 29.7 cm, portrait orientation) are successively presented in front of the child. Each page presents a superposition of outlines of common objects (ranging from 2 to 7 objects with a total of 23 object drawings). Participants are asked to identify as many objects as he/she can see. One point is attributed for each

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006

correct response for a maximum score of 23 points. Note that one supplementary board showing 2 drawings is initially presented to ensure the child correctly understood the instructions.

9. Matching test (Fig. 1d): Eight sheets of paper (21 cm × 29.7 cm, landscape orientation) with seven black and white drawings (geometric shapes, horizontally aligned) are individually and successively presented in front of the child. The seven stimuli consists of one target shape presented on one side of the sheet, and a line of six stimuli (the target and five distractors). In half of the trials, the target model is on the left side and in the other half of the trials it is on the right side of the sheet of paper. Each child is asked to match the target stimuli. The number of correct responses constitutes the score.

2.3. Data analyses

First, the specificity of the test battery was investigated using an Analysis of Variance (ANOVA) comparing the three groups' mean scores within each test. Post hoc analyses (LSD test) were run to detail the group effect when the group effect was significant (α-level set to .05). Second, cut-off scores were determined following a previously used procedure (Dellatolas, Watier, Giannopulu, & Chevrie-Muller, 2007; Watier, Dellatolas, & Chevrie-Muller, 2006) and using a dichotomous variable (pass vs. fail) with a 5% threshold (arbitrarily chosen). In other words, within each test, the score isolating 5% (or the closest to 5%) of control children with the worst performance determined the cut-off score. Note that when at least two scores isolated the same percentage, indicating a weak discrimination in the control population, the lowest score was always chosen as the cut-off score to ensure that an excessive number of children in the other groups were not selected. Thus, for each test a cut-off score was determined. Scores above the cut-off were passing scores, and scores below or at the cut-off were considered failing scores. This pass/fail dichotomy was used for the overall battery to determine the number of tests failed by 5% (or the closest to 5%) of the general population. This criterion was then used, within each group, to determine the number of participants suspected of a neurovisual disorder. All statistical analyses were run with the Statistica software package (version 7.1, 2006).

3. Results

Note that data were missing for 7 control children and 3 neurovisual children for the visual field test, and in 1 ophthalmologic child and 5 neurovisual children for the visual extinction test.

3.1. Battery specificity

The different ANOVAs comparing the mean performance of the three groups in each task (detailed in Table 2) showed a significant group effect in all tasks except the "A" cancellation task (Gaze fixation: $F(2,129) = 6.67$; $p < .01$; Visual field: $F(2,119) = 11.27$; $p < .001$; Visual extinction: $F(2,123) = 8.03$; $p < .001$; Binocular visual pursuit: $F(2,129) = 20.13$; $p < .001$; Visual memory: $F(2,129) = 3.33$; $p < .05$; Teddy bears cancellation: $F(2,129) = 3.47$; $p < .05$; "A" cancellation: $F(2,129) = 1.79$; $p = .17$; Embedded figures: $F(2,129) = 14.80$; $p < .001$; Matching: $F(2,129) = 6.28$; $p < .01$). Post hoc analyses (LSD test) showed poorer performance in the ophthalmologic group than in the control group in the visual field test and in the binocular visual pursuit (both $p < .01$) whereas both groups had similar performance in the gaze fixation, the extinction test, the visual memory task, the teddy bears cancellation, the embedded figures, and the matching task (all $p > .15$). The neurovisual group showed poorer performance than the control group in all tasks (but the "A" cancellation with no significant group effect; all $p > .05$), and poorer performance than the ophthalmologic group in the gaze fixation, the extinction test, the binocular visual pursuit, the visual memory task, the embedded figures, and the matching test (all $p < .05$). Nevertheless, the neurovisual group and the ophthalmologic group showed similar performance in the visual field test and the teddy bears cancellation (both $p > .20$).

3.2. Cut-off scores

From the performance distribution of the control group, cut-off scores with a threshold of 5% were as follows: 0 for gaze fixation (13 children; 11.82%), 6 on the visual field test (2 children, 1.94%), 0 on the visual extinction test (1 child; .91%), 0 on

Table 2
Performance of the three groups in the different tasks of the battery. In the left column, the maximum score is indicated between brackets.

	Controls	Ophthalmologic	Neurovisual
Fixation (1)	0.88 ± .32	0.85 ± .37	0.44 ± .53
Extinction (1)	0.99 ± .09	1,00 ± .00	0.75 ± .50
Visual field (12)	11.82 ± 1.32	9.91 ± 3.59	9.33 ± 4.84
Visual pursuit (3)	2,65 ± .71	1.85 ± 1.14	1.11 ± 1.17
Visual memory (4)	3.54 ± .74	3.61 ± .77	2.89 ± .78
Teddy bears cancellation (15)	14.85 ± .45	14.61 ± .77	14.33 ± 1.66
"A" cancellation (15)	13.11 ± 1.98	13.15 ± 1.68	11.78 ± 3.15
Embedded figures (23)	22.08 ± 1.33	21.92 ± 1.38	18.56 ± 5.41
Matching (8)	7.54 ± .84	7.92 ± .28	6.56 ± 1.94

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006

the binocular visual pursuit (3 children; 2.73%), 1 on the visual memory test (2 children, 1.82%), 13 on the Teddy bears cancellation task (2 children, 1.82%), 9 on the "A" cancellation test (6 children, 5.45%), 18 on the embedded figures task (3 children, 2.73%), and 2 on the matching test (1 child, .91%).

From these scores, the number of tests successfully completed by each control child was calculated. Then, the distribution of the control group in the whole battery was used to establish the cut-off of the battery. Note that in this analysis, 7 control children with missing data (in the visual field test) were discarded. Results showed that 6.80% of the control group (7 children) successfully completed less than eight tasks. Thus, one can consider that 2 or more failed tests may suggest a neurovisual disorder. Applied to our three groups, 7 out of 110 controls, 2 out of 13 ophthalmologic, and 5 out of 9 neurovisual children failed the battery. In screened controls, failures were mainly observed in the gaze fixation ($n = 4$) and the "A" cancellation ($n = 4$) tests. Nevertheless, deficits were also observed in the visual field ($n = 2$), the binocular visual pursuit ($n = 2$), and the embedded figures ($n = 2$) tests and to a lesser extent in the visual extinction ($n = 1$), the visual memory ($n = 1$), the Teddy bears cancellation ($n = 1$), and the shape matching ($n = 1$) tasks. These results strongly suggest that ocular motor control and selective attention are impaired more often than other functions in these screened children. Although a full neuropsychological examination (of visual cognition) was proposed to each of these seven control children, only one child subsequently was evaluated. It is noteworthy that the examination confirmed the presence of neurovisual disorders (alteration of: selective attention orientation, visuo-spatial representation, and constructive praxis; signs of simultagnosia and optic ataxia) in this child.

4. Discussion

Our study aimed to assess visuo-attentional abilities in young children from the general population in comparison to young children with a neurovisual or an ophthalmological disorder. Overall, all children, both healthy controls and patients, were able to complete the selected tasks confirming the adequacy of our instrument for such populations.

Between-group comparisons revealed significant group differences in all tests except the "A" cancellation task. In contrast to other cancellation tasks able to assess visuo-attentional defects in adults (e.g., Bells cancellation; Gauthier, Dehaut, & Joanette, 1989) or in children (e.g., Laurent-Vannier et al., 2006), the lack of significant group effect in this test suggests that the "A" cancellation task may be too easy, and thus not sensitive enough, to discriminate between controls, ophthalmological, and neurovisual children. Nevertheless, it is noteworthy that our neurovisual group still presents the lowest score in this task. Further studies are needed to assess the sensitivity of the A cancellation task when assessing a visuo-attentional deficit in children.

The ophthalmologic group differed from the control group only in the visual field test and the binocular visual pursuit task. This is not surprising in that a peripheral visual disease such as cataract or strabismus can alter these oculo-motor functions of the visual system. On the other hand, the neurovisual group differed from the control group in all tasks (except the "A" cancellation as mentioned above). This is consistent with the known ability of these tests to detect and diagnose neurovisual disorders in adults, such as visual extinction (Rapcsak, Watson, & Heilman, 1987), unilateral spatial neglect or defective selective attention (cancellation task; Gauthier et al., 1989), visual working memory deficit (Wechsler, 1987), or simultagnosia (embedded figures; Gainotti, D'Erme, & Bartolomeo, 1991). Moreover, the neurovisual group performed poorly in 6 out of the 9 tests in comparison to the ophthalmologic patients. This showed that except for the two cancellation tasks and the visual field extent examination, our tests detected (quite logically) larger impairments in patients with a neurovisual disorder than in patients with an ophthalmologic disease. It is noteworthy that a similar degree of deficit in the cancellation tasks and the visual field test can be expected. Indeed, it has been shown that a peripheral disease (such as amblyopia, optic nerve atrophy, ocular albinism) can alter high-order visual processing (Grönqvist et al., 2001; Maurer, Mondloch, & Lewis, 2007). The ophthalmologic diseases included in the present study (amblyopia, strabismus, cataract, with or without refraction deficit), could thus be responsible for decreased visuo-attentional abilities in young ophthalmologic patients even when they received an appropriate ophthalmological treatment or rehabilitation. On the other hand, this result also raised the question of a complementary attentional training in this population. Further studies are obviously needed to further assess attentional capacities in ophthalmologic children. Finally, regarding the visual field extent, its integrity depends upon the peripheral visual system (i.e., from the eye to the optic chiasm), but also upon the central visual system (from the optic chiasm to the occipital lobe). Thus, both a peripheral and a central lesion can alter visual field extent (e.g., retinitis pigmentosa vs. homonymous hemianopia) (Lim, Siatkowski, & Farris, 2005).

Altogether, group comparisons suggest that the selected tests are specific and sensitive enough to discriminate between control, ophthalmologic, and neurovisual children, and thus may be used to screen for neurovisual impairment in children from the general population. Cut-off scores, calculated for a threshold of 5%, confirmed this assumption. The overall battery isolated only 2 ophthalmologic patients out of 13 (15.38%) and 5 neurovisual patients out of 9 (55.56%). Whereas the number of ophthalmologic children screened with that battery is consistent with the (expected) low sensitivity of our battery to such types of disorders, the number of neurovisual children screened looked low. Nevertheless, one should consider that children with neurovisual disorders were recruited in a neurological department where most of them came for rehabilitation. Thus, several children from our neurovisual group were probably familiar with several of the tasks in our battery (e.g., visual fixation, cancellation tasks, ...). Overall, our battery may not screen for neurovisual children under rehabilitation because of a practice effect to several of our tasks.

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006

Finally, in the general population, our tests detected 7 out of 110 children (6.8%). None of these children were previously identified as having any medical disability (i.e., neurological or psychiatric diagnosis) and only one of them was treated for an ophthalmological disorder (i.e., myopia, which was corrected to-normal). Thus, these children had never received any appropriate remedial interventions. The current study suggests that even when visual acuity is considered as normal, children can be impaired in their visual functioning. Consistent with previous reports (Blohmé & Törnqvist, 1997; Rosenberg et al., 1996), a (functional) neurological abnormality, and not an ocular disease, may be responsible for visual impairments in children. In turn, this confirms the need to develop a screening instrument to detect such a deficit in the general population. Such an instrument is particularly needed for young children to avoid the deleterious consequences of visual impairment on academic learning (Watson et al., 2003).

A final important point is that of follow-up. The selected tests appear to be well-adapted for screening in young children. However, it is very important that the screenings are followed through with more exhaustive testing. Although seven children were suspected to have a neurovisual disorder, only one of them followed through for further examination (for which the suspicion of a neurovisual disorder was confirmed). Continuing studies are needed to confirm the sensitivity of this battery of tests and to determine the exact proportion of children suffering from neurovisual impairment in the general population. Furthermore, a system that facilitates the follow-up testing of detected children must be incorporated. This is important not only for providing a proper diagnosis, but also to treat these previously 'overlooked' children with the appropriate interventions.

5. Conclusion

The present study assessed visuo-attentional abilities in young children from the general population, without confounding the impairments with those due to an ophthalmological disease. Although a peripheral visual disorder should always be taken into account when a child presents a visual cognitive impairment, our data highlighted that even when visual acuity is normal children can suffer from impaired vision.

Due to the deleterious consequences of a higher-order visual function deficit on learning abilities (Watson et al., 2003), the present findings raise the question of a systematic neurovisual screening in young children in addition to the ophthalmologic screening already completed in grade 1. Several studies have repeatedly reported the presence of visual analysis disorders in children with autistic traits (for review Trachtman, 2008). For example, visual perceptual problems can strain social interactions because they affect many aspects of social communication – perception of facial expressions, gestures, movement, and the environment in general (Jambaqué, Mottron, Ponsot, & Chiron, 1998; Mottron et al., 1997). Thus, the present study also raises the question of the effects of neurovisual disorder on behavioural and social development. Second, our data also suggest that even treated, a peripheral visual disorder can alter higher-order visual functions, such as attention. Future research should assess visuo-attentional functions in the latter population and the possible necessity to add attention rehabilitation to the classical ophthalmological treatment. Finally, to a large extent, the present battery would not only provide epidemiologic data (unfortunately missing in this domain) about neurovisual disorders in young children but would also give the opportunity to provide detected children with rehabilitation specific to neurovisual disorders (Chokron et al., 2008).

Competing interest

None declared.

Acknowledgements

This research was supported by the Edmond and Benjamin de Rothschild Foundations (Geneva, Switzerland, and New York, USA) and by the French Health Ministry (Grant from the Direction Générale de la Santé, Paris, France). The second author, MV, was supported by a MNERT grant attributed to Pierre Mendès-France University, Grenoble, France.

References

Blohmé, J., & Törnqvist, K. (1997). Visual impairment in Swedish children. III. Diagnoses. *Acta Ophthalmoogical Scandinavica, 75*, 681–687.

Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology, 33*, 205–228.

Chokron, S., Perez, C., Obadia, M., Gaudry, I., Laloum, L., & Gout, O. (2008). From blindsight to sight: Cognitive rehabilitation of visual field defects. *Restorative Neurology and Neuroscience, 26*, 305–320.

Corkum, V., Byrne, J. M., & Ellsworth, C. (1995). Clinical assessment of sustained attention in preschoolers. *Child Neuropsychology, 1*, 3–18.

Dellatolas, G., Watier, L., Giannopulu, I., & Chevrie-Muller, C. (2007). Comportement perturbateur, difficultés d'attention et apprentissages entre 3,5 ans et 8 ans: une étude longitudinale en milieu scolaire. *Archive of Pediatry, 14*, 227–233.

Dutton, G. N., Saaed, A., Fahad, B., Fraser, R., McDaid, G., McDade, J., et al. (2004). Association of binocular lower visual field impairment, impaired simultaneous perception, disordered visually guided motion and inaccurate saccades in children with cerebral visual dysfunction—A retrospective observational study. *Eye, 18*, 27–34.

Eken, P., de Vries, L. S., van der Graaf, Y., Meiners, L. C., & van Nieuwenhuizen, O. (1995). Haemorrhagic-ischaemic lesions of the neonatal brain: Correlation between cerebral visual impairment, neurodevelopmental outcome and MRI in infancy. *Developmental Medicine and Child Neurology, 37*, 41–55.

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006

Gainotti, G., D'Erme, P., & Bartolomeo, P. (1991). Early orientation of attention toward the half space ipsilateral to the lesion in patients with unilateral brain damage. *Journal of Neurology, Neurosurgery, and Psychiatry, 54*, 1082–1089.

Gauthier, L., Dehaut, F., & Joanette, Y. (1989). The bells test: A quantitative and qualitative test for visual neglect. *International Journal of Clinical Neuropsychology, 11*, 49–53.

Grönqvist, S., Flodmark, O., Tornqvist, K., Edlund, G., & Hellström, A. (2001). Association between visual impairment and functional and morphological cerebral abnormalities in full-term children. *Acta Ophthalmologica Scandinavica, 79*, 140–146.

Helveston, E. M., Weber, J. C., Miller, K., Robertson, K., Hohberger, G., Estes, R., et al. (1985). Visual function and academic performance. *American Journal of Ophthalmology, 99*, 346–355.

Jacobson, L., Lundin, S., Flodmark, O., & Ellström, K.-G. (1998). Periventricular leukomalacia causes visual impairment in preterm children. *Acta Ophthalmologica Scandinavica, 76*, 593–598.

Jambaqué, I., Mottron, L., Ponsot, G., & Chiron, C. (1998). Autism and visual agnosia in a child with right occipital lobectomy. *Journal of Neurology, Neurosurgery, and Psychiatry, 65*, 555–560.

Laurent-Vannier, A., Chevignard, M., Pradat-Diehl, P., Abada, G., & de Agostini, M. (2006). Assessment of unilateral spatial neglect in children using the Teddy Bear Cancellation Test. *Developmental Medicine and Child Neurology, 48*, 120–125.

Lim, S. A., Siatkowski, R. M., & Farris, B. K. (2005). Functional visual loss in adults and children patient characteristics, management, and outcomes. *Ophthalmology, 112*, 1821–1828.

Lindstedt, E. (1972). Severe visual impairment in Swedish children. *Documenta Ophthalmologica, 31*, 173–204.

Maurer, D., Mondloch, C., & Lewis, T. L. (2007). Effects of early visual deprivation on perceptual and cognitive development. *Progress in Brain Research, 164*, 87–104.

Mottron, L., Mineau, S., Décarie, J. C., Jambaqué, I., Labrecque, R., Pépin, J. P., et al. (1997). Visual agnosia with bilateral temporo-occipital brain lesions in a child with autistic disorder: A case study. *Developmental Medicine and Child Neurology, 39*, 699–705.

Rapcsak, S. Z., Watson, R. T., & Heilman, K. M. (1987). Hemispace-visual field interactions in visual interaction. *Journal of Neurology, Neurosurgery, and Psychiatry, 50*, 1117–1124.

Rosenberg, T., Flage, T., Hansen, E., Riise, R., Rudanko, S., Viggosson, G., et al. (1996). Incidence of registered visual impairment in the Nordic child population. *British Journal of Ophthalmology, 80*, 49–53.

StatSoft. (2006). *Statistica for windows. Version 7.1*. Tulsa, OK, USA: StatSoft.

Trachtman, J. N. (2008). Background and history of autism in relation to vision care. *Optometry, 79*, 391–396.

Watier, L., Dellatolas, G., & Chevrie-Muller, C. (2006). Difficultés de langage et de comportement à 3 ans et demi et retard en lecture au cours élémentaire. *Revue d'Epidemiologie et de Santé Publique, 54*, 327–339.

Watson, C. S., Kidd, G. R., Homer, D. G., Connell, P. J., Lowther, A., Eddins, D. A., et al. (2003). Sensory, cognitive, and linguistic factors in the early academic performance of elementary school children: The Benton-IU project. *Journal of Learning Disabilities, 36*, 165–197.

Wechsler, D. (1987). *Wechsler memory scale revised. The psychological corporation*. Harcourt Brace Jovanovich Inc.

Please cite this article in press as: Cavézian, C., et al. Assessment of visuo-attentional abilities in young children with or without visual disorder: Toward a systematic screening in the general population. *Research in Developmental Disabilities* (2010), doi:10.1016/j.ridd.2010.03.006