THE IMPACT OF CONTRAST SENSITIVITY ON PERFORMANCE ON THE SONKSEN PICTURE GUIDE TO VISUAL FUNCTION

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Abstract

The Sonksen picture guide to visual function (SPGVF) was developed to assess the ability to discriminate everyday objects and pictures. Sonksen added the SPGVF to tests of visual acuity, because real objects, miniatures and pictures are the main learning medium for young children. Knowledge of a child's functional vision for pictures can be very helpful for practitioners in early intervention programs for visually impaired children for giving correct advice to parents and teachers and for implementing adequate intervention strategies. Associations have been found between visual acuity and responding on the SPGVF. However, no studies have been done with visually impaired children, who have totally different visual experiences than sighted children, and, therefore, a different knowledge base to rely on by making responses in the SPGVF task. In the current study the associations between performance on the SPGVF task and visual acuity and contrast sensitivity were studied. The subjects were 17 visually impaired, 10 deaf, and 29 normal children, 4-6 years old. The children were tested at school or a regional health care center. All lighting conditions were adapted when necessary, so that illumination levels ranged between 650-800 lux. The contrast sensitivity functions were converted to single values. The results showed that visual acuity was more important for picture recognition than contrast sensitivity. Contrast sensitivity below the calculated value of 30 implied that not all SPGVF-pictures could be recognized.

Introduction

Several attempts have been made to measure every day visual discrimination and visual functioning of infants, children and adults. Among the more well known are the Diagnostic Assessment Procedure (DAP) of the program to develop efficiency in visual functioning of Barraga (1980) and the Look and Think checklist (Bozic, 1995; Chapman, Tobin, Tooze, & Moss, 1989). Both these checklists are part of an intervention program to stimulate visual development of young children. Bishop (1988) promotes the use of homemade observation scales to assess the visual functioning of visually impaired infants, preschool, school aged, and multiply handicapped children. The homemade observation scales typically consist of variables not covered by clinical ophthalmologic vision assessments. These variables are often of a perceptual nature, and heavily influenced by psychological and environmental factors. Sometimes these observation scales are completed with an interview of the parents or a checklist. These interviews and checklists are used to assess all the visual behaviors not observable in a standard vision examination, which is mostly performed in an unfamiliar atypical environment especially for young children (see, e.g., Bolduc, Gresset, Sanschagrin, & Thibodeau, 1993; Hall, Orel-Bixler, Haegerstrom-Portnoy, 1991; Katsumi, Chedid, Kronheim, Henry, Jones, & Hirose, 1998). A serious disadvantage of most observation scales of visual functioning, whether homemade or not, is their lack of psychometric foundations. Interpretations of the results of these instruments rely heavily upon clinical judgement of the observer. A second drawback is that most observation scales are unpublished, and, as a result of that, not available for other practitioners. Exceptions are the earlier mentioned DAP, the Look and Think checklist, the Visual Ability Score (Katsumi et al., 1998), and for those who can read Dutch the visual profiles for professionals (Looijestijn, 1995a), parents (Looijestijn, 1995b), and for use with the Bayley Scales (Looijestijn & Smrkovsky, 1995). The Sonksen Picture Guide to Visual Function (SPGVF) takes into account the aforementioned two disadvantages, although partly. The test is published, but only the instructions not the test materials, and some psychometric properties are known (see Hodes, Sonksen, & McKee, 1994).

Initially the test was developed by Patricia Sonksen to add information about every day discrimination to standardized tests of the minimum observable and minimum separable (Sonksen, 1983). The reasoning behind the test was that: “At nursery age real objects, miniatures and pictures, are the learning medium of sighted children both at home and at the nursery. It is therefore logical to try to assess how well a handicapped child can see such items at different distances” (Sonksen, 1983, p.87). The sets of pictures selected by Sonksen were all from the ladybird ‘Baby’s first Book’ series, and are realistic and life size.

The test is conducted like a game of ‘Grandmother’s Footsteps’, that is the tester starts at a distance of three meters and steps nearer until the picture is identified. Pictures and not objects were chosen, because they have the advantage over objects that they give no clue on touch if vision is so poor that the child needs to peer. Sonksen (1983, p. 88) found: “the test invaluable if done in front of the parents and teachers, who tend to overestimate children’s visual ability while underestimating the way they use any previous experience of the object.” The clinical application of the test is that the results can be used to prescribe the type of visual material suitable for the visually impaired child.

In a second study Sonksen and Macrae (1987) explored the relationship between visual acuity for single optotype Snellen letters at 3 meters or less and vision for realistic life-size pictures for normally sighted children. In these children a refractive error was artificially superimposed. The intentions of this study were first to establish the extent to which children with different degrees of refractive error experience difficulty with picture material. Second, to select a set of pictures, out of o total of 33 pictures, which could be used as a test tool to identify children in need of further visual examination. Third and last, to provide baseline data for a parallel study in visually disabled children. After having superimposed a refractive error, the children were allocated to a control group and five groups according to the measured visual acuity. The results showed that: (a) the distance at which the pictures were recognized diminished as the degree of myopia increased; (b) the visually more simple pictures tended to be identified at greater distances than those of complex or multiple objects; (c) there was an interaction between visual acuity and the complexity of the pictures, that is, the intermediate vision groups showed the most difficulty in identifying the complex pictures; and (d) the size of the Snellen letters seen at three meters was much smaller than that of the component items in a picture only seen clearly at closer distances. Criteria were chosen to group the pictures into three grades of visual complexity. This procedure resulted in the selection of 18 pictures for the final SPGVF. For those 18 pictures the mean, mode, and range of the full identification distance data are given. Sonksen and Macrae (1987) explained the discrepancy between seeing the size of letters and the size of component items in a picture by the fact that colored pictures are more complex than letters, because there is great variation in the spatial and spectral frequencies of the components. Furthermore, there are great differences in contrast between subject and background, in clutter and overlap of the content, and definitive value of silhouette, color, and shape.

Two noteworthy remarks can be made about the Sonksen and Macrae 1987 article. First, although the concluding remark of Sonksen and Macrae (1987, p. 345) was that: "The original clinical application of all the 33 pictures in the assessment of 'Vision for learning' (Sonksen, 1983) is unaffected by the study", the interest of Sonksen apparently shifted from developing a test for everyday discrimination to constructing a screening device. The second remark concerns the fact that a study on the SPGVF with children with abnormal vision is announced but, to my knowledge, never published. The main goal of the current study was therefore to study the SPGVF in a population of visually impaired children. As a result, the SPGVF was not used as a screening device, because the children had known visual impairments, but as an instrument to study every day discrimination. Since the SPGFV was only studied in normally sighted children it is still unknown whether the three complexity levels for the pictures are also valid for visually impaired children. These children have different visual experiences compared to normally sighted children. Their ability to recognize pictures may, therefore, be different. Given the facts that contrast sensitivity greatly affects visual discrimination (Hyvärinen & Lindstedt, 1981) and contrast sensitivity is closely related to visual acuity, especially in visually impaired individuals (Thompson, 1993), we decided to study the impact of contrast on performance on the SPGVF in addition to the effect of visual acuity.
The research questions were:

1) Is there an association between visual acuity and the results on the SPGVF for visually impaired children?
2) What is the impact of contrast sensitivity on the performance on the SPGVF?
3) Are there three complexity levels for the pictures for visually impaired children?

Methods

<u>Subjects</u>

A group of 17 visually impaired children, aged between 4 and 6 years participated in the study. The mean age for the visually impaired children was 5.12 (SD .86). The visual acuity of the visually impaired children ranged from 0.1 to .63. Not all of the children were truly visually impaired. Five children with 0.63 vision were probably not adequately corrected for refractional errors. Four visually impaired children had also serious hearing problems, and visited a school for the deaf. Eight children with visual acuity 10/20 or less were enrolled in the early intervention program of Theofaan, a center for care for visually impaired and blind people. Ten deaf and 29 hearing children without visual impairments were studied as a control group. The mean ages were 5.0 (SD .67) and 5.03 (SD .78), respectively. All subjects passed the vocabulary test of the MacCarthy Developmental Test before actually testing took place. This was done to ensure that the children possessed the necessary language skills (i.e., naming of pictures and pointing to pictures) necessary to complete the tests.

Setting and Materials

The children were studied in the most convenient setting. This could be at school or the regional center of Theofaan. All children were tested alone. The visual test charts were externally illuminated, with illuminance levels ranging between 650-800 lux. Whenever natural illuminance levels were below 650 lux, lamplight was used to achieve the minimum illuminance of 650 lux. The following tests were used:

- Every day discrimination: SPGVF (Sonksen & Macrae, 1987)
- Visual acuity: LH acuity test
- Contrast sensitivity: LH linear contrast test

The SPGVF pictures are not commercially available anymore. Therefore a borrowed set of the original pictures were digitally scanned and printed on high quality paper. For ease of handling during examinations these papers were mounted on plastic cards.

The LH tests were chosen because they are quickly and easily to perform with young children. Moreover, in these tests the optotypes are presented at a distance of 3 meters from the child. This distance corresponds with the starting distance in the SPGVF.

Procedure

After the illuminance was measured and, if necessary, intensified to a minimum of 650 lux the three vision tests were carried out in a fixed order. The examination started with the SPGVF. The discrete pictures were shown in a set order to the child at a distance of 3 meters. After an incorrect response the viewing distance was diminished to 2, 1, 0.5 and less than 0.5 meters, respectively, until the child correctly identified the picture (see also Sonksen & Macrae, 1987). Next, the LH acuity test was performed. The child was asked to name the four LH-optotypes (circle, square, house, and apple) at a distance of three meters. The deaf children could point to one of four identical copies of the LH-optotypes. The LH contrast test was performed last. The maximum number of optotypes seen at 3, 2, 1, 0.5 and <0.5 was noted. All the tests were performed binocular.

Statistical analysis

Contrast sensitivity is normally depicted in a contrast sensitivity function (CSF). In order to be able to correlate the contrast sensitivity with visual acuity and the SPGVF results the CSF was transformed to a single value. This was done by first counting the number of LH optotypes seen in the LH contrast test, this is the raw score. This raw score was transformed to contrast sensitivity values by the formula $Y = 10 * 2^{(0.2X-2)}$, where X is the raw score and X is ≥ 10. For X < 10 the corresponding contrast sensitivity value is given on the score sheet. Next the five contrast sensitivity values were transformed to weighted linear values. Weighting factors were derived from the LH-contrast test score sheet by looking at the corresponding number of cycles per degree for each test distance. The near distance values for distances < 0.5 meters were given a weight of 1. The values measured at 0.5, 1, 2, and 3 meters were weighted with the factor 1.5, 3, 6, and 10 respectively.

Results

The product moment correlations between the 18 SPGVF items and LH visual acuity are shown in table 1, as well as the partial correlation between the SPGVF items and visual acuity after removing the effect of contrast sensitivity. All children saw picture three, a spoon, at three meters. As a result of this lack of variation no correlation could be calculated for this item. All other correlations were high and significant. The partial correlations were only significant for the items: 6, 7, 12, 13, and 17.

The product moment correlations between the 18 SPGVF items and the transformed LH contrast values are also shown in table 1, as are the partial correlations between the SPGVF items and LH contrast sensitivity after removing the effect of visual acuity. Again, no correlations could be calculated for item three. Two additional items did not correlate significantly with contrast sensitivity, pictures two and four. All the other correlations were high and significant. The partial correlations were all non-significant.

Table 1
Linear correlations and partial correlations between SPGVF-items and LH visual acuity and LH-contrast sensitivity

	Visual Acuity		Contrast Sensitivity	
Item	r*	partial r**	r*	partial r***
1 shoe	.59	n.s.‡	.48	n.s.
2 cup	.44	n.s.	n.s.	n.s.
3 spoon	-.-	-.-	-.-	-.-
4 ice cream	.54	n.s.	n.s.	n.s.

5	banana	.68	n.s.	.61	n.s.
6	watch	.83	.64	.71	n.s.
7	telephone	.82	.56	.72	n.s.
8	pencils	.82	n.s.	.77	n.s.
9	glass of milk	.75	n.s.	.67	n.s.
10	apple	.64	n.s.	.62	n.s.
11	car	.53	n.s.	.54	n.s.
12	socks	.78	.52	.68	n.s.
13	sweets	.85	.58	.76	n.s.
14	comb/brush	.89	n.s.	.90	n.s.
15	chocolate	.77	n.s.	.75	n.s.
16	bicycle	.75	n.s.	.69	n.s.
17	orange	.93	.65	.88	n.s.
18	buttons	.80	n.s.	.82	n.s.

* $\underline{p} < 0.05$
** Controlling for contrast sensitivity, $\underline{p} < 0.05$
*** Controlling for visual acuity, $\underline{p} < 0.05$
‡ n.s. = non significant

To study the joint effect of visual acuity and contrast sensitivity 18 multiple regression analyses were performed. Visual acuity was entered first in the analyses, contrast sensitivity second. The variance on items 2, 3, 4, and 11 could not be explained by the visual acuity and contrast sensitivity. For the remainder of the items the explained variance ranged from 0.36 to 0.87. There was no significant additional explained variance when contrast sensitivity was entered as a factor in the equation, probably due to the high collinearity between visual acuity and contrast sensitivity.

To study the possibility that the association between contrast sensitivity and performance on the SPGVF is not linear, we looked for critical values of contrast sensitivity, which could affect performance on the SPGVF. The LH-contrast test results were plotted against the SPGVF results for each testing distance and for each child. The plots showed that, with one exception, whenever a child saw less than 18 LH-contrast optotypes at 0.5, 1, 2 or 3 meters distance it did not recognize all of the SPGVF items. Identifying 18 LH-contrast test optotypes corresponds with a contrast sensitivity value of 30 and a contrast threshold of 3.33%, This suggests there is a critical value for contrast sensitivity to be able to recognize the SPGVF pictures.

Table 2 shows the mean and standard deviations for the identification distances for the three sets of items of the SPGVF for the visually impaired children. Three separate T-tests with Bonferroni post hoc multiple comparisons correction showed that set 1, 2 and 3 differed significantly from each other (each $\underline{p} < .0167$). The ten deaf and 29 hearing children without visual impairments saw nearly all the pictures at three meters, the means ranged from 2.96 – 3.0 meters.

Table 2
Full Identification distance for SPGVF picture sets for visually impaired children

	Mean	SD	
Set 1	2.71	0.50	set 1 – 2, t(df = 16) = 3.21, p = 0.005
Set 2	2.36	0.82	set 1 – 3, t(df = 16) = 3.70, p = 0.002
Set 3	2.12	0.99	set 2 – 3, t(df = 16) = 2.85, p = 0.011

Discussion

The results showed that performance on the Sonksen Picture Guide to Visual Function is highly correlated with visual acuity and hardly with contrast sensitivity. The three sets of pictures of the SPGVF could be clearly identified for the visually impaired children. The deaf and hearing control children saw almost all the pictures at a distance of three meters. The visually impaired children had to see the pictures, especially those from set two and three, at closer distances than the deaf and hearing control children do. Because all the children were able to recognize the picture eventually, it is unlikely that the SPGVF results are influenced by perceptual problems.

The present study does not specify what it is that makes the three sets of pictures differ in the distance of recognition. It could be the complexity level of the pictures, but also differences in contour, hue and saturation of the pictures. In contrast with letter charts the SPGVF-pictures may differ in reflection level, and, as a result, luminance levels could differ per picture. This large number of confounding variables causes the practitioner using the SPGVF to be extremely cautious in extrapolating the results from the SPGVF to everyday discrimination tasks. Note also that young children often look from small distances at books, pictures and drawings, that is reading distance. At this distance most visually impaired children could detect the content of the SPGVF items. It is, therefore, difficult to predict from the results of the SPGVF what kind of reading materials and picture books are suited for visually impaired children. Moreover, the SPGVF contains no line drawings, color photos, and miniature sized pictures. These kind of pictures are also used in books and learning material for young children and should also be implemented in everyday discrimination tasks for young visually impaired children.

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