Quantification of Visual Orienting Responses to Coherent Form and Motion in Typically Developing Children Aged 0–12 Years

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Purpose. Brain damage or brain development disorders can affect (the maturation of) visual processing functions, such as form and motion detection. The aim of our study was to investigate visual orienting responses of children to a coherent form and motion stimulus as a measure for maturation of visual information processing.

Methods. The 213 typically developing children aged 0–12 years included in this study were shown a 100% coherent form and motion expansion stimulus on a remote eye tracking monitor. Orienting eye movements were quantified in terms of ocular motor reaction time to fixation (RTF). Children were divided in age groups, and their performance was compared to 30 healthy adults with a mean age of 24.49 years (SD 3.62 years).

Results. The RTF values of coherent form in children up to six years old were significantly higher compared to the adult group ($P < 0.05$, Dunnett post-hoc test). For motion, mature levels were reached at eight years old. RTF values depended on stimulus type ($F_{1,168} = 240.8$, $P < 0.001$) and age ($F_{11,168} = 25.8$, $P < 0.001$), and there was a significant age by stimulus type interaction ($F_{11,168} = 2.2$, $P < 0.05$).

Conclusions. Remote eye tracking may provide objective insight into the maturation of visual information processing of coherent form and motion without complex instructions or active cooperation. The quantification of typical visual orienting behavior in childhood may be used as a reference for children with brain dysfunction. (*Invest Ophthalmol Vis Sci.* 2012;53:2708–2714) DOI:10.1167/iovs.11-8893

Two classical cortical visual processing streams described in literature are: (1) the ventral stream, which connects the visual cortex with the temporal lobes, and (2) the dorsal stream, which connects the visual cortex with the parietal lobes. The ventral stream, often called the "what" pathway, involves visual processing functions, such as visual orientation, memory, and recognition of objects and faces. The dorsal stream, or "where" pathway, involves spatial cognition, motion sensitivity, simultaneous perception, and visual motor planning.[1,2] It has been thought that form and motion processing can serve as indicators of the ventral and dorsal stream performance, respectively.[3] Form and motion processing have been assessed using psychophysical threshold detection methods. A visual stimulus is shown and repeated stepwise at different levels of coherence to determine thresholds of detection. Children must understand the task, and give a verbal or motor response to identify the presented target (e.g., pressing a button). This makes testing of very young children (<3 years), and children with an intellectual and/or motor disability almost impossible. In view of the postnatal maturation of the visual system, it would be best to detect dysfunctions as early as infancy to adjust daily support and improve individual rehabilitation.

Another method to study visual processing functions is measurement of eye movements during the presentation of visual stimuli. This relates to the behavioral discrimination task preferential looking (PL),[4] in which visual stimuli induce reflexive eye movements to their target area when the visual information is processed by the brain. Quantifying visual orienting responses includes the integrity of the complete visual pathways (peripheral and central), and the ocular motor system.[5–7] Impaired visual orienting responses may relate to an increased risk of higher visual processing dysfunctions, possibly in combination with ocular motor disorders. We developed a remote eye tracking method using this concept to quantify visual orienting behavior in children.[8,9] A variety of stimuli is shown on the monitor, and gaze is measured without giving specific verbal instructions before the test or asking active cooperation. This means that young children (<3 years) and children with an intellectual disability can participate. One of the outcome measures that quantify visual processing is the ocular motor reaction time to a predefined target area of a stimulus.

Previous studies investigating form and motion processing using threshold detection methods show developmental trajectories that appear to depend on stimulus type. Gunn et al. used a coherent form stimulus, which consisted of tangentially oriented line segments, and showed that adult levels were reached at the age of 6–7 years.[10] Lewis et al. studied development of form processing using Glass patterns, and found that maturity was reached between six and nine years of age.[11] Directional motion discrimination was studied by Parrish et al. in children aged 3–12 years.[12] In this study, the performance of a simple global motion perception task did not show significant improvement with age. A more complex motion detection task, in which coherently moving dots oscillated in opposite phase to those in the surrounding region, was studied by Gunn et al.[10] and Spencer et al.[13] They

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Supported in part by a grant from the Novum Foundation, a nonprofit organization providing financial support to (research) projects that improve the quality of life of individuals with a visual impairment (www.stichtingnovum.org).

Submitted for publication October 27, 2011; revised February 4 and March 8, 2012; accepted March 12, 2012.

Disclosure: **F.H. Boot**, None; **J.J.M. Pel**, None; **H.M. Evenhuis**, None; **J. van der Steen**, None

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Investigative Ophthalmology & Visual Science, May 2012, Vol. 53, No. 6

showed that coherent motion detection thresholds reached adult levels at 10–11 years. In conclusion, coherent motion processing seems to show a relatively slow delay in reaching adult levels compared to coherent form processing.

The aim of our study was to investigate if developmental trends exist in ocular motor reaction time to a 100% coherent form and a 100% coherent motion stimulus in typically developing children aged 0–12 years.

Materials and Methods

Study Population

We approached 460 typically developing children 0–12 years old in the region of Rijnmond, Rotterdam, The Netherlands. The children attended regular day care centers or primary schools. Parents were informed about the study by letter and 219 (48%) written consents were received. Children had normal or corrected-to-normal vision, and children with a history of developmental disorders or learning disabilities were excluded. At the time of measurement, three children were unable to attend and three children refused to participate on the day of measurement. This resulted in 213 children who were included in this study (115 females and 98 males, mean age 5.81 years, SD 3.47 years). The performance of the children was compared with a group of 30 healthy adults (18 females and 12 males, mean age 24.49 years, SD 3.62 years) to show mature levels for form and motion processing. A subgroup of 35 children (20 females and 15 males 1–9 years old, mean age 4.44 years, SD 2.32 years) was retested to assess test-retest reliability. The experimental procedures were approved by the Medical Ethical Committee of Erasmus University Medical Center, Rotterdam, The Netherlands (METC-2006-055). The study adhered to the Declaration of Helsinki for research involving human subjects.

Measurement Setup and Procedure

The setup consisted of a 17-inch monitor with an integrated infrared eye-tracking system (Tobii 1750, Tobii Corporation, Sweden). The eye-tracker measured gaze position of each eye separately using cornea reflection at 50 Hz. The experiments were conducted in a quiet room at ambient light conditions, and the monitor was positioned against a uniform background. Each child sat in a comfortable chair, at approximately 60 cm distance of the monitor to ensure efficient tracking of the eyes. The youngest children (4∼12 months old) sat on a parent or investigator's lap. The system's latency was ±30 ms and it compensated free head movements, allowing a visual angle toward the monitor of 30 × 24 degrees (1280 × 1024 pixels). In general, tracking of the eyes is influenced by tracking distance, pupil diameter and wearing glasses. First, a standardized 5-point calibration procedure of both eyes was performed. Next, one sequence of approximately 15 minutes was shown with the objective to present randomly visual stimuli. Each sequence contained smiley-like stimuli to test basic eye movements, such as saccades and pursuit, to exclude children with ocular motor apraxia. In addition, stimuli were shown to test visual orienting behavior and higher order visual processing functions, such as form and motion coherence, and competitive and non-competitive dots. Two different sequences were used for this study, both consisting of the same visual stimuli but presented in a different order.

All sequences shown to the 213 children included the form stimulus. Of these 213 sequences, 178 also included the motion stimulus. The stimuli contained a specific area with a higher salience, defined as the target area, which was presented in one of the quadrants of the monitor. The form stimulus consisted of an array of randomly orientated short white lines (0.2 × 0.6 degree, density 4.3 lines/degree^2) on a black background. In the target area, all the lines were orientated coherently to form a curved pattern (Fig. 1A). The motion stimulus consisted of white dots (diameter 0.25 degree, density 2.6 dots/degree^2) that expanded over a black background, starting at the

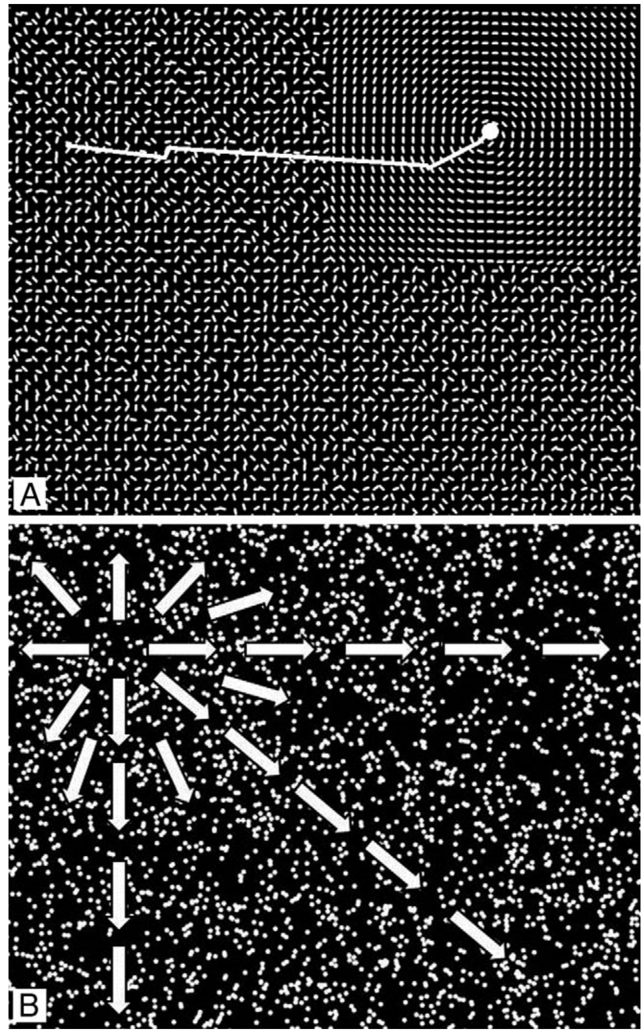

Figure 1. Visual stimuli. (**A**) The 100% coherent form stimulus. In the upper right corner all the short white lines (0.2 × 0.6 degree, density 4.3 lines/degree^2) are orientated coherently to form a circle (target area). The thick white line represents the eye movement of a child. The child was fixating at the upper left corner at $t = 0$, when the stimulus was shown, and made an eye movement to the target area in the upper right corner. (**B**) The 100% coherent motion stimulus. The stimulus consisted of white dots (diameter 0.25 degree, density 2.6 dots/degree^2) that expanded over a black background. In this example, the expansion originated from the upper left corner (target area). The *white arrows* illustrate the direction of the moving dots to the borders of the monitor. The expansion had a velocity of 11.8 degree/s and each dot had a limited life time of 0.4 seconds.

center of the target area and moving to the borders of the monitor (Fig. 1B). This expansion had a velocity of 11.8 degrees/s and each dot had a limited life time of 0.4 seconds. At the viewing distance of 60 cm, the light intensity of the form and motion stimulus was 16 and 9 lux, respectively. Both stimuli were repeated four times during the sequence (each time with the target area in another corner), and were shown for four seconds.

For the test-retest analysis, both sequences were presented to one child with a 10-minute break. For all 35 children within the subgroup, both shown sequences included the form stimulus. For 17 children within the subgroup, both sequences included the motion stimulus. The total testing time for children who participated in one sequence was 15 minutes. The total testing time for children who participated in test-retest analysis was approximately 40 minutes. All measurements

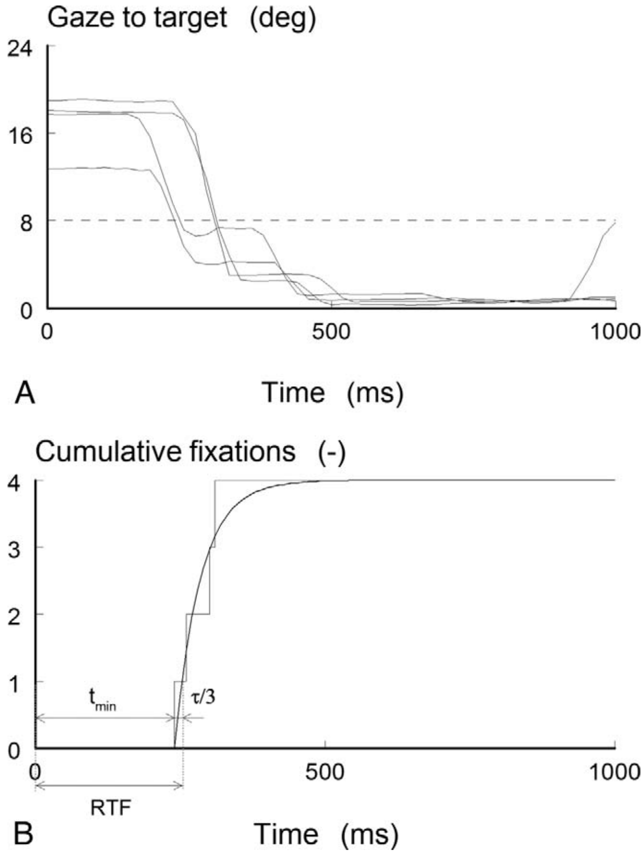

FIGURE 2. Data analysis. (**A**) The visual angle between gaze and the center of the target area as a function of time. The reaction time was defined as the time when the stimulus was shown on the monitor ($t = 0$) until gaze to the target area first crossed the dotted line (within eight degrees). Because each stimulus was repeated four times, four gaze lines are shown in this figure, and resulted in reaction time values. Note that the duration of presentation is 4.0 seconds. We plotted the first 1.0 second for illustration purpose only. (**B**) A cumulative plot of the reaction time values. An exponential curve was fitted to this cumulative plot to quantify the RTF, which was the minimum reaction time (t_{min}) plus 1/3 of the time constant τ of the exponential curve.

were stored on the hard disk and analyzed manually off-line using self-written Matlab programs (Mathworks Inc., Natick, MA).

Data Analysis and Statistics

The eye tracker provided data of average viewing distance and gaze position on the monitor. To analyze gaze shifts to the predefined target area of the stimulus, gaze data were recalculated as a visual angle between gaze location and the center of the target area using the average viewing distance. The target area was a circle with a radius of eight degrees, and its center was identical to the center of the coherent form or coherent motion expansion in one quadrant. With an average viewing distance of 60 cm, the target area was approximately the size of one quadrant. For each stimulus presentation, the reaction time to fixation of the target area was defined as the time when the stimulus was shown on the monitor ($t = 0$) until gaze was within eight degrees from the center of the target area, as illustrated in Figure 2A. Based on chance, gaze already could be in the target area at $t = 0$. These eye movements were excluded from analysis. The reaction time value was excluded from further analysis if, in the same measurement, (1) no gaze data were available in the first 500 ms, (2) the value was $\leq$120 ms, (3) more than three saccades were made to reach the target area, (4) duration of fixation before an eye movement was $\geq$1500 ms, or (5) the duration of fixation after reaching the target area was $\leq$200 ms. A cumulative plot was constructed of the available reaction time values (at least one, Fig. 2B). An exponential curve was fitted to this cumulative plot to quantify the reaction time as the minimum reaction time (t_{min}) plus 1/3 of the time constant τ of the exponential curve. This value was denoted as the reaction time to fixation (RTF).

The children were divided in subgroups based on age (one year per group) to analyze the development over time and to compare different age groups with the adult group. To find age of maturity, an ANOVA combined with Dunnett post-hoc testing was done on RTF values of the different age groups, with the adult group as the control group for both stimuli. In addition, a mixed ANOVA was done in those children who provided an RTF value for form as well as motion. Stimulus type was selected as the within-subject variable, and age group as a between-subject variable to verify maturation of orienting responses to coherent form and motion, and to verify stimulus type by age interaction. For the test-retest analysis the RTF value for the first and second sequence was labeled as RTF_1 and RTF_2, respectively. Reliability was calculated using the Intraclass Correlation Coefficient (ICC) of the RTF values, and this was confirmed with a Bland-Altman difference plot.[14] All statistical analyses were performed in SPSS-17 (SPSS, Chicago, IL).

RESULTS

Form

In eight of the 213 children no reaction time values were available, or were excluded from further analysis based on the criteria as mentioned in the Materials and Methods section. As a result, in 205 children (96%) the RTF was calculated successfully for form coherence. The majority of insufficient measurements were due to failure of eye tracking, either caused by glasses of a child or a lack of attention. The mean RTF per age group is summarized in the Table. Figure 3A illustrates the RTF values of the form stimulus against the age of the children. The ANOVA revealed that age contributed significantly to the decline of RTF values ($F_{12,222} = 47.8$, $P < 0.001$). The Dunnett post-hoc test showed significant higher RTF values in the age groups 0 to 5 compared to the adult group ($P < 0.05$), indicating that adult levels were reached at the age of six years. One of the 35 children, who participated in the test-retest analysis, was excluded from analysis, since only one RTF value was available for the form stimulus. Of both sequences shown to the 34 children, a mean of 71% (SD 21%) and 69% (SD 18%) gaze data were measured during the first and second sequences, respectively. The ICC was 0.79 with a 95% confidence interval of 0.58 to 0.89 ($P < 0.001$), indicating an excellent reliability.[15] This was confirmed with a Bland-Altman difference plot,[14] showing an average difference of 38 (SD 132) ms.

Motion

During the presentation of the motion stimulus, 156 children (88%) showed successful gaze data. In 22 children the reaction time values were excluded, mainly due to pursuit-like eye movements with a duration of 1500 ms or longer. The mean RTF per age group is summarized in the Table. Figure 3B illustrates the RTF values against age. Again, the ANOVA revealed that age contributed significantly to the decline in RTF values ($F_{12,170} = 11.4$, $P < 0.001$). Here, we found that the RTF values of the children until seven years old were significantly higher compared to the adult group ($P < 0.05$, Dunnett post-hoc test). For motion expansion processing, age of maturity was found at eight years old. For the test-retest analysis of motion, nine of the 17 children had only one RTF value. Of the sequences shown to the remaining eight children, means of

TABLE. Summary of Orienting Responses to the 100% Coherent Form and Motion Stimulus

		Form			Motion		
			Mean (SD)			Mean (SD)	
	Group	*n*	Age (y)	RTF (ms)	*n*	Age (y)	RTF (ms)
0	0–1 yrs.	5	0.72 (0.26)	901 (315)	2	0.61 (0.11)	915 (368)
1	1–2 yrs.	20	1.54 (0.27)	789 (185)	10	1.66 (0.17)	1075 (447)
2	2–3 yrs.	21	2.41 (0.29)	686 (185)	7	2.37 (0.26)	1030 (298)
3	3–4 yrs.	35	3.44 (0.26)	544 (133)	20	3.50 (0.26)	803 (421)
4	4–5 yrs.	10	4.52 (0.29)	488 (164)	8	4.56 (0.27)	853 (235)
5	5–6 yrs.	18	5.56 (0.30)	399 (79)	14	5.54 (0.31)	672 (213)
6	6–7 yrs.	20	6.60 (0.29)	327 (42)	20	6.60 (0.29)	593 (122)
7	7–8 yrs.	15	7.32 (0.23)	328 (48)	15	7.32 (0.23)	614 (156)
8	8–9 yrs.	10	8.45 (0.28)	326 (51)	9	8.45 (0.30)	567 (64)
9	9-10 yrs.	14	9.35 (0.33)	306 (41)	13	9.31 (0.30)	540 (153)
10	10–11 yrs.	15	10.42 (0.24)	292 (33)	16	10.42 (0.23)	543 (85)
11	11–12 yrs.	22	11.72 (0.23)	277 (41)	22	11.72 (0.23)	474 (58)
20	Adult	30	24.49 (3.62)	295 (53)	27	24.62 (3.78)	399 (89)

Subgroups are based on age, which resulted in 13 age groups, including the adult group. Presented for each age group are the number of children (*n*), mean age, and the RTF values. We found decreasing RTF values for the form and motion stimulus.

86% (SD 12%) and 86% (SD 14%) gaze data were measured during the first and second sequences, respectively. The reliability analysis of the RTF showed an ICC of 0.89 with a 95% confidence interval of 0.45 to 0.98 ($P < 0.01$). Although this result indicates an excellent reliability,[15] we emphasize that this analysis was based on only 8 test-retest observations. Given this low number, the test-retest reliability with current data has limited meaning.

A subgroup of 180 children provided an RTF value for form and motion. A mixed ANOVA applied in this group confirmed that RTF values depended significantly on stimulus type ($F_{1,168} = 240.8$, $P < 0.001$) and age ($F_{11,168} = 25.8$, $P < 0.001$), and that the age by stimulus type interaction was statistically significant ($F_{11,168} = 2.2$, $P < 0.05$). Figure 3C shows for this subgroup the mean RTF values and SD to illustrate maturation over time for both stimuli ($P < 0.05$, Dunnett post-hoc test). The asterisks illustrate those age groups with significantly higher RTF values compared to the adult group.

DISCUSSION

To study form and motion processing, orienting eye movements in response to a coherent form and motion stimulus were quantified in terms of ocular motor RTF. We found that the RTF of the coherent form stimulus developed until the age of six years, and of the coherent motion stimulus until eight years. Our results suggested that maturation of coherent form and motion processing follow different timelines. This difference in trajectory of development is comparable to the outcome of other studies using psychophysical threshold detection methods.[10,11,13] The study of Gunn et al. showed that form processing reached adult levels at an earlier age compared to motion processing.[10] Still, the age of maturation for form and motion processing found by previous studies may differ from our study. This difference may be explained by the difference in methods applied: (1) our method is based on the reaction time as an outcome measure, while other studies present threshold levels; (2) our method analyzed only 100% coherent stimuli, while threshold detection methods use different levels of coherence to determine the development of visual processing; and (3) our method does not include perception. Orienting eye responses are induced reflexively toward visual stimuli when its information is processed by the brain. At this level of visual processing, the perception, that is to understand what is seen and give verbal responses, like in psychophysical threshold methods, might not even be completed yet. In a future study, it would be interesting to test ocular motor reaction times to fixation as a function of decreasing coherent threshold levels. It might be that the age of maturation is different for levels of coherence.

Recent studies reported that the relative maturation of form processing is stimulus dependent. The 4–5.5-month-old infants showed relatively strong sensitivity to line patterns, compared to a limited sensitivity to conventional Glass patterns. Moreover, sensitivity to patterns depended on the length of the local line segments.[16] Lewis et al. found that for each type of Glass pattern used, thresholds for 9-year-olds were no different than those of adults.[11] However, for all ages, thresholds were significantly worse for patterns with parallel structure than for patterns with concentric structure. We acknowledge that the presented developmental timelines must be placed in context with the coherent form and motion stimulus used. As stated, visual orienting responses reflect visual processing, including ocular motor control. It might be that reduction of reaction times to fixation relates to maturation of eye movement control. Often the onset of eye movements, the so-called saccadic reaction time (SRT), is used as a measure for visual processing time. In a previous study, we compared the RTF values to a cartoon stimulus with their corresponding SRT values in a subgroup of the children presented in the current study.[8] SRT values were derived from the moment that eye velocity of the saccade toward the target area of the cartoon exceeded 50 degrees/s. The difference between RTF and SRT, the duration of the eye movement, can be regarded as a measure for eye movement control. We applied a similar approach for the complete group of children, and constructed a Bland-Altman difference plot against age (Fig. 4). On average, it lasted 46 (SD 15) ms between the onset of the eye movement and reaching the target area. Based on ANOVA, no age-related changes in eye movement control were found in the typically developing children between 0 and 12 years old. This suggests a fixed duration for eye movement control in RTF values. Note that the sample frequency of 50 Hz is rather low to calculate SRT values accurately and we found better repeatability for RTF values compared to SRT values. For

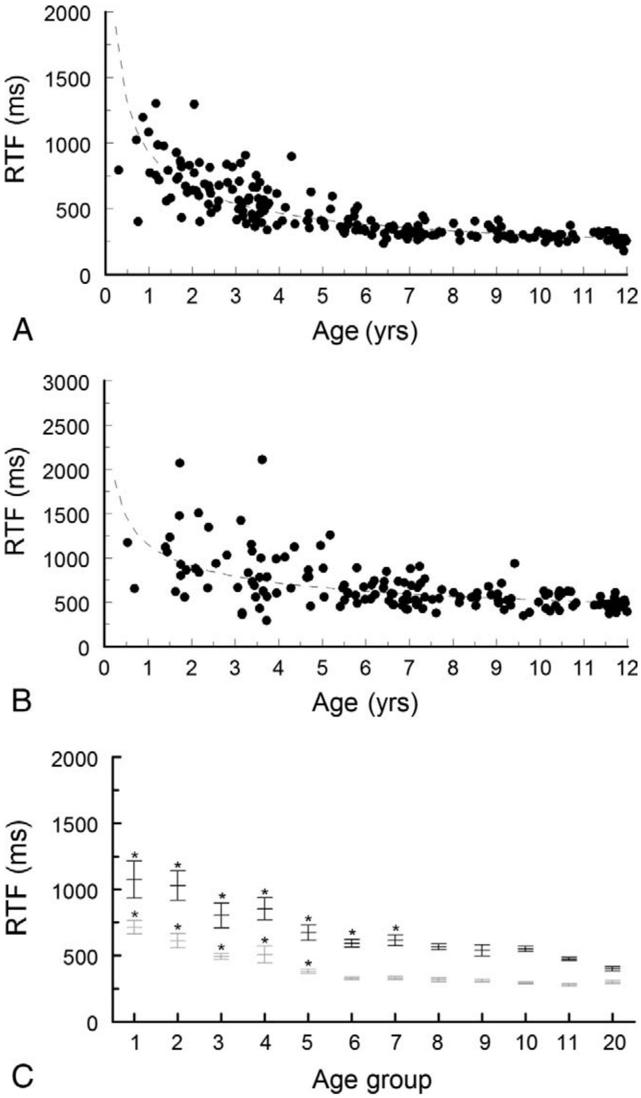

FIGURE 3. RTF values as a function of age. (A) 100% coherent form stimulus. The dotted line represents a power curve estimation of all RTF values using regression analysis. The fitted equation is $y = 928x^{-0.497}$. (B) 100% coherent motion stimulus with a power curve estimation. The fitted equation is $y = 1153x^{-0.343}$. (C) The mean RTF and standard deviations of the form (*grey*) and motion (*black*) stimulus per age group. The age groups in this figure include only those children who had available data for both stimuli. *The age groups that showed significant higher RTF values compared to the adult group ($P < 0.05$, Dunnett post-hoc test).

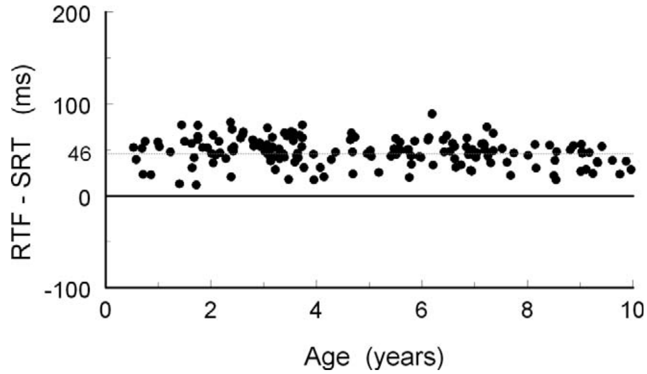

FIGURE 4. The difference between RTF and SRT is plotted as a function of age. An average difference of 46 (SD 15) ms existed between saccade onset and cartoon fixation. No age-related changes in eye movement control were found in typically developing children 0–12 years old.

this reason, we preferred to analyze orienting responses in terms of reaction times to fixations. We concluded that remote eye tracking is well suited to assess the ocular motor reaction time to fixation during visual orienting behavior tasks.[8]

The relatively late maturation of using motion information in orienting behavior seems paradoxical to the organization of this visual pathway in the brain. Motion is processed through the fast conducting magnocellular layers, via the lateral geniculate nucleus (LGN), toward the visual cortex. This is in contrast with form, which is processed mainly via the parvocellular layers with slower conduction velocities.[17] The processing pathways of form and motion beyond the visual cortex may go through reorganization between infancy and adulthood.[3] Recent theories on visual attention argue that the brain constructs an internal saliency map based on features, such as color, form, and movement.[18,19] We compared RTF data of the form and motion stimulus with earlier obtained data using a colored cartoon stimulus within the same group of children.[9] Figure 5 illustrates that children have the fastest RTF to the cartoons, followed by form and then motion. An explanation may be offered by differences in saliency between the visual stimuli. The cartoon stimulus had the highest contrast to its background, had colors, and moved with modest speed up and down. The combination of these visual aspects presumably increased its saliency over that of form and motion alone. In addition, processing of motion expansion, presented in a random array of dots, requires local information on dot speed, size, density, luminance and direction. This integration of information might reduce the saliency of the motion stimulus compared to the form stimulus. Future studies should analyze the impact of saliency on the reaction time to fixation, and on age of maturation by including stimuli that vary in visual aspects. However, many intrinsic and extrinsic aspects can influence processing time. With current knowledge, we do not know to what extent each aspect influences this process from retinal input to ocular motor output.

A main distinctive feature of our study is based on the applicability of the remote eye tracking method. Children of all ages, from approximately four months old, can participate. since no instructions, assignments, or verbal responses are necessary. Eye-hand related demands, such as pressing a button, are avoided and the method compensates for free head movements. This means that children with motor disabilities are expected to be able to perform the task as well. The duration of the measurement is relatively short (15 minutes), and the method is non-invasive, and has a low burden for children. Since the equipment is portable, the measurements can be performed at schools or at other surroundings familiar for the child. These advantages resulted in a relatively large group of children 0–12 years old who were included for this study.

For clinical application, the limitations of the method applied in our study relate to the small number of repetitions per stimulus type and the visual behavior of a participant. The emphasis of our study is on group behavior across an age spectrum between 0 and 12 years. This large group of children did show missing gaze data to coherent stimuli, with the consequence that RTF values could not be calculated. For clinical testing, we would increase the number of repetitions per coherent stimulus to at least eight (for form as well as motion) to improve the success rate of a measurement. The

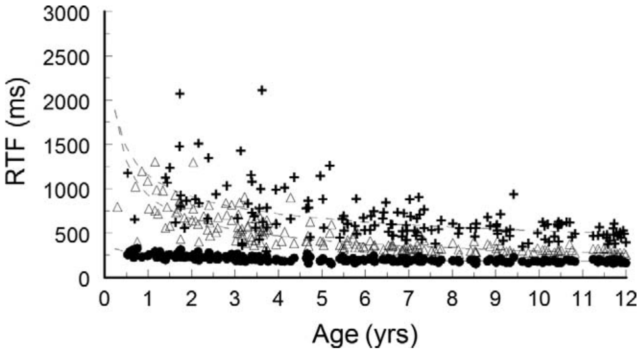

FIGURE 5. The RTF of the motion (*plus symbols*), form (*open triangles*) and cartoon (*closed circles*) stimulus as a function of age. The lines represent a power curve estimation per stimulus of all RTF values using regression analysis. This figure illustrates that orienting responses to cartoons were on average fastest, followed by form and, finally, motion.

application of cartoon stimuli that were distributed equally in each trial seemed to retain visual attention. Still, some children did show reduced visual attention at the onset of the stimulus, which resulted in loss of the first reflexive orienting responses. If no gaze data were available within the first 500 ms after presentation of the stimulus, this part of gaze signal was not included for calculating an RTF value. When data were missing for a longer period of time, one cannot exclude the possibility that during such data gaps, an eye movement already was made. The consequence was, for example when 450 ms gaze data were missing, that this time was added up to the total reaction time to fixation. This may affect the spread of the data, however, to a limited extent. We found a rather low percentage of orienting responses that missed part of the first 500 ms of gaze data. These gaps mostly were the result of eye blinking or a lack of visual attention, meaning that a child simply was not looking at the monitor during the presentation of a stimulus. The majority of gaze data gaps was at the end of a stimulus presentation and resulted from a lack of visual attention. Occasionally, the eye tracker had problems with detecting the eyes of children who wore glasses. This also reduced tracking quality. To overcome some of the stated limitations, we are developing and testing a more interactive measurement setup. Such a system includes real-time decision criteria to quantify objectively whether a first reflexive orienting response to a cartoon or a coherent stimulus was measured successfully.

We believe that the quantification of typical orienting behavior in childhood represents a reference of neurological development. Future studies may assess abnormal development and diagnosis of visual processing dysfunctions in a case control experiment. One group that has our special attention includes children with a high risk of having visual processing dysfunctions, possibly combined with ocular motor disorders due to brain damage or brain development disorders. This includes children with developmental and/or intellectual disabilities in general, or children with a specific etiology, such as cerebral palsy, periventricular leukomalacia, prematurity, and hydrocephalus. Another case group includes children diagnosed with a loss of visual function without damage to the ocular structures, which is labeled commonly as cerebral visual impairment (CVI). CVI currently is a very broad diagnosis of exclusion and based on anatomical landmarks. A separate description of the types of visual dysfunctions can be useful and a good addition to clinical practice.[20] Future studies may focus on the correlations between abnormal visual orienting responses and the type of brain damage, and to dissociate the abnormal orienting responses from ocular motor disorders.

CONCLUSION

Visual orienting responses to coherent form and motion stimuli were quantified in typically developing children aged 0–12 years without complex instructions or active cooperation. The ocular motor reaction times to fixation must be placed in context with the stimuli used, but the results confirm that coherent form processing reaches adult levels at an earlier age than coherent motion processing. The remote eye tracker may be a potentially good method for testing visual information processing in childhood. The method can give us objective and reliable insight into the visual behavior of young children.

Acknowledgments

We thank the children, their parents, the schools, and daycare centers for their cooperation.

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