The elevated risk on problems with

executive functioning in children diagnosed

with trigonocephaly

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Name: Maureen Fokke

ID Number: 199927

Internship: Erasmus MC, Sophia Children's hospital

Supervisor: Dr. J.M. Okkerse

University: Erasmus University Rotterdam

University mentor: Dr. E.H.M. van Rijen

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Abstract

This study investigated (1) the possible elevated risks of children diagnosed with trigonocephaly on developing cognitive problems compared to children without trigonocephaly, (2) the possible elevated risks for boys with trigonocephaly on developing cognitive problems compared to girls with trigonocephaly, (3) the predictive value of the potential risk factors (brain anomalies, Digital Impressions and Intracranial Pressure, severity of the stenosis, type of trigonocephaly, and Social Economic Status) for the expected abnormalities in the domains of executive functioning. 47 children diagnosed with trigonocephaly in the ages of 1-8 years were included in this study. Different tests were used to assess cognitive problems: intelligence tests, visual motor tests, language tests, reading tests and executive functioning tests. Children diagnosed with trigonocephaly had only an elevated risk on delays in Motor Coordination skills and language development; the other cognitive tests scores were comparable to these of the normal population. Boys had an elevated risk on developing receptive and productive language problems and set shifting problems. No other elevated risks for boys (compared to girls) diagnosed with trigonocephaly on cognitive problems were found. Of the five potential risk factors only the type of trigonocephaly could predict problems on the executive functioning domains of working memory, inhibition, emotional control and total executive functioning. Syndromal forms of trigonocephaly had significant more problems on the above mentioned domains of executive functioning compared to the isolated form of trigonocephaly.

Keywords: trigonocephaly, executive functioning, risk factors, cognitive problems.

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I Background information

Craniosynostosis

Craniosynostosis refers to the premature fusion of one or more of the fibrous sutures that normally separate the bony plates of the infant skull. As an infant develops in the uterus, the open sutures allow the skull to expand as the brain grows, forming a relatively normal head shape. If one suture prematurely fuses, there is restricted growth to the fused suture and a compensatory growth in the skull's unfused bony plates, producing abnormal head shapes (Bottero, Lajeunie, Arnaud, Marchac & Renier, 1998). Craniosynostosis has a prevalence of approximately 1 in 2,500 children (Kuper, 2000). There are different isolated fusions (Figure 1), like the metopic (front), right coronal sutures (line of union between occipital and parietal bones) and sagittal (side). This thesis will focus on the metopic fusion.

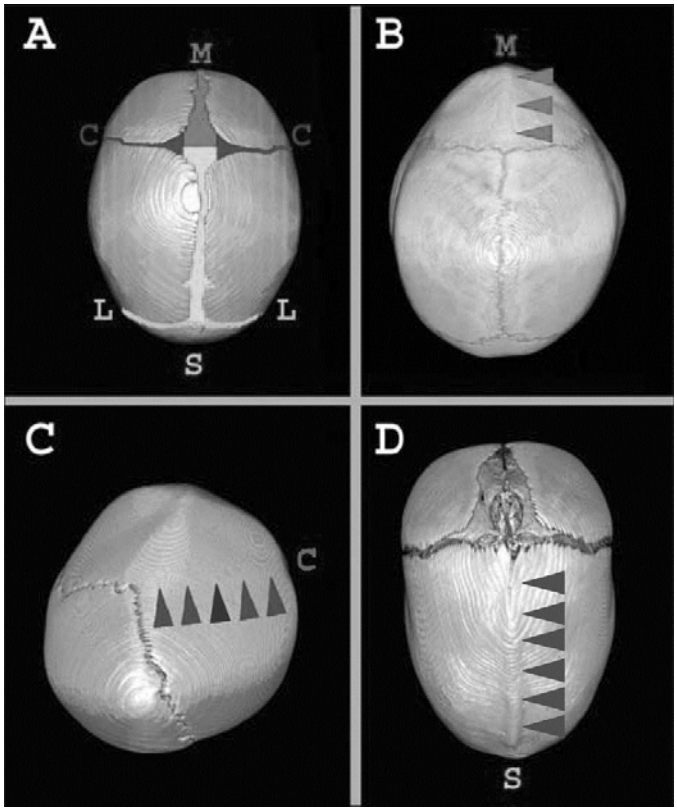

Figure 1. Different skull types; A: normal skull 3D CT scan, B: metopic synostosis, C: unilateral right coronal synostosis, D: sagittal synostosis. (Speltz, Kapp-Simon, Cunningham, Marsh & Dawson, 2004)

Trigonocephaly

Synostosis of the metopic suture is also called trigonocephaly (literally triangular skull), which means that there has been a premature closure of the metopic suture. The condition is characterized by a triangular head shape, a midline frontal ridge and hypotelorism (abnormal closeness of the eyes) (Figure 2).

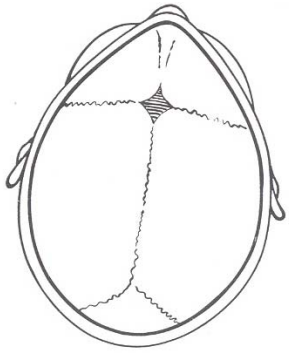

Figure 2. The premature closure of the metopic suture results in a triangular head shape (Vaandrager, Prahl-Andersen, Niermeyer & Heinemann-de Boer, 2005).

Trigonocephaly occurs in two forms, the most common form is isolated trigonocephaly, where the premature closure of the metopic suture is the only malformation that occurs in the child. The other group has, besides trigonocephaly, more kinds of malformations, which is referred to as the syndromal form of trigonocephaly. Little is known about the prevalence of both forms of trigonocephaly. Sidoti, Marsh, Marty-Grames and Noetzel (1996) made an estimation of 1 in 7,000 to 1 in 70,000 live births for children with either form of trigonocephaly. The incidence of an isolated craniosynostosis, which include the isolated as well ass the syndromal form of trigonocephaly, is about 1 in 2,000 live births (Shuper, Merlob, Grunebaum & Reisner, 1985). Incidence figures for each of the specific craniosynostosis vary extremely within different studies, so the actual numbers are still unknown. Most studies report that trigonocephaly accounts for less than 10 percent of the different types of craniosynostosis and has a male to female ratio of 3:1 (Lajeunie, Le Merrer, Marchac & Renier, 1998). The Erasmus MC, Sophia Children's Hospital, in the Netherlands reports an incidence of approximately 25 live births with trigonocephaly in the Netherlands. Nearly all operations take place in this hospital, what makes this Dutch incidence estimate quite accurate. Unfortunately some children with a mild form of trigonocephaly are not diagnosed correctly as trigonocephaly, so this number is probably a little underestimated.

Surgery

Preferably, surgery takes place within the first year of life, since this will lead to the slightest chance of problems, taking into account the rapid growth of the infant's brain and the decreasing chance of secondary facial deformations (Marsh, Jenny, Garlic, Picker & Vannier, 1991; Bottero et al., 1998). Researchers argue that surgery for trigonocephaly is mainly performed for cosmetic reasons (Figure 3) (Collmann, Sorenson & Krauss, 1996). However some recent researchers have described a high rate of developmental delay in patients who suffer from trigonocephaly. Therefore, surgery can also have a functional purpose (Shimoji, Shimabukuro, Sugama & Ochiai, 2002; Shimoji & Tomiyama, 2004; Bottero et al., 1998). Figure 4a and 4b give an impression of the reshaping process of the child's skull during this operation.

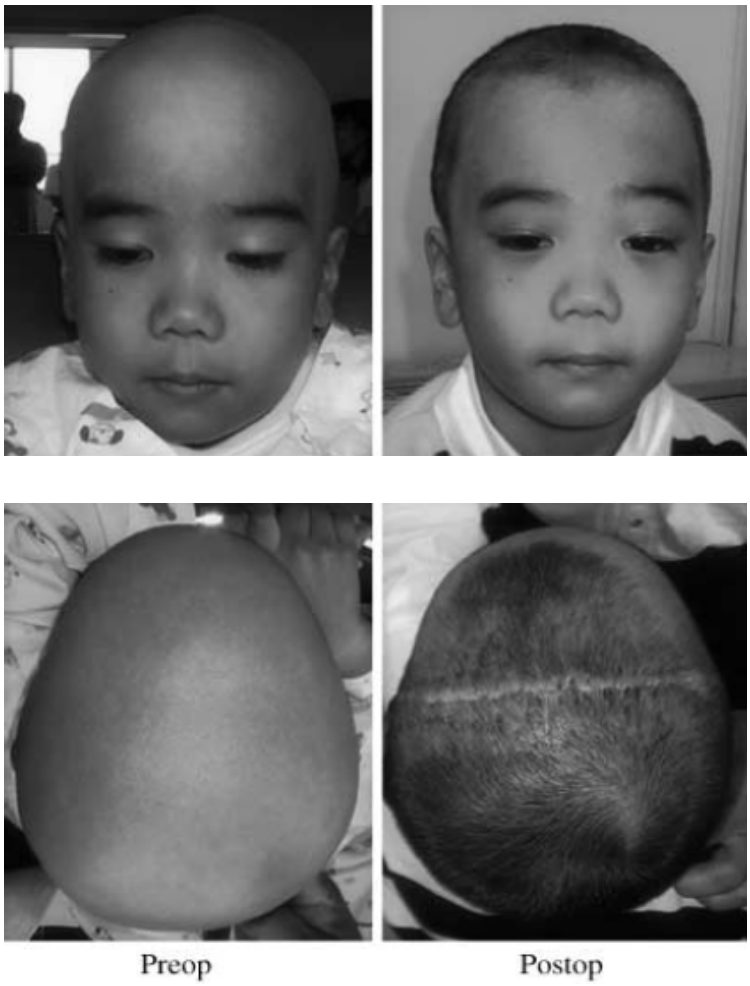

Figure 3. Pictures of the preoperative and postoperative skull of a child with trigonocephaly (Shimoji et al., 2002).

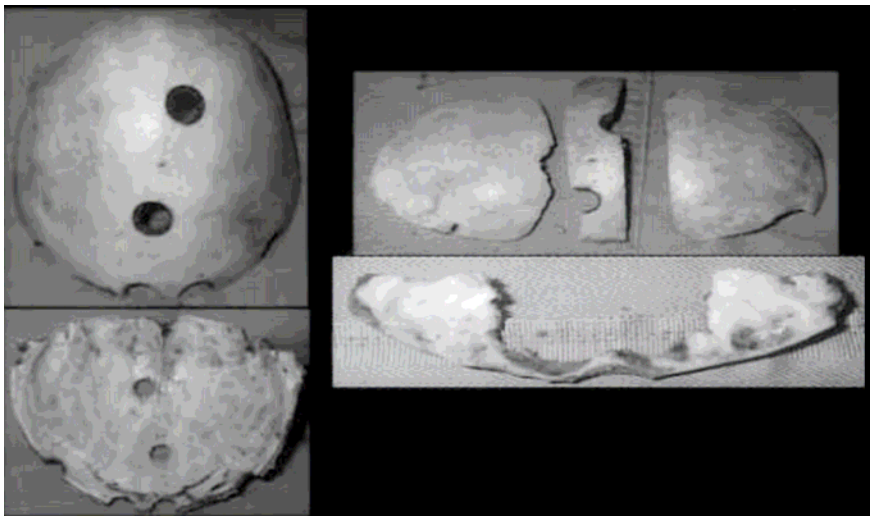

Figure 4a. Operative views: removal of the frontal bone, which is divided into three pieces (Shimoji et al., 2002).

Figure 4b. Operative views: replacing the trimmed frontal bones and lateral bones, calculating enough room for the skull to expand (Shimoji et al., 2002).

Aetiology

Little is known about the causes of trigonocephaly in the syndromal as well as the isolated form. For both trigonocephaly groups extrinsic causes are reported which include head constraints in the uterus (Graham & Smith, 1980), medication during pregnancy and exposure to environmental toxins in the uterus, such as nicotine (Honein & Rasmussen, 2000). Other extrinsic causes for both trigonocephaly groups, reported by Cogulua, Onaya and Ozgenca et al. (2005), are primary fusion of a cranial vault (top part of the skull) suture; abnormal tensile (tension without breaking) forces acting on the cranial sutures and fetal constraints. Intrinsic causes for both groups of trigonocephaly include deficient brain growth, gene mutations (Azimi, Kennedy & Chitayat et al., 2003) and genetic defects (Cogulua et al., 2005). Familial cases have been reported for the isolated as well as the syndromal form of trigonocephaly, and abnormalities of chromosome 9P, 11P, 13Q are possibly associated with both groups of

trigonocephaly (Cogulua et al., 2005). Cogulua et al. (2005) also claimed that isolated trigonocephaly can be inherited as a distinct autosomal dominant or recessive entity.

Potential risk factors: Brain anomalies

Potential risk factors have previously been reported for cognitive, emotional and behavioural problems in children with trigonocephaly (Bottero et al., 1998; Shimoji et al., 2002; Sidoti et al., 1996). One of these potential risk factors is a brain anomaly. Bottero et al. (1998) concluded that brain anomalies in children with trigonocephaly are associated with developmental delay. The most common brain anomalies reported in this study were frontal subdural space distention (frontal subdural space is swollen up), hydrocephalus, anomalies of the corpus callosum, and hypoplasia of the frontal lobes (incomplete or less development of the frontal lobes). No significant relationship was found between frontal subdural space distention and final mental development. On the contrary children with hydrocephalus or an anomaly of the corpus callosum did have a worse final mental development compared to those without these abnormalities (Bottero et al., 1998).

Other anatomic brain deviations for trigonocephaly are widen precentral sulci, abnormalities in the subarachnoid space beneath the region of suture fusion and increased amount of subarachnoid cerebrospinal liquid in the ventricles (Sidoti et al., 1996; Speltz et al., 2004). Shimoji et al., (2004), when using a preoperative Single-Photon Emission Computed Tomography (SPECT), found that 57 percent of the patients with trigonocephaly have decreased cerebral blood flow (CBF), mainly in the frontal lobes.

Another frequently observed brain anomaly in children with trigonocephaly is the small frontal lobes, probably because of the narrow anterior cranium (Anderson, Gwin & Todt, 1962). Some researchers suggest that symptoms like a delay in language development, motor dysfunctions, hyperactivity, autistic tendencies, and self-mutilation (for example head banging) are probably related to the frontal lobe dysfunction (Barkley, Grodzinsky & DuPaul, 1992).

Potential risk factors: Digital Impressions / Intracranial Pressure (ICP)

It has been claimed that the Intracranial Pressure (pressure on the skull, from the inside), or ICP, in trigonocephaly is low (Thompson, Harkness, Jones, Gonzalez & Hayward, 1995). However, Shimoji et al. (2004) noted elevated ICP in mild cases of trigonocephaly. ICP was measured by inserting a sensor in the right frontal lobe (Shimoji et al., 2004). Shimoji et al. (2004) also found a high rate of marked Digital Impressions on skull X-rays (Figure 5) in

these patients with elevated ICP. These X-rays were divided in four areas: frontal, parietal, temporal and occipital. The X-ray showed Digital Impressions on three or four of these areas in 75 percent of all patients.

The majority of the patients diagnosed with trigonocephaly, who show Digital Impressions and elevated ICP, exhibit developmental problems (language delay, hyperactivity, autistic tendencies and motor dysfunction). Improvements of these clinical symptoms were found to be due to the release of the constricted frontal lobe, after surgery (Shimoji et al., 2002). Tuite, Evanson and Chong et al. (1996) also found higher ICP in patients with trigonocephaly, which had many Digital Impressions compared to those without these Digital Impressions. So, Digital Impressions and elevated ICP seem to appear simultaneously in patients with trigonocephaly. Tuite et al. (1996) also found a connection between intelligence and the severity of Digital Impressions. In short, the severity of these Digital Impressions and high ICP are a combined potential risk factor.

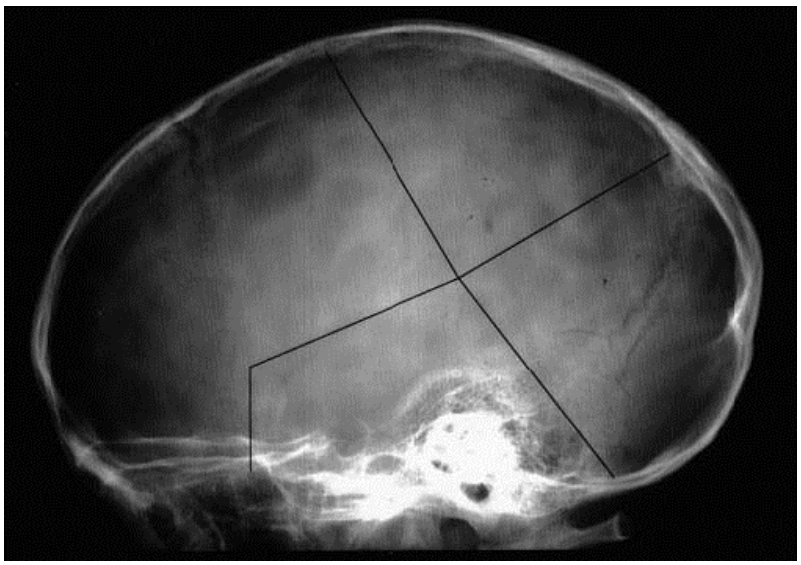

Figure 5. Digital Impressions on skull X-ray: the lateral X-ray showed Digital Impressions in 75% of all patients over three quarters of the area (Shimoji et al., 2004).

Potential risk factors: Severity of the stenosis

Another potential risk factor for the cognitive, behavioural and emotional problems in children with trigonocephaly is the severity of the metopic stenosis. Bottero et al. (1998) used the ratio of the interparietal to the intercoronal distance to assess the degree of frontal stenosis (Figure 6). Shimoji et al. (2002) found for the children diagnosed with trigonocephaly a ratio of 1.25 and for the children of the normal population 1.21. The higher the ratio, the more

severe the stenosis and the more developmental delay was reported. The severity of the frontal stenosis can therefore be considered as a major predictor of mental development (Bottero et al., 1998).

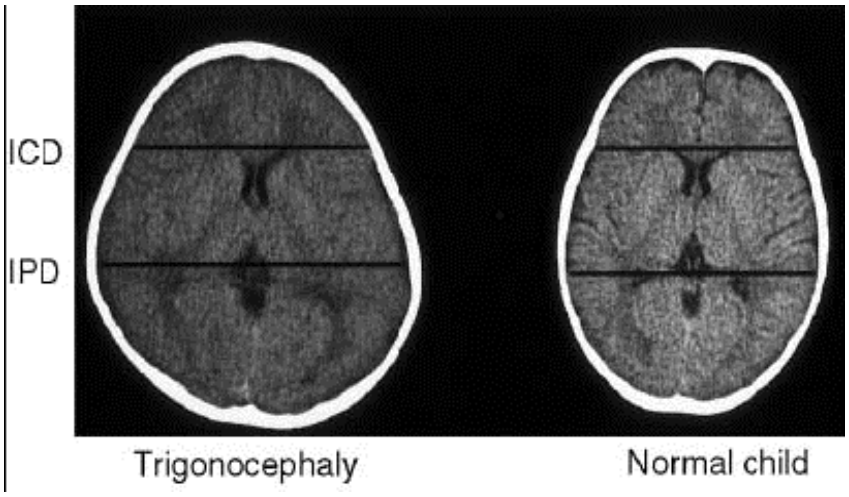

Figure 6. Interparietal distance (IPD) / Intercoronal distance (ICD) ratios. Left: IPD / ICD ratio of a patient with trigonocephaly. Right: IPD / ICD ratio of a normal child. Patients with trigonocephaly seem to have a higher ratio compared to normal children (Shimoji et al., 2002).

Potential risk factors: Type of trigonocephaly

The type of trigonocephaly found in children is also considered as a risk factor. As stated earlier, trigonocephaly can occur in two forms, isolated trigonocephaly (nonsyndromal) and the syndromal form, which is associated with other extra cranial associated malformations. Examples of additional malformations are limb anomalies like clinodactyly (a congenital defect in which one or more toes or fingers are abnormally positioned), arachnodyctyly (a condition in which the hands and fingers, and often the feet and toes, are abnormally long and slender). Other abnormalities found are urogenital anomalies like ectopic kidney (abnormal positioned kidney), hydronephrosis (abnormal enlargement of the kidney), hypospadias (abnormality of the penis in which the urethra opens on the underside). Also ear anomalies, maxillofacial abnormalities (abnormality of the jaw and face) and cardiac abnormalities were found in children with the syndromal form of trigonocephaly (Lajeunie et al., 1998).

Lajeunie et al. (1998) found that the isolated form occurs more often (78%) compared to the syndromal form (17%). Bottero et al. (1998) found that children with the syndromal form were more often delayed in development compared to the isolated forms of trigonocephaly. However, the degree of frontal stenosis in the syndromal group was not more severe than the isolated group of children with trigonocephaly. Probably the additional extra cranial malformations lead to the more severe delay in development.

Potential risk factor: Social Economic Status (SES)

Social Economic Status (SES) is a multidimensional concept that takes material, social resources and the individual's position in the social hierarchy into account (Corvalan, Amigo, Bustos & Rona, 2005). Bottero et al. (1998) showed that family environment has a major influence on mental development of children diagnosed with trigonocephaly, because 66 percent of the children living in non optimal conditions are showing developmental delay, as opposed to 27 percent in those from a more stable background. The family setting was considered unfavourable for child development; when the parents were separated or one of them were absent; when the child had been removed to foster care; when there was a history of ill treatment or the situation was judged unfavourable according to the psychologist.

SES can have a direct effect and an indirect effect on the development of children with trigonocephaly. Higher family SES and parental IQ could lead to more enriching environments (direct effect). Families with higher SES and intelligence might have better access to diagnostic services and therefore medical care can be provided to them at an earlier age (indirect effect) (Bottero et al., 1998).

Gender differences

An important correlate of early development is child gender. Boys with trigonocephaly appear to have a higher risk on delayed development than girls with trigonocephaly (Kapp-Simon, Leroux, Cunningham & Speltz, 2005). However, girls with trigonocephaly seem to have more severe developmental problems than boys with trigonocephaly (Okkerse, Beemer, Mellenbergh, Wolters & Heineman-de Boer, in press). In this study, gender differences are also considered as an important matter of interest.

Review of published psychological studies

Because only four psychological studies focused on the behavioural, cognitive and emotional problems in children diagnosed with trigonocephaly, a short review of these studies is presented below. Most findings concerning the consequences of trigonocephaly on the cognitive, emotional and behavioural development of children diagnosed with this condition, described in next paragraph, are retrieved from these four studies.

Table 1

Review psychological studies concerning the consequences of trigonocephaly.

Authors	Sample size	Age range sample	Operated yes/no	Test battery	Summary of results	Limitation study
Sidoti, Marsh, Marty-Grames & Noetzel (1996)	36: 27 males-9 girls	6 months up to 22 years	yes	Reviewing patient medical records and developmental/ behavioural questionnaire	One third of the patients with metopic synostosis have behavioural and cognitive abnormalities.	No control group, retrospective study, small sample size
Bottero, Lajeunie, Arnaud, Marchac & Renier (1998)	76: 62 boys-14 girls	36 months up to 16,5 years	yes	Psychometric tests: Brunet-Lézine, échelle complémentaire non verbale de Brunet-Lézine,WISC, reports of parents, teachers, clinical team to determine presence/ absence of developmental problems	32% of the patients with trigonocephaly have developmental problems. Mental development was worse: when frontal stenosis was more severe; when cranial reconstruction was performed after 1 year of age; when there were extracranial malformations.	No control group, small sample size, retrospective study
Shimoji, Shimabukuro, Sugama & Ochiai (2002)	65: 47 boys-18 girls	0 up to 9 years	yes	K-Form Developmental Test, Japanese Child Behaviour Checklist, neurological assessments	94% have language delay before surgery but some improved after surgery. Also behaviour problems improved after surgery. Control group didn't significantly change.	Small sample size, retrospective study
Shimoji & Tomiyama (2004)	56: 44 boys-12 girls	2 up to 8 years	yes	K-Form Developmental Test, Japanese Child Behaviour Checklist, neurological assessments	30 out of 56 patients ICP and digital impressions improved, many children with developmental delay and mental retardation have mild trigonocephaly, decompressive carniopasty may improve the clinical symptoms of children with trigonocephaly.	No control group, retrospective study, small sample size

Consequences in general

Early publications often compared children with single-suture fusions or isolated synostosis like trigonocephaly, with children with multi-suture fusions, children with metopic synostosis as well as sagittal synostosis, and thereby created the impression that isolated synostosis had little effect on brain development compared to multi-suture fusions (Kapp-Simon et al., 2005). Recent studies focused more on children with only single-suture fusions, comparing their neurobehavioral functioning with normative data or a control group and concluded that the single-suture children also have an elevated risk on clinical symptoms (Speltz et al., 2004). The children with trigonocephaly are also prone to these risks. Many clinical symptoms are reported for this group, like delay in language development (Bottero et al., 1998; Sidoti et al., 1996), cognitive impairments (IQ lower than average) (Bottero et al., 1998; Sidoti et al., 1996), hyperactivity, autism like behaviour, and motor delay (gross and fine motor) (Bottero et al., 1998; Shimoji et al., 2002; Sidoti et al., 1996).

Consequences: Emotional and behavioural problems

Bottero et al. (1998) found that 70 percent of their sample of children diagnosed with trigonocephaly showed evidence of behavioural disturbances and 32 percent of these children showed developmental delay. Developmental delay is estimated in the general paediatric population to occur in 10 percent of the children (Bottero et al., 1998). Therefore, developmental problems seem to occur more often in children with trigonocephaly compared to the general paediatric population.

Sidoti et al. (1996) found that 33 percent of their sample of children diagnosed with trigonocephaly demonstrated behavioural abnormalities (ADHD and overaggressive behaviour). This is a three- to six fold increase beyond the 5-10 percent reported incidence of ADHD in the general paediatric population (Sidoti et al., 1996). The incidence of behavioural problems approached 50 percent when the pre-school aged children were eliminated. The incidence of behavioural problems becomes greater in children older than the age of five years, because these behavioural problems are not easily diagnosed in preschool-aged children (Sidoti et al. 1996). Shimoji et al. (2002) found hyperactivity and/or attention deficit/ hyperactivity disorder in 41 of 65 patients. Related symptoms included difficulty in sitting still, constant fidgeting with the hands or feet, wandering away from parents, and excessive running and climbing behaviour. Half of the patients exhibited impaired social interactions (autistic tendencies), like difficulty in maintaining eye contact and lack of social or emotional reciprocity. Ten patients demonstrated self-mutilation behaviour, mostly in the form of head banging. Panic and irritability when they were prevented from doing what they wanted was noted in thirty-five patients.

Consequences: Cognitive Problems

Bottero et al. (1998) found that 28 percent of the 70 percent of the children with trigonocephaly that exhibited behavioural and cognitive problems also had problems with speech, reading and/or writing. Within this group of children with trigonocephaly that showed behavioural and cognitive problems, 35 percent was at least one year delayed in their schooling. Compared to the developmental delay in the general paediatric population of 10 percent, it can be concluded that children with trigonocephaly have a significant higher risk on developmental problems (Bottero et al., 1998). Sidoti et al. (1996) also found that 38 percent of their metopic synostosis sample exhibited abnormalities such as delay in speech and language development, low IQ scores, dyslexia and gross mental retardation.

Consequences: Executive functioning problems

Executive functions may be defined as those skills necessary for purposeful, goal-directed activity, and are generally considered to be moderated by the frontal and prefrontal brain cortices (Anderson, 1998). The executive functions consist of several separate functions. A couple examples are planning, emotional control, set shifting, working memory, inhibition and flexibility.

Cohen (Speltz et al., 2004) assumed a linear pathway between calvarial (skull cap) suture fusion and neurodevelopment, in which suture fusion adversely affects brain development. Two specific pathways, operating alone or together, have been proposed in this regard. Renier, Sainte-Rose, Marchac & Hirsch (1982) suggest that elevated ICP with hypovascularity (shortage of blood vessels) as a result of the suture fusion causes the negative effect on brain development. On the other hand Fernbach and Feinstein (1991) suggest secondary cerebral deformations, which cause a negative effect on brain development, resulting from brain growth in an abnormal shaped skull. However, it is not yet clear if the synostosis is a cause or a correlate of neuropathology. Even when single-suture synostosis was shown to directly affect brain structure, compensatory systems and adaptive processes could significantly alter the severity and the form of the associated neuropathology (Speltz et al., 2004).

Link risk factors and Executive functioning

The potential risk factors in this study are the presence of additional brain anomalies, severity of the Digital Impressions and/or ICP, severity of the stenosis, the syndromal or isolated form of trigonocephaly and SES differences. It is expected that more negative results concerning the risks on behavioural, emotional and cognitive problems in children diagnosed with trigonocephaly will be found in future studies. However, this study will focus on the cognitive problems in children with trigonocephaly. Especially, the possible affected executive functions will be an important focus of this study. The focus on executive functions is based on the assumption that trigonocephaly has a negative effect on frontal lobe development, which makes it assumable that the executive functions could be more problematic for these children (Shimoji et al., 2002; Shimoji et al., 2004; Barkley et al, 1992). Studies have proven that damage to frontal lobe regions has wide-ranging implications for ongoing development in children. Deficits in many aspects of neurobehavioral function have been observed in people with damaged frontal lobe regions, like attention, impulse control, language and memory (Anderson, Levin & Jacobs, 2002).

Link brain anomalies and Executive functioning

Garth, Anderson and Wrennall (1997) reviewed the developmental changes in executive functioning in children with moderate-to-severe-frontal lobe injury. Results revealed that frontal lobe injury disrupts development of both executive and general intellectual skills (Garth et al. 1997). Another link between brain anomalies and executive functions has been shown by the A not B task (Piaget, 1954), which assesses working memory and response inhibition (domains of executive functions). This test has frequently been linked to the dorsolateral prefrontal cortex in primates and humans, suggesting relative specificity of linkage to the frontal lobe (Diamond & Goldman-Rakic, 1989). Absher and Cummings (1995) found that frontal lobe dysfunction has a pervasive compromising effect on neuropsychological domains including executive functions. The affected domains are attention, language, verbal and non-verbal fluency, memory, planning, judgment and motor programming. In addition, mood disturbances and personality changes are common consequences of frontal lobe dysfunction.

Link Digital Impressions/ Intracranial Pressure (ICP) and Executive functioning

Shimoji et al. (2004) found no abnormal brain anomalies before surgery except for small frontal lobes. High ICP and Digital Impressions were believed to contribute to a worsening effect on these frontal lobes. After surgery, these frontal lobes were grown bigger and the clinical symptoms (language delay, hyperactivity, autistic tendencies and motor dysfunction) declined. Shimoji et al. (2004) suggest that the improvements of these clinical symptoms after surgery were to some degree due to the release of the frontal lobes. ICP and Digital Impressions are indirectly related to executive functioning, because of the above-proposed relation between ICP/ Digital Impressions and the frontal lobes (Shimoji et al., 2004). As mentioned in the previous paragraph, support was found for the relationship between the frontal lobes and the executive functions.

Link severity of the stenosis and Executive functioning

Bottero et al. (1998) found that the severity of the stenosis can be considered as a major predictor of mental development. Executive functions have a substantial influence on mental development, so it is expected that the severity of the stenosis also will influence the executive functions.

Link other risk factors and Executive functioning

There are no known research results concerning executive functions and the other risk factors type of trigonocephaly and SES.

Research objectives

Only four psychological studies (Table 1.) have been performed on this subject, which all have methodological problems. Therefore additional research in the developmental risks of children diagnosed with trigonocephaly is needed. This study will contribute to existing literature, by using reliable standardized instruments so valid conclusions concerning elevated risks on cognitive problems can be drawn; and by focusing on cognitive problems in specific the executive functions, which is a relatively unknown research area in the psychological trigonocephaly literature. The aim of this study is to explore the relationships between a number of risk factors (brain anomalies, Digital Impressions and ICP, severity of the stenosis, type of trigonocephaly and SES), discovered by earlier studies, and different domains of executive functioning. This study is a part of an extensive PhD study executed by the Erasmus MC, Sophia Children's Hospital in Rotterdam. The social relevance of this study is to discover which cognitive problems (intelligence (IQ), visual motor skills, language development, reading and different domains of executive functioning) have the most elevated risk to develop in children diagnosed with trigonocephaly and which risk factor(s) is (are) responsible for these elevated risks. This way early intervention and more specific interventions and support programs can be assigned and implemented.

Research questions and hypotheses

There are three major questions in this study. First, do children diagnosed with trigonocephaly have an elevated risk on developing cognitive problems compared to children without trigonocephaly? Second, do boys diagnosed with trigonocephaly have an elevated risk on developing cognitive problems compared to girls diagnosed with trigonocephaly in this sample? Third and last, can the discussed potential risk factors (brain anomalies, Digital Impressions and ICP, severity of the stenosis, type of trigonocephaly and SES) predict the proposed abnormalities of the executive functions in children diagnosed with trigonocephaly?

To answer these major questions three hypothesis were constructed. First, children diagnosed with trigonocephaly have an elevated risk on developing cognitive problems compared to children without trigonocephaly. Second, boys diagnosed with trigonocephaly in this sample have an elevated risk on developing cognitive problems compared to girls diagnosed with

trigonocephaly in this sample. Third, the discussed potential risk factors (brain anomalies, Digital Impressions and ICP, severity of the stenosis, type of trigonocephaly and SES) can predict abnormalities of the executive functions in children with trigonocephaly.

II Methods

Design

The research design for this study was a cross-sectional prediction study, like most research published on this topic. The trigonocephaly sample was an intact group which was compared to a norm group that represents the normal population. It was not possible to do a pretest-posttest design because all children were already operated on which made it impossible to test the children on cognitive problems prior to the operation.

Participants

In total 87 children were invited to participate in this study, of which 40 children did not respond to the invitation letter. Unfortunately, the reason why these children did not want to be included in this research is unknown. Finally 47 (54%) children diagnosed with trigonocephaly wanted to participate in this study and were examined in the Erasmus MC, Sophia Children's Hospital, in Rotterdam from November 2005 to July 2006. The sample consisted of seven girls (14.9%) and 40 boys (85.1%) with a mean age of 4.6 years (*SD*= 2.25, range 1.10 – 8.6 years). The great amount of ear problems (tubes) in this sample (25.5%) was remarkable. Despite the fact that four (8.5%) children wore glasses, none of the examined children had serious problems with their sight. The sample is obtained from the medical records, which are in ownership of the Erasmus MC, Sophia Children's hospital, Rotterdam in the Netherlands. Three inclusion criteria were applicable for this research. Only the patients with synostosis of the metopic suture (trigonocephaly) were selected for this sample, consisting of the syndromic as well as the isolated form. Further, the primary language of the child and parents had to be Dutch. Also, the child had to be operated on in the cranial facial centre of the Erasmus MC.

Materials

Different cognitive tests were administered in this sample, which were divided in intelligence tests, visual motor skills test, language tests, reading tests and executive functioning tests (Table 2).

Table 2

Review of the tests used in this study with age ranges and assessment type.

Cognitive tests	Test	Original test age range	Age range in this study	Assessed in
Intelligence	Mullen	1 to 68 months	1 to 48 months	Child
	WPPSI-R	4 up to 7.5 years	4 up to 6 years	Child
	WISC III	6 up to 16 years	7 up to 16 years	Child
Visual and Motor skills	VMI	4 up to adulthood	4 up to 17 years	Child
Language	N-CDIs	16 to 30 months	16 up to 30 months	Parents
	VTO	3 up to 5 years	3 up to 5 years	Parents, Child
Reading	DMT	2nd up to 7th grade	2nd up to 7th grade	Child
	Klepel	2nd up to 8th grade	2nd up to 8th grade	Child
Executive functioning	Brief -P	2 up to 5 years	2 up to 5 years	Parents
	Brief	6 up to 18 years	6 up to 18 years	Parents
	SSRT	6 to 17 years	6 to 17 years	Child
	SOP	4.5 to 19 years	4.5 to 19 years	Child
	Digit Span	6 up to 16 years	6 up to 16 years	Child

Note. Mullen= The Mullen Scales of Early Learning; WPPSI-R= The Wechsler Preschool and Primary Scale of Intelligence; WISC III= The Wechsler Intelligence Scale for Children III; VMI= The Developmental Test of Visual-Motor Integration; N-CDIs= The Nederlandse (Dutch) Communicative Development Index Scales; VTO= Vroegtijdige Taalontwikkelingsstoornissen; DMT= Drie Minuten Test; Brief-P= The Behaviour Rating Inventory Executive Function Preschool Version; Brief=The Behaviour Rating Inventory Executive Function; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing task.

Intelligence: Mullen

The Mullen Scales of Early Learning was used for assessing IQ in the younger children (Mullen, 1995). This test is for children between the ages of one month and 68 months and assesses Visual Perception, fine and gross motor, receptive language and expressive language. The Mullen Scales of Early Learning is intended to help determine the need for special services by assessing learning styles and the strengths/ weaknesses within the assessed domains. The average administration time is 25-40 minutes. The test has to be individually administered. Because the Dutch IQ results are based here on US norms, the Dutch IQ's are a little underestimated. The internal consistency of the five scales is satisfactory, where the mean values range between .75 and .83. The test-retest reliabilities and the interscorer reliability for the five Mullen scales vary between respectively .71 and .96 and .91 and .99. Various studies have demonstrated the convergent and divergent validity of the five scales (Mullen, 1995).

Intelligence: WPPSI-R

The Wechsler Preschool and Primary Scale of Intelligence (WPPSI-R; Wechsler, 1997) measures the general intelligence for children between the ages of four years and six months and seven years and six months old. The WPPSI-R raw score results in a Verbal IQ (VIQ), Performal IQ (PIQ) and Total IQ (TIQ). The VIQ and PIQ both have received logical and empirical support (Wechsler, 1997). In this study a short version of the WPPSI-R was used,

with the subtests Block Design and Picture Completion as Performal IQ indices and Similarities and Vocabulary as Verbal IQ indices. The subtest Block Design assesses spatial technical insight of abstract material. The child has to copy the block design represented in the pictures of the test material. Picture Completion assesses the ability of detail perception. Children get to see incomplete pictures and have to say what crucial aspect misses in the picture. The verbal subtest Similarities assesses logical abstract reasoning capabilities, and consists of two words where the child has to point out the similarity between the two words. The subtest Vocabulary assesses the verbal capability to describe words. Estimates of the reliability for the VIQ, PIQ and TIQ are respectively .95, .92, and .96. Also the validity is substantially improved with the new version of the WPPSI-R (http://www.cps.nova.edu). The reliability of the separate subtests varies between .63 and .86 (Wechsler, 1997).

Intelligence: WISC III

The Wechsler Intelligence Scale for Children III (WISC III; Wechsler, 1992) also sees intelligence as a global but multifaceted entity that can be assessed by a child's performance on several tasks. The WISC III is intended for children of 6 up to the age of 16 years and 11 months and also results in a VIQ, PIQ en TIQ. This study used a short version of the Wechsler Intelligence Scale for Children, consisting of the Picture Completion and Block Design as performance tests and Similarities and Vocabulary as verbal tests (WISC III; Wechsler, 1992). The content of these subtests are similar as the subtests of the WPPSI-R, mentioned in the paragraph above. The only difference in the tests is that they are more complex, because the children are older for the WISC III. The WISC III is fully validated by UK data. This data was collected through stratified sampling procedures reflecting gender, age, region urbanicity and parental occupation (http://www.tpc-international.com). Subtest reliabilities vary between .61 and .92. Subtest stability coefficients, based on 353 children subdivided into three age groups, are between .56 and .89. Interrater reliabilities for selected Verbal Scale subtest are excellent (all greater than .92) (http://www.tpc-international.com).

Visual and motor skills: VMI

The Developmental Test of Visual-Motor Integration (VMI; Beery, 1997) assesses the visual-motor integration of children in the age of three to adulthood. The VMI is designed to assess the extent to which children can integrate their visual and motor abilities by copying 27 or 18 geometric forms on paper. Integration of visual and motor abilities is the degree to which Visual Perception and finger-hand movements are well coordinated. The administration time

is approximately 15 minutes. In this study the shorter version of 18 geometric forms was used. The inter-scorer reliability, internal consistency and test-retest scores for the VMI are respectively .94, .96 and .87. The content validity of the VMI is strongly supported as well as the concurrent validity and construct validity (Beery, 1997).

After the VMI two supplemental standardized tests have to be administered in a strict order, first the Visual Perception followed by the Motor Coordination. These tests make it possible to statistically compare an individual's VMI result with relatively pure visual and motor performances. During three minutes, the task of the Visual Perception test is to identify the exact match for as many of the 27 stimuli as possible. The mean inter-scorer reliability and internal consistency for the Visual Perception are respectively .98 and .81 (Beery, 1997). In the Motor Coordination test, the goal is to trace the stimulus forms within 5 minutes with a pencil without going outside double-lined paths (Beery, 1997). The mean inter-scorer reliability and internal consistency for the Motor Coordination are respectively .95 and .82. Also these two supplemental tests are reported to have a strongly supported content validity as well as the concurrent validity and construct validity (Beery, 1997).

Language: N-CDIs

The "Nederlandse (Dutch) Communicative Development Index Scales" (N-CDIs; Zink & Lejaegere, 2003) is a questionnaire for parents concerning the receptive and expressive language skills of their child between the ages of 8-16 months and 16-30 months. In this study the short version of the age 16-30 months was used, which consisted of a total of 112 words. Parents had to fill in if their child said or understands the given words summed up on the form. Examples of words are ranging from "beh beh (sheep)" until "koelkast" (refrigerator). The reliability and validity of the questionnaire is good (Zink & Lejaegere, 2003).

Language: VTO

The questionnaire "Vroegtijdige Taalontwikkelingsstoornissen" (VTO) or Early Recognition of Developmental Disorders is two folded, there is a parental and child version and both have to be administered (Gerritsen, 1994). The experimenter asks the child questions if he/she can tell his/her name, point out body parts, can replicate words, give opposites of words etc. In the parental version, parents have to indicate if the child can tell his/her name, point out body parts etc. The test is administrated from the age of three up to five years old in approximately five to ten minutes. The internal consistency expressed in the Cronbach's alpha of this test is .90 and the test-retest reliability is .80. The construct validity for the three, four and five year

olds are respectively .58, .57 and .47 (Gerritsen, 1994).

Reading: DMT

The “Drie Minuten Test” or Three Minutes Test (DMT; Verhoeven, 1995) assesses a child’s ability to read words increasing in difficulty, also called technical reading. The test consists of three reading carts; one with vowel-consonant/ consonant-vowel / consonant-vowel-consonant; the second with consonant- consonant- vowel- consonant/ consonant-vowel-consonant- consonant etc; the third with two-three-four syllable words. The child has one minute for every cart and has to read as many words out loud as possible. The test can be administered at the age of six (2nd grade) until the age of 12 (7th grade) years old. The reliability is good according to the Cotan (Moelands, Kamphuis & Verhoeven, 2004). Separate reliability scores for every cart are: cart one between .86 and .90; cart two between .92 and 96; cart three between .86 and 94. The content validity is good, which is supported by relationships between the reading carts and the relationship between speed and accuracy (Moelands et al., 2004).

Reading: Klepel

The “Klepel” is a language test consisting of 116 pronounceable pseudo words, which have to be read out loud in two minutes, and 116 normal words that have to be read out loud in one minute (One Minute Test) (van den Bos, Spelberg, Scheepstra & de Vries, 1994). The fact that normal and pseudo words both have to be tested is based on the dual route theory, which consists of two different mental routes that a reader can use to identify words. First, the lexical route is the direct route where word recognition is accomplished by usage of the mental lexicon every individual has. The second route is phonological, where word recognition dependents on the phoneme-letter linkage the child has to make (Bates, Castles & Coltheart et al., 2004). “De Klepel” is a combination of a power test and a speed test. The test is administered from the age of six (2nd grade) up to 13 (8th grade) years old. The reliability is assessed for every age and the lowest reliability score is .89. The same is done for the validity, which is good but has a decrease in validity when the children get older (van den Bos et al., 1994).

Executive functioning

The executive functions were also measured. Executive functions consist of different domains, which had to be assessed by neuropsychological tests.

Executive functioning: Brief-P

The Behaviour Rating Inventory Executive Function Preschool Version (BRIEF-P; Gioia, Espy & Isquith, 2003) is a questionnaire, which is appropriate for children between the ages of two and five years and 11 months old. The Brief-P consists of 63 items that measure various aspects of executive functioning: inhibition, set shifting, working memory, emotional control and planning. The administration time for this questionnaire is 10-15 minutes and is filled in by the parents. Example items are *Overreact with small problems* or *Has explosive tantrums*, which has the answer categories: never, sometimes and often. Reliability is measured by the internal consistency, interrater agreement and test-retest stability. For parents is the internal consistency high, with alpha coefficients ranging between .80 and .97. The test-retest correlation for the parents across the clinical scales ranges from .78 to .90. (Gioia et al., 2003). Convergent and discriminant evidence of validity for the BRIEF-P clinical scales is based on their correlations with a variety of clinical and normative samples (ADHD-IV-P scale and CBCL; parent normative sample, parent clinical sample; Gioia et al., 2003).

Executive functioning: Brief

The Behaviour Rating Inventory Executive Function (Brief; Gioia, Isquith, Guy & Kenworthy, 2000) is useful in evaluating children in the ages of 6 to 18 years old with a wide range of developmental and acquired neurological problems. The Brief is administered by parents and consists of 86 items that measure various aspects of executive functioning in different non overlapping clinical scales. The assessed clinical scales are: inhibition, set shifting, emotional control, initiation, working memory, planning/organize, organization of materials and monitoring (Gioia et al., 2000). Administration time is approximately 10-15 minutes. Reliability indexes are good for this instrument, with an internal consistency of .80 - .98, and a test-retest reliability of .82. Convergent validity is demonstrated with other measures of inattention, impulsivity and learning skills. Norms for this questionnaire are based on child ratings from 1,400 parents. The clinical sample also included children with developmental and acquired neurological disorders.

Executive functioning: SSRT

“Stop Signaal Reactietijd” or Stop Signal Reaction Time (SSRT; Logan & Cowan, 1984) is a test for children between the ages of 6 and 17 years old and assesses reaction time and inhibition. To administer the SSRT, children have to sit behind a computer screen with a push button on each side. The first 64 trials are presented in which a small plane is shown pointing

to either the right or the left corner of the screen. Children are instructed to push as quickly as possible either the right or the left button to match the direction of the plane. The next five sets of 64 trials consist of go trials and stop trials in random order. Stop trials are identified by the same plane, but at the last moment the plane gets a red cross, and then the child is prohibited to push any button. The interval between the onset of the go stimulus and the onset of the stop signal varies dynamically, adapted on the child's responses, using a tracking algorithm. The administration time is approximately 20 minutes. Bedard, Ickowicz and Logan et al. (2003) found an internal consistency .93. The content validity is confirmed by different studies that SSRT can differentiate ADHD children and normal children (Aman, Roberts & Pennington, 1998; Nigg, 1999). The convergent validity is supported by correlations between SSRT and the Attention, aggressive behaviour and delinquent behaviour scales of the Children Behaviour Check List and Teachers Report Form (Achenbach, 1991).

Executive functioning: SOP

The Self Ordered Pointing task (SOP: Petrides & Milner, 1982) is included to measure visual working memory capabilities and is one of the rare tests that have been validated as a relative selective frontal cortex measure (Petrides, Alivisatos, Evans & Meyer, 1993). Children in the age of 4-5 up to 19 years are presented four series of cards containing 6, 8, 10, 12 abstract designs, respectively. For each series, children are presented with one card at a time (with 6, 8, 10, 12 designs where the positions varied randomly) and are instructed to point to a different design on each of the cards. Children are informed that they could point to designs in any order they wishes, but without pointing to one of the designs more than once. Following the administration procedure of Petrides and Milner (1982), each series is presented three times in succession. Children are instructed to work accurate and speed is not emphasised. Children are not allowed to respond consistently to the same location, because by adopting such a strategy, the child will not need to identify the abstract design. The demand on working memory increases as the number of designs on each card increased during the task.

The number of errors is calculated for each difficulty level (6. 8. 10, 12) and contains the number of times a design is responded to more than once. Also the number of preservative errors, which is the number of times the same item is picked on a subsequent trail, is calculated. Difficulty level is taken into account in calculating the dependent variable, the number of errors. It is expected that there will be a linear relation between difficulty level and this dependent variable (Geurts, Verté, Oosterlaan, Roeyers & Sergeant, 2004, 2005; Oosterlaan, Sheres & Sergeant, 2005; Scheres, Oosterlaan & Geurts et al., 2004).

Executive functioning: Digit Span

Digit Span, a subtest of the Wechsler Intelligence Scale for Children (WISC III) is also used to assess working memory. This subtest is administered in children between the ages of 6 and 16 years old. The experimenter reads out loud digit series and the child has to repeat these same digits in the right order. The number of digits in the digit series increases when the answer is correct. The children have to repeat these digits forward and backwards. As mentioned earlier, good reliabilities and validities are reported for the WISC III (Wechsler, 1992).

Procedure

This study was approved by the Medical Ethical Committee of the cranial facial centre of the Erasmus MC. A letter informed the parents of the children with trigonocephaly who met the inclusion criteria. The parents had to sign a consent form. Then they could make an appointment for their child to be tested. The neuropsychological tests, intelligence (IQ) tests, visual motor tests and language tests were all assessed in the child. During the tests they were also being observed on their behaviour, appearance, shyness, social competences etc. The administration time for the whole test battery was approximately two-three hours, but varied with the age of the child. Further, parents had to fill in questionnaires concerning possible developmental problems in the child. Parents also were being interviewed. Written reports concerning the test results, test descriptions and child observations were send to all parents. The whole study was conducted under supervision of a registered clinical psychologist.

Information regarding the abnormality of the frontal lobes was collected by the plastic surgeon. This surgeon had composed a medical record of all operated children, which consists of a medical form, an X-ray and CT-scans. The preoperative CT-scan assessed the structural brain anomalies and therefore also the abnormality of the frontal lobes. The severity of the stenosis was measured on the 3D CT-scan, using the ratio between the interparietal and the intercoronal distance (Sidoti et al., 1996). Further, the Digital Impressions were being assessed by the pre- and post operational X-Rays (method Posnick, Lin, Chen & Armstrong, 1994); the ICP by inserting the sensor in the brain; and the kind of trigonocephaly was written down on the medical form, in the above-mentioned medical record. SES was two folded because it was based on the education level of both parents, which was asked during the parental interview. The possible education levels were low (no education, primary school, special education, and other low educations), middle (secondary school and other middle education) and high (university). The highest education level where the parent graduated in

was used for this assessment of SES. All risk factors and used measures and materials are represented in Table 3.

Table 3

Overview risk factors used in this study

Risk factors	Measures	Materials
Brain anomalies	Development of the frontal lobe and other brain regions	CT-scan
Severity of the stenosis	Ratio of the interparietal to the intercoronal distance	3D CT-scan
Severity Digital Impressions/ICP	Percentage of digital impressions on the skull/ICP yes or no	X-ray /sensor
Type of trigonocephaly	Isolated trigonocephaly or syndromal trigonocephaly (extra cranial associated malformations)	Medical record
SES	Education level both parents	Interview

Note. ICP= Intracranial Pressure; SES= Social Economic Status

Statistical analyses

The statistical analyses were divided in different parts. The first part consisted of descriptive information concerning cognitive problems in this sample of children diagnosed with trigonocephaly. By using a one-sample t-test, comparisons were made between the sample mean of different tests (and where possible also the means for boys and girls separately) and the mean of the norm groups that represent the normal population scores on these tests. Some results of this sample could only be compared with the cut off scores in the normal population. Therefore binomial tests were used to conclude if this sample differed significantly from the normal population. Finally, independent t-tests were conducted for every cognitive test to check if there were any significant gender differences within this sample. Because DMT was an ordinal variable, gender differences could only be analysed by a non-parametric test (Mann-Whitney test).

The second part consisted of information concerning the prevalence of the risk factors. If possible, the prevalence of these risk factors in this sample was compared to the prevalence of these same risk factors in the normal population by performing a one-sample t-test. Thereby could be concluded if the prevalence of these risk factors were significantly higher in this sample compared to the normal population. The information concerning the prevalence of the risk factors was necessary, because if a risk factor was not present in this sample, no further analysis could be done for this risk factor.

The final part of analyses consisted of linear regression analyses of two different risk factors which consisted of continue data (Digital Impressions and severity of the stenosis).

The aim of conducting linear regression analyses was to conclude if any of these two risk factors had a predictive value concerning the level of the different domains of executive functioning. Before performing these linear regression analyses a histogram was composed to check if this sample resembles a normal distribution. Because that was the case, linear regression analyses could be conducted. The other risk factors (ICP, type of trigonocephaly and SES) were ordinal data; therefore a one-way ANOVA was conducted to see if the presence of ICP, the different types of trigonocephaly or the different levels of SES, had a significant effect on the level of the domains of executive functioning.

Missing data

Technical difficulties and different tests that were applicable for different ages led to missing data. A review of all tests and risk factors, with the number of children or parents of whom data were available and of whom data was missing are represented in Table 4.

The cognitive tests: intelligence (IQ), visual motor skills (VMI) and language (N-CDIs and VTO) were administered in all children with the corresponding age range for each test. The age range for the intelligence tests was: Mullen Scales of Early Learning 0-48 months, the WPPSI-R 4-6 years, and the WISC III 7-16 years. The visual motor skills were assessed in children within the ages of 4-17 years old. The age range for the language tests were respectively N-CDIs 16-10 months and VTO 3-5 years. Missing data for these tests represented in Table 4, were children who were not in these age ranges.

Two reading tests were also included in the cognitive test battery (DMT and Klepel). These tests were applicable for children between the 2nd grade and 7$^{th\ or\ 8th}$ grade. Only 13 children of this sample were in these grades. The DMT was administered in 11 children and missed two children because they could not read all three cards. The Klepel was administered in all 13 children therefore the only missing data consisted of children that did not fit the age range of this test.

The executive functioning tests consisted of the Brief-P, the Brief, the SSRT, the SOP and the Digit Span. The Brief-P was a parental questionnaire which was applicable for children in the age of 2-5 years. The total number of questionnaires which could be returned by the parents was 31 questionnaires. The father reports of the Brief-P were returned by 25 fathers; therefore six questionnaires were not received at the Erasmus MC, Sophia Children's hospital, in Rotterdam. Perhaps, the questionnaires were not returned by these fathers or maybe they got misplaced at the post office. All mother reports of the Brief-P were received back.

Table 4

Missing data and explanations for the different cognitive tests and medical risk factors

Cognitive tests and (medical) risk factors	Number of children	Missing data	Reason missing data	Number of fathers	Missing data	Reason missing data	Number of mothers	Missing data	Reason missing data
Mullen	20	0	-	0	0	-	0	0	-
WPPSI-R	16	0	-	0	0	-	0	0	-
WISC-III	11	0	-	0	0	-	0	0	-
VMI	27	20	Age range test	0	0	-	0	0	-
N-CDIs	0	0	-	20	27	Age range test	20	27	Age range test
VTO	10	37	Age range test	10	37	Age range test	10	37	Age range test
DMT	11	36	Age range test (34) Card 3 to difficult (2)	0	0	-	0	0	-
Klepel	13	34	Age range test	0	0	-	0	0	-
Brief -P	0	0	-	25	22	Age range test (16) Not returned (6)	31	16	Age range test
Brief	0	0	0	11	36	Age range test (31) Not returned (5)	14	33	Age range test (31) Not returned (2)
SSRT	20	27	Age range test	0	0	-	0	0	-
SOP	27	20	Age range test	0	0	-	0	0	-
Digit Span	10	37	Age range test	0	0	-	0	0	-
Brain anomalies	0	47	Technical difficulties	0	0	-	0	0	-
Digital impressions	21	26	Technical difficulties	0	0	-	0	0	-
ICP	47	0	-	0	0	-	0	0	-
Severity of the stenosis	15	22	Technical difficulties	0	0	-	0	0	-
Type trigonocephaly	47	0	-	0	0	-	0	0	-
SES	0	0	-	47	0	-	47	0	-

Note. Mullen= The Mullen Scales of Early Learning; WPPSI-R= The Wechsler Preschool and Primary Scale of Intelligence; WISC III= The Wechsler Intelligence Scale for Children III; VMI= The Developmental Test of Visual-Motor Integration; N-CDIs= The Nederlandse (Dutch) Communicative Development Index Scales; VTO= Vroegtijdige Taalontwikkelingsstoornissen; DMT= Drie Minuten Test; Brief-P= The Behaviour Rating Inventory Executive Function Preschool Version; Brief=The Behaviour Rating Inventory Executive Function; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing task.

The Brief was also a parental questionnaire which was applicable for children in the age of 6-18 years. The total of questionnaires which could be returned by the parents was 16 questionnaires. The number of returned questionnaires for the father reports of the Brief was 11 questionnaires and for the mother reports were 14 questionnaires. The respectively five and one missing questionnaire(s) were either not returned or got misplaced at the post office.

The SSRT assessed inhibition and was administered in the age of 6-17 years old. The SOP assessed the executive functioning domain working memory and the age range for this test was 4.5 – 19 years. Digit Span also assessed working memory and was administered in the age of 6-16 years. All children that fitted these age ranges did these tests. Missing data for these tests represented in Table 4, were children that were not in these age ranges.

The risk factors which were used in this study were all based on the child, except SES which was based on the education level of both parents. Unfortunately because of technical difficulties (incomplete medical records) there was no possibility to assess the brain anomalies. Therefore all data was missing and this risk factor could not be included in the statistical analysis. The risk factors Digital Impressions and severity of the stenosis could also not be calculated for the whole sample because of technical difficulties. These difficulties were mainly caused by missing 3D CT scans and no time to search for them at other locations

or hospitals. ICP, type of trigonocephaly and SES were assessed for all children in this sample, therefore no missing data was registered.

III Results

Elevated risks on cognitive problems

Intelligence (IQ)

Intelligence (IQ) scores were retrieved from the whole sample. The Mullen Scales of Early Learning was administered in 20 children, the WPPSI-R in 16 children and the WISC III in 11 children. All IQ results were merged and compared to the mean IQ of the Dutch population (*M*=100, *SD*=15*)*. This sample had a mean IQ of 104, which is very near the population mean of 100. A one-sample t-test showed no significant difference in IQ between this sample and the normal population (*t*(46) =1.10, *p*>.05). Also a one-sample t-test was conducted for the IQ of girls and boys separately. These IQ's separately showed no significant difference from the IQ of girls and boys in the normal Dutch population (respectively (*t*(6) =2.25, *p*>.05; (*t*(39) =.64, *p*>.05). The IQ scores of the boys and the total group had a large variance, which means extreme scores were present. The variance of the IQ scores of the girls was comparable with the normal Dutch population. Because the literature reported a more severe developmental delay for girls diagnosed with trigonocephaly compared to boys diagnosed with trigonocephaly, an independent t-test was conducted (Kapp-Simon et al., 2005). No significant gender differences within this sample were found in IQ (*t*(45)=.89, *p* >.05).

Table 5

Mean, SD and results of a one-sample t-test for IQ girls, IQ boys and Total IQ represented separately.

Intelligence test	*M*	*SD*	*p*
Girls	115	12.9	.07
Boys	104	25.5	.53
Group	104	25.1	.28

Note. IQ scores normal population (M=100, SD=15).

Visual and motor skills

Visual and motor skills were assessed by the VMI, which consisted of three scores: a Visual Motor Integration score, a Visual Perception score and a Motor Coordination score. Of the 47 children in this sample, 27 children were in the age range of this test. For every subtest only the standard scores were used in the analyses (*M*=100, *SD*=15). After performing a one-

sample t-test could be concluded that this sample did not significantly differ from the normal population on Visual Motor Integration ($t(26)=.34$, $p>.05$) and Visual Perception ($t(26)=-.35$, $p>.05$). However, the Motor Coordination skills of this sample were significantly lower than children of the same ages in the normal population ($t(26)=-4.16$, $p<.05$) (Table 6). The variance of the Visual Motor Integration scores as well as the Visual Perception scores and the Motor Coordination scores was large (SD was respectively 29.04; 18.50; 18.40; Table 6), which means extreme scores were present in this sample. A one-sample t-test was also conducted for the boys and girls in this sample separately. Boys showed significantly more problems in Motor Coordination compared to the normal population ($t(22)=-3.75$, $p<.01$). Girls did not differ significantly on Motor Coordination compared to the normal population ($t(3)=-1.7$, $p>.05$). No significant differences were found on Visual Motor Integration and Visual Perception, when comparing boys and girls separately with their peers in the normal population (Table 6). All three subtests did not show significant gender differences within this sample (Visual Motor Integration, $t(25)=.79$, $p>.05$; Visual Perception, $t(25)=-.29$, $p>.05$; Motor Coordination, $t(25)=.14$, $p>.05$).

Table 6

Mean, SD and results of a one-sample t-test and independent t-test for the VMI subtests: girls, boys and total represented separately.

VMI	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Total *M*	Total *SD*	Total *p*	Gender difference *p*
Visual Motor Integration	112.5	19.7	.30	100.0	30.3	.99	101.9	29.0	.74	.44
Visual Perception	96.3	18.5	.71	99.2	18.9	.84	98.7	18.5	.73	.78
Motor Coordination	86.5	15.9	.19	85.1	19.1	.00**	85.3	18.4	.00**	.89

Note. VMI = Visual Motor Integration. VMI and subtests were represented in standard scores (M=100, SD=15)
Girls, Boys and Total mean scores were compared with the mean score of the population, which represents the p value.
Gender difference p values were based on comparisons between genders within the sample and Visual Motor skills scores for this sample.

Language

The N-CDIs were only applicable for children in the age of 16-30 months. Within this sample 20 children were in this age category, of which 3 were female and 17 were male. N-CDIs scores were represented by raw scores and percentiles (M=50, SD=10). The mean score of these 20 children for the receptive language skills was 96 words of the total 112 words. The corresponding percentile was 56.8%, which means that nearly 57% of the normal Dutch population, scored below the average score of this sample on the N-CDIs. To conclude if the mean score of this sample significantly differed from the mean of the normal Dutch

population (*M*=50, *SD*=10), a one-sample t-test based on percentiles was conducted. No significant differences were found between the receptive language skills of this sample and the normal Dutch population (*t*(19)=.91, *p*>.05). If the genders were separately compared, no significant differences were found between the receptive language skills of boys and girls separately and the normal Dutch population (boys *t*(16)=.46, *p*>.05; girls *t*(2)=1.79, *p*>.05) (Table 7).

With respect to the language production, 71 words could be pronounced correctly by the children in this sample, which corresponded with a percentile of 44.8% of the normal Dutch population. Therefore almost 45% of the normal Dutch population scored below the average score of this sample. Also a one-sample t-test was conducted based on percentiles to see if the language production scores of this sample significantly differed from those of the normal Dutch population (*M*=50, *SD*=10). No significant differences were found in the productive language skills between this sample and the normal Dutch population (*t*(19)=-.64, *p*>.05). If the productive language skills for boys and girls were separately compared to the normal Dutch population, also no significant differences were found (boys *t*(16)=-.52, *p*>.05; girls *t*(2)=-.57, *p*>.05) (Table 7). For both language skills (receptive and productive) significant gender differences within this sample were found, as shown by Table 7 (respectively *t*(18)=2.98, *p*<.01; *t*(18)=2.23, *p*<.05). Girls were significantly better in receptive and productive language skills than boys, according to the parent reports.

Table 7

Mean, SD, results of one-sample t-tests and independent t-tests for different language skills.

Language test	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Total *M*	Total *SD*	Total *p*	Gender difference *p*
N-CDIs receptive language	111	1.7	.22	93	24.5	.65	96	23.4	.37	.00**
N-CDIs productive language	92	9.9	.63	67	40.3	.61	71	38.2	.53	.04*
VTO child	34	-	-	40	4.9	-	40	5.0	-	.25
VTO parents	4	-	-	10	1.3	-	10	2.4	-	.00**

Note. N-CDIs= Nederlandse (Dutch) Communicative Development Index Scales; VTO = Vroegtijdige Taalontwikkelingsstoornissen. M and SD of N-CDIs and VTO were represented in raw scores. P values for N-CDIs were based on a comparison between percentiles of the normal population and this sample. SD for VTO girls could not be calculated because there was only one girl. P values for VTO could not be calculated because the lack of means of the norm group. Gender difference p values were based on comparisons between genders within the sample and both language scores for this sample.

The VTO was also a test to assess language development and was applicable for children in the ages of 3 up to 5 years old. This sample had 10 children that were in this age range; one was a girl and 9 were boys. Two versions were assessed; one was administered in the child by the experimenter and one was a questionnaire that had to be filled in by the parents. The

scores of the VTO were represented as a dichotomy and in raw scores. Because no mean VTO scores were available for the normal Dutch population, only the cut off scores could be used to compare this sample and the normal Dutch population on this test. In the normal Dutch population 10% of the children have a deviant language development, opposed to 90% that have a normal language development. The percentage, found in the child version of the VTO, which developed their language normally was exactly 90% and the percentage which had a deviant language development was 10%. A binomial test was conducted to compare the language development in the normal Dutch population with this sample; no significant difference in language development was found (Table 8).

When the parents were asked to rate the language development of their children, different results were found. This parental questionnaire showed that 50% of the parents rated the language development of their children as deviant, in stead of the 10% that resulted from the VTO children's test. A binomial test was also conducted for the VTO for parents. A significant difference was found in language development skills between the normal Dutch population and this sample (Table 8). It was impossible to compare the genders separately with the cut off score for the normal Dutch population; because only one girl was included for the VTO which number was too small to perform a binomial test.

Table 8

Binomial test of the VTO compared to the normal Dutch population

Measure	Groups	Observed proportion	Test Proportion	*n*	*p*
VTO Child	Good	.90	.90	10	.65
	Weak	.10			
VTO Parents	Good	.50	.90	10	.00**
	Weak	.50			

Note. VTO=Vroegtijdige Taalontwikkelingsstoornissen.

No significant gender differences within this sample were found in the VTO children's test ($t(8)=-1.23$, $p>.05$) (Table 7). The VTO for parents did have a significant gender effect; boys were significant better in language development ($t(8)=-4.59$, $p<.05$), but this difference was only based on one girl (Table 7).

Reading

Reading skills were measured by the Dutch reading tests: Three Minutes Test (DMT) and the Klepel. Of the 47 children in this sample, only 11 children performed the DMT. The data of

the DMT was ordinal and ranged from “very weak” up to “very good”. Most children in this sample read existing words, measured by the DMT, between good/very good and good/sufficient (73%) (Table 9). To check if reading skills of existing words for this sample did not differ from the reading skills of the normal Dutch population in this age range a binomial test was performed (Table 10). This test showed no significant difference in reading skills between the normal Dutch population and this sample. However, the percentage of children which scored in the category “good/very good” of this sample was more then twice the percentage of the normal Dutch population for this category. On the other hand, the percentage of children which scored in the category “very weak” of this sample, was also more than twice as much as the percentage of children in the normal Dutch population. None of the children within this sample scored in the categories “sufficient” and “Weak”, compared to respectively 25% and 15% of the normal Dutch population (Table 9). Of the 11 children, 10 were boys (mode: reading level between good/sufficient and sufficient) and one girl (reading level good/sufficient). The amount of girls that conducted this test was too small to compare reading skills for boys and girls separately with the reading skills of the normal Dutch population. To compare gender differences within this sample on word reading a Mann-Whitney test had to be conducted, because the DMT variable is ordinal and gender is a nominal variable. Between the 10 boys and 1 girl that conducted the DMT, no significant gender differences were found in word-reading (U= 4.00, p>.05).

Table 9

Reading level distribution in this sample and in the normal Dutch population.

Reading test	Level	Percentage in sample	Percentage in Dutch population
DMT	Good/ very good	54.5	25
	Good/ sufficient	18.2	25
	Sufficient	0	25
	Weak	0	15
	Very weak	27.3	10

Note. DMT= Drie Minuten Test.

Table 10

Binomial test to compare the DMT score in this sample with the normal Dutch population.

Measure	Groups	Observed proportion	Test Proportion	*N total*	*p*
DMT	Very good to weak	.70	.90	11	.09
	Very weak	.30			

Note. DMT= Drie Minuten Test

The Klepel assessed the ability to read pseudo words. Only the standard scores were used to analyse the data of the Klepel (*M*=10, *SD*=3). Thirteen children were in the age range for this test. When comparing the Klepel scores of the children in this sample with the mean Klepel score of the normal Dutch population, no significant differences were found ($t(12)$= -.05, p>.05) (Table 11). The scores of the boys and the total group had large standard deviations, which mean extreme scores were present. The scores of the girls had comparable standard deviations as the normal Dutch population. When comparing both genders separately with the normal Dutch population, also no significant differences were found (Table 11). The Klepel was administered by 11 boys and two girls. By performing an independent t-test, boys and girls within this sample were compared with each other on reading pseudo words, no gender differences were found ($t(11)$=.57, p>.05).

Table 11

Mean, SD and results of a one-sample t-test and independent t-test for the Klepel; girls, boys and total represented separately.

Reading test	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Total *M*	Total *SD*	Total *p*	Gender difference *p*
Klepel	12.0	2.8	.50	9.6	5.8	.80	9.9	5.4	.96	.58

Note. All Klepel scores were represented in standard scores (M=10, SD=3).
Girls, Boys and Total mean scores were compared with the mean score of the population, which represents the p value.
Gender difference p values were based on comparisons between genders within the sample and the Klepel scores for this sample.

Table 12

Mean, SD and results of a one-sample t-test for the Brief-P compared to the normal population

Domain	Assessed in:	*M*	*SD*	*p*
Inhibition	Mother	50.4	11.3	.86
	Father	49.2	10.6	.70
Set Shifting	Mother	48.3	11.7	.43
	Father	46.6	10.1	.11
Emotional Control	Mother	46.4	10.5	.06
	Father	43.2	7.1	.00**
Working Memory	Mother	54.1	14.7	.14
	Father	52.5	12.5	.33
Planning/ Organize	Mother	47.3	12.0	.22
	Father	46.7	13.9	.25
EF Total	Mother	49.4	12.5	.81
	Father	47.5	10.9	.27

Note. All Brief-P (Behaviour Rating Inventory Executive Function Preschool Version) scores were represented in T-scores (M=50, SD=10).

Executive functioning

The different domains of executive functioning were measured by two questionnaires, the Brief-P (2-6 years) and Brief (6-18 years). Father's reports of the Brief-P consisted of 25

questionnaires (4 girls and 21 boys). Mother's reports of this questionnaire consisted of 31 questionnaires (4 girls and 27 boys). The Brief version (6-18 years) consisted of 11 questionnaires of the fathers (2 girls and 9 boys) and 14 questionnaires of the mothers (2 girls and 12 boys). Only T scores were used in the analyses for these questionnaires (M=50, SD=10). Most of the different mean scores on both questionnaires were close near the population mean (Table 12-13). However, three domains of executive functioning differed significantly from the population mean (Table 12-13). First, the father reports of the Brief-P differed significantly on emotional control compared to the normal population (t(24)=-4.78, p<.05) (Table 12). Second, the mother reports of the Brief differed significantly from the normal population on monitoring (t(13)=-3.7, p<.05) (Table 13). Finally, the father reports of the Brief differed also significantly from the normal population on monitoring (t(10)=-.2.74, p<.05) (Table 13). These significant results showed that parents from this sample reported fewer problems on emotional control and monitoring compared to the parents of the normal population. On the other domains of executive functioning was the sample diagnosed with trigonocephaly comparable with the normal population.

Table 13

Mean, SD and results of a one-sample t-test for the Brief compared to the normal population.

Domain	Assessed in:	*M*	*SD*	*p*
Inhibition	Mother	45.9	10.9	.18
	Father	46.9	10.6	.36
Set Shifting	Mother	44.3	18.7	.27
	Father	48.6	8.7	.61
Emotional Control	Mother	46.2	17.2	.42
	Father	47.7	10.0	.47
Initiate	Mother	52.7	16.1	.54
	Father	51.2	14.9	.80
Working Memory	Mother	47.2	14.9	.50
	Father	48.4	13.5	.70
Planning/ Organize	Mother	47.1	12.8	.42
	Father	49.2	13.5	.85
Organisation of materials	Mother	47.5	9.4	.34
	Father	47.3	10.4	.40
Monitor	Mother	41.2	8.9	.00**
	Father	33.2	20.3	.02*
EF Total	Mother	46.1	12.3	.26
	Father	46.6	12.6	.38

Note. All Brief (Behaviour Rating Inventory Executive Function) scores were represented in T-scores (M=50, SD=10).

Comparing executive functioning of the boys and girls separately with the normal population, showed significant results for boys on set shifting, emotional control (Brief-P father) and Monitor (Brief mother) (Table 14-15). One significant result for girls was found on emotional control (Brief father) (Table 15). The significant findings for the boys and girls

separately showed also fewer problems for this sample on these domains of executive functioning compared to the normal population. There was also checked for gender differences within this sample on the domains of the Brief en Brief-P (Table 14-15). One significant gender effect was found for set shifting (Brief father) ($t(9)=-2.65$, $p<.05$). Fathers of the boys in the age range of the Brief reported significantly more problems on set shifting than fathers of the girls.

Table 14

Mean, SD, results of one-sample t-tests and independent t-tests for the Brief-P; girls, boys and total represented separately.

Domain EF	Assessed in:	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Gender difference *p*
Inhibition	Mother	50.3	8.9	.97	50.4	11.7	.87	.98
	Father	52.5	13.8	.74	48.5	10.2	.52	.51
Set Shifting	Mother	53.8	18.2	.71	47.5	10.7	.24	.33
	Father	53.8	19.6	.73	45.2	7.3	.00**	.45
Emotional Control	Mother	46.8	15.0	.69	46.3	10.1	.07	.94
	Father	43.5	9.6	.27	43.2	6.8	.00**	.94
Working Memory	Mother	58.0	23.1	.54	53.5	13.5	.21	.57
	Father	54.0	18.5	.70	52.2	11.7	.40	.80
Planning/ Organize	Mother	47.8	13.7	.76	47.2	12.0	.24	.57
	Father	52.0	17.6	.84	45.7	13.4	.15	.42
EF Total	Mother	51.5	17.8	.88	49.1	11.9	.71	.73
	Father	51.5	18.7	.88	46.7	9.3	.13	.44

Note. All Brief-P (Behaviour Rating Inventory Executive Function Preschool Version) scores were represented in T-scores (M=50, SD=10).
Girls p and Boys p were based on comparisons with the mean scores for the normal population (M=50, SD=10)
Gender difference p values were based on comparisons between genders within the sample and Brief-P scores for this sample.

Table 15

Mean, SD, results of one-sample t-tests and independent t-tests for the Brief; girls, boys and total represented separately.

Domain EF	Assessed in:	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Gender difference *p*
Inhibition	Mother	38.0	.0	-	47.2	11.2	.40	.29
	Father	39.5	2.1	.09	48.6	11.1	.71	.30
Set Shifting	Mother	37.0	.00	-	45.5	20.1	.45	.57
	Father	37.0	.00	-	51.2	7.3	.63	.00**
Emotional Control	Mother	36.0	.00	-	47.9	18.1	.70	.39
	Father	37.0	1.4	.04*	50.1	9.4	.97	.09
Initiate	Mother	55.0	.00	.84	52.3	15.2	.61	.84
	Father	55.0	17.0	.75	50.3	15.4	.95	.71
Working Memory	Mother	36.0	.0	-	49.1	15.4	.84	.27
	Father	37.5	2.1	.08	50.8	13.8	.87	.22
Planning/ Organize	Mother	39.5	2.1	.09	48.4	13.5	.69	.38
	Father	48.5	10.6	.87	49.3	14.6	.89	.94
Organisation of materials	Mother	39.0	.0	-	48.9	9.5	.70	.18
	Father	39.0	.0	-	49.1	10.7	.81	.23
Monitor	Mother	33.0	.0	-	42.6	8.9	.02*	.17
	Father	34.5	2.1	.06	32.9	22.7	.05	.93
EF Total	Mother	35.5	3.5	.11	47.9	12.4	.57	.20
	Father	37.5	3.5	.13	48.6	13.1	.75	.28

Note. All Brief (Behaviour Rating Inventory Executive Function) scores were represented in T-scores (M=50, SD=10).Girls p and Boys p were based on comparisons with the mean scores for the normal population (M=50, SD=10). Some questionnaires were missing or incomplete therefore not all domains could be compared to the normal populations for the girls (only 2 girls). Gender difference p values were based on comparisons between genders within the sample and Brief scores for this sample.

The SSRT test also assessed inhibition. Unfortunately no data of the norm group, that represents the normal population, was available in time for this study. Therefore no comparison could be made with the normal population and this test. It was possible to check on gender differences within this sample, by conducting an independent t-test (Table16). The raw scores were used to analyse the gender differences. No differences between the genders (17 boys and 3 girls) within this sample were found for the SSRT test ($t(18)=-.58$, $p>.05$).

Table 16

Mean, SD and results of one-sample t-tests and independent t-tests for the SSRT, SOP, Digit Span; girls, boys and total represented separately.

Domain EF	Girls *M*	Girls *SD*	Girls *p*	Boys *M*	Boys *SD*	Boys *p*	Total *M*	Total *SD*	Total *p*	Gender difference *p*
Inhibition (SSRT)	310.00	126.86	-	352.28	115.08	-	345.94	114.39	-	.57
Working Memory (SOP)	11.75	10.53	-	21.52	11.16	-	20	11.43	-	.12
Working Memory (Digit span)	10.50	2.12	.80	9.88	5.77	.95	10	5.15	1.00	.89

Note. SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing Task. All SSRT and SOP scores were represented in raw scores; All Digit span scores were represented in standard scores (M=10, SD=3). Girls p and Boys p were based on comparisons with the mean scores for the normal population (M=50, SD=10). P values for SSRT and SOP could not be calculated because of no available norm data. Gender difference p values were based on comparisons between genders within the sample on SSRT, SOP, Digit Span scores for this sample.

The SOP assessed working memory. The problem concerning the norm group data was also applicable for this test; no comparison was possible with the normal population. Raw scores were used to analyse the gender differences within this sample. No significant gender differences on the SOP were found between the 23 boys and 4 girls within this sample ($t(25)=-1.63$, $p>.05$) (Table 16).

Working memory was also measured by the subtest Digit Span from the WISC III. This subtest was represented in standard scores ($M=10$, $SD=3$). The sample mean was exactly the population mean. Performing a one-sample t-test, no significant differences were found between this sample and the normal Dutch population ($t(9)=.00$, $p>.05$) When girls and boys were separately compared with the normal Dutch population, also no significant differences were found (boys $t(7)=-.06$, $p>.05$; girls $t(1)=.33$, $p>.05$) (Table 16). Further, no gender differences were found within this sample on the subtest Digit Span ($t(8)=.15$, $p>.05$) (Table 16).

Risk factors and executive functioning

Prevalence risk factors

The first described risk factor was brain anomalies. As mentioned earlier, it was impossible to find information concerning the presence of brain anomalies in this sample. Therefore, no prevalence information could be given for this risk factor.

The second risk factor was two folded, because Digital Impressions and an elevated ICP often appear simultaneously. All data was available concerning the presence of Digital Impressions. In 33% of the children in this sample Digital Impressions were present. The exact percentage of Digital Impressions was found for 21 (45%) children in this sample. The Digital Impressions of this sample had a mean of 4.84% (SD 6.47%) (Table 17). The ICP data was available for all children in this sample. Almost 11% of the children had en elevated ICP (Table 17).

Table 17

Mean, percentage and SD for the risk factors

Risk factors	*M*	Percentage	*SD*
Digital Impressions: yes/no *(n=47)*	-	33	-
Digital Impressions: exact percentage *(n=21)*	4.84	45	6.47
ICP	-	11	-
Severity of stenosis (IPDICD ratio)	1.33	32	.06
Type of trigonocephaly: syndromal/ isolated	-	30/70	-

Note. ICP= Intracranial Pressure. All Digital Impressions scores were represented in percentages. All severity of the stenosis scores (IPDICD ratio) were represented in ratio's. ICP and Type of trigonocephaly were dichotome variables, therefore no M and SD could be calculated.

The third risk factor was the severity of the stenosis, assessed by the IPDICD ratio (interparietal distance / intercoronal distance). The severity of the stenosis could only be determined for 15 (32%) children. The mean ratio of the interparietal to the intercoronal distance for this sample was 1.33 (*SD*=.06) (Table 17). Shimoji et al. (2002) reported a mean ratio in the normal population of 1.21. A one-sample t-test compared that mean ratio with 1.33 and the difference reached significance ($t(14)=7.62$, $p<.01$), so this sample could be differentiated from the normal population on severity of the stenosis.

The fourth risk factor was the type of trigonocephaly of which all data could be retrieved. Of the 47 children diagnosed with trigonocephaly, 14 (30%) had additional malformations (syndromal form) in this sample and 70% had the isolated form (Table 17). The

malformations varied, five had cardiovascular pathology, one had a missing finger, three had dysmorphic characteristics like schisis, two had Valproate Syndrome and three had pulmonale problems.

The fifth risk factor was SES, which was based on the education level of both parents. All SES information of the 47 children in this sample was available (7 girls and 40 boys). The mode of education level of both parents in this sample was the middle education level. Table 18 shows the frequency of the low, middle and high education level in this sample and for the normal Dutch population, separated for mothers and fathers. Parents with high levels of education were more frequently observed in this sample than in the normal Dutch population. Parents with low levels of education were less frequently observed in this sample than in the normal Dutch population (Table 18). In short, the parents of this sample were higher educated than the people in the normal Dutch population.

Table 18

Frequency of education levels in this sample and the normal Dutch population

SES	Education level	Percentage trigonocephaly sample	Percentage normal Dutch population
Education level mother	Low	23.4	34
	Middle	42.6	41
	High	34	25
Education level father	Low	19.1	34
	Middle	42.6	41
	High	38.3	25

Note. SES= Social Economic Status. Low education level (no education, primary school, special education, other low educations), Middle education level (secondary school and other middle education), High education level (University).

Brain anomalies

Because of the lack of information concerning brain anomalies, this predictor could not be included in the linear regression analyses.

Digital Impressions / Intracranial Pressure (ICP)

The actual mean Digital Impressions in percentage could only be retrieved for 21 children. For these children a linear regression analysis was conducted to see if Digital Impressions could predict problems on the different domains of executive functioning. The executive functioning domains analysed with Digital Impressions were retrieved from the Brief and Brief -P. Other measures for working memory were submitted, like the SOP and the subtest Digit Span. Inhibition was also measured by the SSRT test. No significant relations between Digital Impressions and any of the domains of executive functioning were found for this sample (Table 19-21).

Table 19

Regression analysis for Digital Impressions and the Brief-P.

Domain EF	Assessed in:	β	R	R^2	p
Inhibition	Mother	.20	.20	.04	.68
	Father	.39	.39	.15	.52
Set Shifting	Mother	.03-	.03	.00	.95
	Father	.30-	.30	.09	.62
Emotional Control	Mother	.59	.59	.35	.17
	Father	.56	.56	.31	.33
Working Memory	Mother	.22	.22	.05	.63
	Father	.30	.30	.09	.63
Planning/ Organize	Mother	.16	.16	.03	.73
	Father	.25-	.25	.06	.69
EF Total	Mother	.35	.35	.13	.49
	Father	.20	.20	.04	.75

Note. EF= Executive Functioning. All Brief-P (Behaviour Rating Inventory Executive Function Preschool Version) scores were represented in T-scores (M=50, SD=10).

Table 20

Regression analysis for Digital Impressions and the Brief.

Domain EF	Assessed in:	β	R	R^2	p
Inhibition	Mother	.18-	.18	.31	.58
	Father	.07	.07	.00	.85
Set Shifting	Mother	.20	.20	.04	.53
	Father	.08	.08	.01	.83
Emotional Control	Mother	.20	.20	.04	.53
	Father	.02-	.02	.00	.95
Initiate	Mother	.08-	.08	.01	.82
	Father	.12	.12	.02	.74
Working Memory	Mother	.10	.10	.01	.77
	Father	.12	.12	.02	.74
Planning/ Organize	Mother	.20-	.20	.04	.54
	Father	.18-	.18	.03	.62
Organisation of materials	Mother	.07-	.07	.01	.83
	Father	.01	.01	.00	.97
Monitor	Mother	.09-	.09	.01	.78
	Father	.19	.19	.04	.59
EF Total	Mother	.03-	.03	.00	.92
	Father	.03	.03	.00	.93

Note. EF = Executive Functioning. All Brief (Behaviour Rating Inventory Executive Function) scores were represented in T-scores (M=50, SD=10).

The beta coefficient showed the direction of the relations between Digital Impressions and the domains of executive functioning. Most of these relations were positive; when children had more Digital Impressions children exhibited more problems with their executive functioning. The domains set shifting (Brief-P both parents), planning (Brief-P father), inhibition (Brief mother and SSRT), emotional control (Brief-father), initiate (Brief mother), planning (Brief both parents), organisation of materials (Brief mother), monitor (Brief both parents), total executive functioning (Brief mother) and working memory (Digit Span) had a negative relation with Digital Impressions (Table 19-21). This means; when children had more Digital Impressions, they exhibited fewer problems on these domains of executive

functioning.

Table 21

Regression analysis for Digital Impressions and the SSRT, SOP and Digit Span.

Domain EF	*β*	*R*	R^2	*p*
Inhibition (SSRT)	.10-	.10	.01	.70
Working Memory (SOP)	.06	.06	.00	.81
Working Memory (Digit span)	.44-	.44	.19	.24

Note. EF= Executive Functioning; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing Task. All SSRT and SOP scores were represented in raw scores; All Digit span scores were represented in standard scores (M=10, SD=3)

ICP could only be reported as a dichotomy; therefore a one-way ANOVA was conducted to analyse the effects of ICP on the domains of executive functioning (Table 22). No significant effects were found for this risk factor on any of the domains of executive functioning.

Severity of the stenosis

The severity of the stenosis was measured in 15 children, by calculating the IPDICD ratio. To determine if the severity of the stenosis could predict outcomes on the different domains of executive functioning, a regression analyses was performed. Only the Brief-P was used in this analysis, because the children with a calculated ratio were the youngest children where the executive functioning was measured by the Brief-P. There were no significant relations found between this risk factor and any domain of executive functioning on the Brief-P (Table 23). However, some differences almost were significant. The severity of the stenosis was nearly a significant predictor for inhibition on the mother's reports of the Brief-P (R^2=.28, $F_{(1.12)}$=4.69, p=.05). On the father reports of the Brief-P, severity of the stenosis almost reached significance on set shifting (R^2=.31, $F_{(1.10)}$=4.55, p=.06). The beta coefficient was reported to address the direction of the relations between the severity of the stenosis and the domains of executive functioning (Table 23). All relations between this risk factor and the father reports of the Brief-P were negative, so when the stenosis got more severe the problems on all domains of executive functioning got smaller. The mother reports of the Brief-P showed a negative relation between the severity of the stenosis and working memory and planning. The other domains of executive functioning had a positive relation with this risk factor; therefore a more severe stenosis was related to more executive problems.

Table 22

Mean, SD and the results of a one-way Anova for the factor ICP and the EF domains as dependent variable.

Domain EF	Assessed in:	No ICP *M*	No ICP *SD*	ICP *M*	ICP *SD*	*p*
Inhibition (Brief-P)	Mother	49.89	9.05	54.67	27.21	.50
	Father	49.36	10.34	47.67	15.14	.80
Set Shifting (Brief-P)	Mother	48.75	12.09	44.33	7.10	.54
	Father	47.00	10.74	43.67	1.16	.60
Emotional Control (brief-P)	Mother	45.93	9.02	50.33	23.12	.50
	Father	43.05	6.61	44.67	11.72	.72
Working Memory (Brief-P)	Mother	53.41	13.65	60.00	25.53	.47
	Father	52.27	12.85	54.00	12.17	.83
Planning/ Organize (Brief-P)	Mother	46.54	9.67	54.33	28.45	.29
	Father	47.27	14.44	42.33	10.21	.58
EF Total (Brief-P)	Mother	48.88	10.24	54.00	28.62	.51
	Father	47.73	10.90	46.00	13.12	.80
Inhibition (Brief)	Mother	47.33	11.07	37.00	1.41	.23
	Father	47.33	11.30	45.00	9.90	.80
Set Shifting (Brief)	Mother	45.50	20.10	37.00	.00	.57
	Father	50.22	8.59	41.50	6.36	.22
Emotional Control (Brief)	Mother	47.75	18.17	37.00	1.41	.43
	Father	48.56	10.19	44.00	11.31	.59
Initiate (Brief)	Mother	52.00	15.55	57.00	25.46	.70
	Father	51.44	16.25	50.00	9.90	.91
Working Memory (Brief)	Mother	48.92	15.49	37.00	1.41	.31
	Father	49.33	14.31	44.00	11.31	.64
Planning/ Organize (Brief)	Mother	48.00	13.74	42.00	1.41	.56
	Father	47.44	14.43	57.00	1.41	.39
Organisation of materials (Brief)	Mother	49.08	9.27	38.00	1.41	.13
	Father	46.67	10.10	50.00	15.56	.70
Monitor (Brief)	Mother	41.67	9.29	38.50	7.78	.66
	Father	31.00	21.79	43.00	9.90	.48
EF Total (Brief)	Mother	47.67	12.72	37.00	1.41	.27
	Father	47.00	13.15	44.50	13.44	.81
Inhibition (SSRT)	Child	359.90	110.45	220.27	78.50	.10
Working Memory (SOP)	Child	20.04	11.64	20.33	11.85	.97
Working Memory (Digit span)	Child	9.88	5.77	10.50	2.12	.89

Note. Brief-P = Behaviour Rating Inventory Executive Function Preschool Version; Brief = Behaviour Rating Inventory Executive Function; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing Task.
All Brief-P and Brief scores were represented in T-scores (M-50, SD=10); All SSRT and SOP scores were represented in raw scores; All Digit span scores were represented in standard scores (M=10, SD=3).

Table 23

Regression analysis for severity of the stenosis and the Brief-P.

Domain EF	Assessed in:	*β*	*R*	R^2	*p*
Inhibition	Mother	.53	.53	.28	.05
	Father	.16-	.16	.03	.61
Set Shifting	Mother	.05	.05	.00	.85
	Father	.56-	.56	.31	.06
Emotional Control	Mother	.45	.45	.20	.09
	Father	.22-	.22	.05	.48
Working Memory	Mother	.01-	.01	.00	.97
	Father	.23-	.23	.05	.47
Planning/ Organize	Mother	.12-	.12	.01	.68
	Father	.32-	.32	.10	.31
EF Total	Mother	.24	.24	.06	.42
	Father	.34-	.34	.12	.27

Note. All Brief-P (Behaviour Rating Inventory Executive Function Preschool Version) scores were represented in T-scores (M=50, SD=10). All severity of stenosis scores were represented in ratio's

Type of trigonocephaly

Type of trigonocephaly was also retrieved from the medical records. This variable was not a continue variable because the only two possibilities were either isolated or syndromal trigonocephaly. By conducting a one-way ANOVA, the effect of type of trigonocephaly on the different domains of executive functioning could be analysed.

Table 24

Mean, SD and the results of a one-way Anova for the factor syndromal/not syndromal form of trigonocephaly and the EF domains as dependent variable.

Domain EF	Assessed in:	Not syndromal *M*	Not syndromal *SD*	Syndromal *M*	Syndromal *SD*	*p*
Inhibition (Brief-P)	Mother	49.62	12.42	52.11	8.27	.59
	Father	46.50	8.91	56.00	12.32	.04*
Set Shifting (Brief-P)	Mother	46.68	8.81	52.33	16.82	.23
	Father	44.89	6.38	51.00	16.20	.18
Emotional Control (brief-P)	Mother	44.91	9.77	49.89	12.03	.24
	Father	41.50	5.48	47.71	9.07	.04*
Working Memory (Brief-P)	Mother	52.95	14.22	57.13	16.52	.50
	Father	50.17	9.53	58.43	17.72	.14
Planning/ Organize (Brief-P)	Mother	47.36	13.08	47.11	9.47	.96
	Father	43.56	11.61	54.71	16.99	.07
EF Total (Brief-P)	Mother	48.15	12.28	52.63	13.34	.40
	Father	44.83	7.33	54.43	15.66	.04*
Inhibition (Brief)	Mother	44.67	10.43	48.00	12.51	.60
	Father	41.50	5.61	53.40	12.10	.06
Set Shifting (Brief)	Mother	42.22	22.92	48.00	8.00	.60
	Father	44.17	8.45	54.00	5.79	.06
Emotional Control (Brief)	Mother	45.22	20.66	48.00	9.93	.79
	Father	44.33	12.14	51.80	5.07	.23
Initiate (Brief)	Mother	51.56	16.09	54.80	17.64	.73
	Father	47.67	11.15	55.40	18.90	.42
Working Memory (Brief)	Mother	43.00	14.07	54.80	14.60	.16
	Father	38.67	2.66	60.00	11.58	.00**
Planning/ Organize (Brief)	Mother	44.22	8.61	52.40	18.26	.27
	Father	44.17	6.80	55.20	17.71	.19
Organisation of materials (Brief)	Mother	48.56	9.13	45.60	10.76	.60
	Father	44.33	5.09	50.80	14.43	.33
Monitor (Brief)	Mother	38.00	6.14	47.00	10.77	.07
	Father	28.00	13.81	39.40	26.57	.38
EF Total (Brief)	Mother	44.22	11.51	49.60	14.38	.46
	Father	40.00	3.58	54.40	15.37	.05
Inhibition (SSRT)	Child	344.03	124.36	351.64	89.31	.90
Working Memory (SOP)	Child	20.38	11.72	19.00	11.33	.80
Working Memory (Digit Span)	Child	12.43	3.31	4.33	4.16	.01*

Note. Brief-P = Behaviour Rating Inventory Executive Function Preschool Version; Brief = Behaviour Rating Inventory Executive Function; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing Task. All Brief-P and Brief scores were represented in T-scores (M-50, SD=10); All SSRT and SOP scores were represented in raw scores; All Digit span scores were represented in standard scores (M=10, SD=3).

Table 24 shows the significant effects of syndromal trigonocephaly on working memory (Brief father $F_{(1.9)}=19.55$, $p<.01$; Digit Span $F_{(1.8)}=10.97$, $p<.05$) inhibition (Brief-P father $F_{(1.23)}=4.63$ $p<.05$), emotional control (Brief-P father $F_{(1.23)}=4.46$ $p<.05$) and total executive functioning (Brief-P father $F_{(1.23)}=4.48$, $p<.05$). The syndromal form of trigonocephaly had

significant more problems on the domains of executive functioning mentioned in Table 24.

Social Economic Status (SES)

SES was an ordinal variable and therefore a one-way Anova was used to analyse the possible different effects of the different SES categories on the domains of the executive functions (Table 25). All domains of the executive functions were represented in the Brief en Brief-P. Working memory was also measured by the subtest Digit Span and by the SOP. Inhibition was also measured by the SSRT. No significant effects of different SES categories on any domain of executive functioning were found for this sample.

Table 25

Mean, SD and the results of a one-way Anova for the factor SES and the EF domains as dependent variable.

Domain EF	Assessed in:	Ed. low *M*	Ed. low *SD*	Ed. middle *M*	Ed. middle *SD*	Ed. high *M*	Ed. high *SD*	*p*
Inhibition (Brief-P)	Mother	47.00	10.10	51.19	12.43	50.40	10.49	.81
	Father	49.00	18.36	49.86	9.77	48.00	10.57	.93
Set Shifting (Brief-P)	Mother	49.75	8.77	45.53	10.16	52.5	14.52	.33
	Father	42.67	5.03	46.07	7.60	49.00	14.91	.64
Emotional Control (brief-P)	Mother	52.75	13.15	44.71	9.98	46.60	10.52	.40
	Father	45.33	8.08	43.50	7.49	42.00	6.68	.78
Working Memory (Brief-P)	Mother	50.00	15.58	54.94	14.58	54.30	15.86	.84
	Father	52.00	24.25	53.36	9.10	51.13	13.47	.93
Planning/ Organize (Brief-P)	Mother	45.75	9.81	46.71	12.86	48.90	12.16	.87
	Father	50.00	26.85	46.36	12.65	46.00	12.48	.91
EF Total (Brief-P)	Mother	47.75	14.22	49.53	12.60	50.00	13.15	.96
	Father	47.00	17.58	48.29	7.94	46.38	14.10	.93
Inhibition (Brief)	Mother	47.20	13.10	41.33	5.03	47.00	11.97	.75
	Father	44.75	6.80	45.50	10.61	49.20	14.39	.84
Set Shifting (Brief)	Mother	51.40	20.95	29.00	25.94	46.00	9.92	.27
	Father	47.50	8.35	50.00	9.90	49.00	10.46	.95
Emotional Control (Brief)	Mother	45.40	13.07	35.67	31.21	52.17	11.41	.43
	Father	45.40	6.76	46.00	11.31	50.20	12.95	.79
Initiate (Brief)	Mother	56.60	16.15	45.00	8.54	53.33	19.52	.65
	Father	44.25	9.22	49.00	14.12	57.60	18.38	.44
Working Memory (Brief)	Mother	52.00	17.72	43.33	7.57	45.17	16.30	.70
	Father	49.50	9.43	50.50	10.61	46.60	18.73	.94
Planning/ Organize (Brief)	Mother	47.80	9.78	45.00	4.58	47.67	18.44	.96
	Father	50.25	7.85	47.00	1.41	49.2	20.10	.97
Organisation of materials (Brief)	Mother	41.00	5.15	54.67	7.37	49.33	10.56	.11
	Father	43.75	12.09	47.50	2.12	50.00	11.68	.71
Monitor (Brief)	Mother	42.60	6.50	40.33	.58	40.50	12.97	.92
	Father	30.00	21.23	36.00	5.66	34.60	25.89	.94
EF Total (Brief)	Mother	47.20	14.46	43.00	5.57	46.83	14.44	.90
	Father	43.50	7.94	46.00	9.90	49.20	17.43	.83
Inhibition (SSRT)	Child	329.39	145.16	332.03	38.54	375.15	105.19	.73
Working Memory (SOP)	Child	23.89	9.88	22.50	11.81	14.70	11.42	.17
Working Memory (Digit span)	Child	7.75	4.72	8.00	4.36	15.00	3.61	.12

Note. Brief-P = Behaviour Rating Inventory Executive Function Preschool Version; Brief = Behaviour Rating Inventory Executive Function; SSRT= Stop Signal Reaction Time; SOP= Self Ordered Pointing Task.
All Brief-P and Brief scores were represented in T-scores (M-50, SD=10); All SSRT and SOP scores were represented in raw scores; All Digit span scores were represented in standard scores (M=10, SD=3).
Low education level (no education, primary school, special education, other low educations), Middle education level (secondary school and other middle education), High education level (University).

IV Discussion

Elevated risks on cognitive problems

The first research question concerned the possible elevated risk for children diagnosed with trigonocephaly on developing cognitive problems compared to the normal population. Cognitive problems were divided in different parts such as intelligence (IQ), visual motor skills, language, reading and executive functioning.

The intelligence (IQ) results for this sample diagnosed with trigonocephaly were comparable with the mean IQ in the normal Dutch population, therefore no elevated risks were found concerning intelligence for children with trigonocephaly. This finding seems contradicted by Sidoti et al. (1996) who reported that 38% of his sample exhibited cognitive abnormalities like low IQ and mental retardation. However, 26% of this sample had an IQ under 84 (under average) and 11% was mentally disabled (IQ under 70). Sidoti et al. (1996) did not specify what IQ score represented mental retardation or low IQ, therefore comparisons with this sample were difficult, but low IQ's were present in both samples. The reason why the mean IQ did not differ from the IQ of the normal Dutch population was because 28% of this sample had an IQ above 120. Therefore the under average IQ scores and the above average IQ scores were averaged as a mean IQ. A possible explanation for the relatively large group of children in this sample with an above average IQ or an under average / low IQ, could be the type of trigonocephaly present in these children. Perhaps the relative large group of under average IQ's had the syndromal form of trigonocephaly and the relative large group of above average IQ's had the isolated form of trigonocephaly. To check this possible explanation, the effects of type of trigonocephaly on IQ were analysed. The syndromal form of trigonocephaly had a significant lower IQ than the isolated form of trigonocephaly; therefore this possible explanation is very plausible. The fact that the syndromal form had an under average IQ seems assumable because of the extra malformations which are associated with this condition and the earlier studies which reported more developmental problems for this form of trigonocephaly (Lajeunie et al. 1998). The reason for the above average IQ for the isolated form could be because this form of trigonocephaly is characterized by a higher IQ than average. Bottero et al. (1998) and Lajeunie et al. (1998) compared syndromal and isolated trigonocephaly with each other but not separately with the normal population, so perhaps they did not discover that the isolated form can be associated with an above average IQ. Another explanation for the above average IQ of the isolated form of trigonocephaly

could be a selection bias in this sample. The isolated form could have a normal IQ distribution comparable with the normal population, but perhaps the children with an isolated trigonocephaly in this sample were all more intelligent than average. A third explanation could be that IQ and isolated trigonocephaly are not related with each other and the above average IQ was caused by an above average IQ of parents. As seen in the results section, the parents of this sample had an above average education level compared to the normal population; therefore this explanation could also be plausible.

Visual motor skills were tested with the VMI which consisted of three subtests; Visual Motor Integration, Visual Perception and Motor Coordination. No elevated risks were found for children with trigonocephaly on developing more problems in the areas of Visual Motor Integration and Visual Perception. However, an elevated risk was found for this sample on developing significant delay in Motor Coordination, compared to children without trigonocephaly. A side note is that the standard deviations were high in all three subtests therefore extreme scores were present in this sample. However, the difference between the Motor Coordination abilities of this sample diagnosed with trigonocephaly and the normal population remained significant, even after eliminating these extreme scores. This finding was also confirmed by studies of Bottero et al. (1998), Shimoji et al. (2002) and Sidoti et al. (1996) which also found delays in motor skills, gross motor as well as fine motor delays.

Concerning language abilities, no significant differences were found, using the N-CDIs, between the language development for the youngest children in this sample and the normal Dutch population in the same age range. The VTO was used for the older children to assess language development. Two versions of this test were used, the child version and the parental version. The child version, administered by the experimenter, did not show any significant differences in the children's language development compared to the normal Dutch population. The parental reports of the VTO showed a significant underdevelopment of the language skills for this sample compared to the normal Dutch population. A possible explanation for this discrepancy could be the tendency of parents to exaggerate the problems of their children. Another possibility is the small sample size of this test (10 children), which could make the found results unreliable. Language and speech problems were also found by Bottero et al. (1998) and Sidoti et al. (1996), therefore it would be in line of earlier findings if the language development of this sample would be impaired as the parents reported. Bottero et al. (1998) examined children with a mean age of 6.5 years (age range: 36 months- 16.5 years), and Sidoti et al. (1996) had a sample with an average age of 7.1 years (age range: 6 months- 22 years). Both studies did not assess language themselves but used school information (Bottero

et al., 1998) or parental questionnaires (Sidoti et al., 1996). Perhaps because of the comparable methods of information acquisition concerning language development, the results of the parental version of the VTO confirmed these earlier findings and those of the child version of the VTO did not. However, these two studies (Bottero et al., 1998; Sidoti et al., 1996) had a wider age range than this sample, which could give an inaccurate comparison.

The DMT and the Klepel were reading tests, which could provide some insight in the reading problems of this sample diagnosed with trigonocephaly. DMT assessed reading of existing words and the Klepel gave information concerning the reading capabilities of pseudo words. Both reading tests revealed no significant differences between the reading abilities of children in this sample compared to the normal Dutch population. This finding was supported by Bottero et al. (1998). Bottero et al. (1998) also assessed reading capabilities by using school information. Reading problems were present in 5% of the sample, which was also not significantly different than the normal population. Both reading tests consisted of extreme scores expressed by large standard deviations. Unfortunately these extreme scores could not be excluded to check the results without these extreme scores, because only a few scores would be left to do the analyses on. The score distribution is comparable to these of IQ and the VMI; all had relatively more above average scores and more under average scores compared to the normal population. Perhaps children with trigonocephaly could be characterized by extreme scores, either extremely high or extremely low. However, because of the small number of children in the DMT and the Klepel these extreme scores also could be a coincidence.

The executive functions were assessed by the Brief-P, the Brief, the SSRT, the SOP and the Digit Span. Due to data problems no comparison with the normal population could be made for the SSRT en the SOP. There were significant differences found between the normal population and this sample on the executive functioning domains emotional control (Brief-P father reports) and monitoring (Brief both parents). Highly remarkable was the fact that the parents in this sample reported fewer problems for their children on these domains of executive functioning than parents of children from the normal population. No earlier studies have tested the potential problems on executive functioning for children diagnosed with trigonocephaly. Therefore, no comparisons could be made with other studies. However, different studies (Bottero et al., 1998; Sidoti et al., 1996) reported an elevated risk on cognitive problems for children with trigonocephaly, so the expectation that these elevated risks would also be applicable for the executive functions, were not confirmed by this study.

A possible explanation for the fact that this sample reported fewer problems on emotional

control and monitoring could be due to the small sample size (Brief-P father 25; Brief mother 14; Brief father 11). The small sample size could have altered the found results. Another possible explanation was underreporting of the executive functioning problems by the parents. However, it was unlikely that parents underreported emotional control and monitoring relatively more than the other domains of executive functioning. The next possible explanation could be a selection bias where the children with the least executive functioning problems participated in this study and the ones that have more problems on this area declined to participate in this study. However, the prevalence of syndromal children in this sample was 30% in stead of the prevalence of 17% reported by Lajeunie et al. (1998). Lajeunie et al. (1998) also reported more developmental delay for children diagnosed with syndromal trigonocephaly than children diagnosed with isolated trigonocephaly. Therefore, a selection bias for children with fewer problems with their executive functions was unlikely. Even when a selection bias was present is this sample; this only explains the comparable results with the normal population and not why they exhibit fewer problems on emotional control and monitoring than the normal population.

The last test for executive functioning was Digit Span, which assessed working memory skills. Digit Span confirmed the non-significant findings on the Brief and Brief-P for working memory between this sample and the normal population.

It is difficult to reject or confirm the first hypothesis; *children diagnosed with trigonocephaly have an elevated risk on developing cognitive problems compared to children without trigonocephaly*, because of the wide range in findings by the different cognitive tests. This sample diagnosed with trigonocephaly was significantly less developed in their Motor Coordination skills than the normal population. Further, parents of the children in this sample reported significant delays in language development compared to their peers in the normal Dutch population. However, the performances on all other cognitive tests of this sample, including other language tests, were comparable to those of their peers in the normal population. According to some parents, these children with trigonocephaly were even better on some domains of executive functioning, like emotional control and monitoring, compared to the normal population. The elevated risks on cognitive functioning are perhaps mainly restricted to elevated risks on delays in Motor Coordination and language acquisition.

Gender differences in developing cognitive problems

The second research question concerned the elevated risks on cognitive problems for boys diagnosed with trigonocephaly compared to girls diagnosed to trigonocephaly. To answer this

question, gender differences within this sample on the different cognitive tests had to be analysed.

The differences in intelligence (IQ) between the boys and girls within this sample did not differ significantly from each other. Therefore, no elevated risk for either gender was found on intelligence problems. Kapp-Simon et al. (2005) found more intelligence problems in boys with trigonocephaly compared to girls with trigonocephaly. However, Kapp-Simon et al. (2005) used a sample with an average age of 7.3 months which age was not representative for this test (average: 4.6 years). Perhaps this caused the different results on gender differences and intelligence. No other studies examined gender differences within intelligence for children with trigonocephaly. Intelligence scores within the normal population are comparable between genders; this study also claims for children with trigonocephaly comparable gender distributions.

According to the assessment of the visual motor skills assessed by the VMI, no gender differences within this sample were found for all three subtests: Visual Motor Integration, Visual Perception and Motor Coordination. These non significant findings were not expected because, Kapp-Simon et al. (2005) found an elevated risk for boys with trigonocephaly on development delays, which included psychomotor development. However, the sample of Kapp-Simon et al. (2005) was not representative for the ages used in the VMI test, so perhaps this explained the different results between gender and psychomotor development. No other studies in children diagnosed with trigonocephaly assessed possible gender differences in visual motor skills. Therefore; the results that boys in this sample had no elevated risks on developing problems in visual motor skills, compared to girls in this sample seemed assumable.

Concerning the receptive and productive language skills, genders differed significantly within this sample. Girls in this sample were significantly better in their receptive and productive language skills than boys in this sample. This finding was supported by Kapp-Simon et al. (2005), who found more elevated risks for boys with trigonocephaly on developing problems in expressive and receptive language skills than girls. The average age of 7.3 months (range 1.7-30.6 months) included the age range of this test (16-30 months), so these samples seemed comparable. Perhaps girls outperformed the boys in this sample because girls in the age of 16-30 months in general are better in receptive and productive language skills. However, Zink & Lejaegere (2003) found no significant gender differences in the 279 babies and 929 toddlers without trigonocephaly, of which parents also had administered the N-CDIs. Therefore it was not likely that girls in general are better in these

language skills. Another explanation is; the three girls who were assessed by the N-CDIs in this sample were by coincidence better than average in receptive and productive language skills. However, the chances are very small that a sample diagnosed with trigonocephaly, which is a medical condition that is characterised by an elevated risk on developmental problems (Bottero et al., 1998; Sidoti et al., 1996, Shimoji et al. 2002; Shimoji et al., 2004), had three girls which were extremely good in these language skills. To get a clearer view on possible elevated risks for boys with trigonocephaly compared to girls with trigonocephaly, this N-CDIs test should be replicated with more girls.

The VTO was also a language test which consisted of two versions, a child version and a parental version. Unfortunately only ten children were in the age range of this test, of which one was female. The VTO scores of both genders within this sample were compared to each other and a significant gender difference was found for the parent reports of the VTO. The child version of the VTO showed no significant gender difference. Boys were significantly better in their language development than the girl assessed by this test. Unfortunately, this result was unreliable, because the only girl that conducted the VTO has Valproate Syndrome and is delayed in many areas of development. Therefore, no conclusions could be made concerning the elevated risks of boys with trigonocephaly on language development assessed by the VTO compared to girls with trigonocephaly.

Two reading tests were part of the test battery to assess cognitive problems in this sample, the DMT and the Klepel. Only ten boys and one girl performed in the DMT, and eleven boys and 2 girls in the Klepel. If the DMT and Klepel results were compared between both genders within this sample, no significant differences were found. However, only a few girls could perform in these tests, so these results could not be representative for the gender differences of all children diagnosed with trigonocephaly. Bottero et al. (1998) and Sidoti et al. (1996) were the only studies that assessed reading capabilities in a trigonocephaly sample. However, they did not analyse gender differences in reading skills. Therefore no comparisons could be made between this study and other studies. Until no other study can prove the difference, it is assumable that boys with trigonocephaly did not have an elevated risk on developing reading problems, compared to girls with trigonocephaly.

Executive functioning was assessed by two parental questionnaires (Brief-P, Brief). When comparing both genders within this sample on the different domains of executive functioning, boys had significantly more problems on set shifting (Brief father) than girls. Inhibition was also assessed by the SSRT and working memory was also assessed by the SOP and Digit Span. Comparisons between the boys and girls within this sample on the SSRT, SOP and

Digit Span showed no significant gender differences. No earlier studies were performed concerning gender differences in executive functioning for children with trigonocephaly, therefore no comparisons could be made with other studies. Kraft (1984) reported gender differences within the normal population in relation to cognitive functioning. Kraft (1984) described the tendency of males to process information of one stimulus at a time in contradiction to females which process information more globally, responding to a number of stimuli simultaneously. Perhaps this explains the problems with set shifting for boys; because they tend to focus only on one stimulus they lose cognitive flexibility. No other studies could be found concerning gender differences in executive functioning for the normal population.

The second hypothesis was: *boys diagnosed with trigonocephaly in this sample have an elevated risk on developing cognitive problems compared to girls diagnosed with trigonocephaly in this sample.* This hypothesis could only be confirmed for receptive and productive language skills and set shifting (Brief father). Boys were significantly less developed on these cognitive domains. The other cognitive tests did not show an elevated risk on cognitive problems for boys diagnosed with trigonocephaly compared to girls diagnosed with trigonocephaly.

Risk factors and executive functioning

The third question concerned the predictive value of the potential risk factors (brain anomalies, Digital Impressions and ICP, severity of the stenosis, type of trigonocephaly and SES) for abnormalities of the executive functions in children with trigonocephaly. However, no abnormalities of the executive functions were reported for this sample (see conclusion hypothesis 1). This sample showed even fewer problems on the executive functioning domains emotional control (Brief-P father reports) and monitoring (Brief both parents) compared to the normal population. Despite this lack of abnormalities in the executive functions it remained interesting to get some insight in the relation between the risk factors and executive functioning. First the prevalence of the risk factors was described followed by the possible predictive value of these risk factors on the domains of executive functioning.

It was expected that brain anomalies were present in this sample. Unfortunately, caused by a lack of information, this risk factor could not be included in the analyses. Digital Impressions were present in 33% and ICP was present in 11% of the children in this sample. The severity of the stenosis could only be assessed in 35% of the children in this sample and was significantly more severe compared to children in the normal population. Therefore, this sample could be differentiated from the normal population on this risk factor. The type of

trigonocephaly was divided in 30% of the children in this sample with a syndromal form and 70% with an isolated form of trigonocephaly. SES was assessed in all parents of the children in this sample. The most frequently reported highest education of these parents was the middle education level. In conclusion, the risk factors: Digital Impressions, ICP, severity of the stenosis, type of trigonocephaly and SES, were all present in the children of this sample.

Digital Impressions had no predictive value for any of the domains of executive functioning and the presence of ICP had no significant effect on any of the domains of executive functioning. No earlier studies examined the relation between Digital Impressions / ICP and the different domains of executive functioning, so no comparisons between studies could be made for these results. A possible explanation for the lack of predictive value of both risk factors in this sample could be the surgery all children underwent. Shimoji et al. (2002) reported after surgery a decline of all developmental problems and of Digital Impressions and ICP compared to before surgery. Improvements of these clinical symptoms were found to be due to the release of the constricted frontal lobe after surgery (Shimoji et al., 2002). Perhaps because the surgery created more space for the brains, these risk factors declined and lost (parts of) their predictive value for potential executive functioning problems in children with trigonocephaly. Another possibility is that because the surgery released the constricted frontal lobes, which are strongly related with executive functioning (Anderson et al., 2002), this sample exhibited no problems on any domain of executive functioning resulting in no relation between Digital Impressions/ ICP and executive functions. The beta's showed the nature of the relations between Digital Impressions and the domains of executive functioning. Remarkable, some relations were negative which means that more severe Digital Impressions lead to fewer executive functioning problems. However, no significant relations were found for any relation between Digital Impressions and executive functioning, so these possible negative relations had very limited interpretive value.

Severity of the stenosis was not a significant predictor for any domain of executive functioning. However, inhibition (Brief-P mother) and set shifting (Brief-P father) almost reached significance; perhaps with a larger sample size, severity of the stenosis will be a significant predictor for these domains. Bottero et al. (1998) found a positive relation between the severity of the stenosis and cognitive, emotional and behavioural problems. The domains of executive functioning were not explicitly included in this study. Therefore no real comparison could be made between Bottero et al. (1998) and this study. Perhaps no relation was present between the severity of the stenosis and executive functions because this sample did not have executive functioning problems. This lack of problems could be caused by the

surgery, which released the constricted frontal lobes and thereby stimulated the development of executive functioning. The beta's for the severity of the stenosis also showed the nature of the relations between this risk factor and the domains of executive functioning. All domains of executive functioning of the father reports and some of the mother reports were negatively related with the severity of the stenosis, which means that a more severe stenosis lead to fewer executive functioning problems. However, no significant relations were found for any relation between this risk factor and executive functioning, so these possible negative relations had very limited interpretive value.

The relation between type of trigonocephaly and the domains of executive functioning was analysed and showed significant effects for syndromal trigonocephaly on working memory (Brief) inhibition (Brief-P father), emotional control (Brief-P father) and total executive functioning (Brief-P father). The syndromal form of trigonocephaly had significantly more problems on these domains of executive functioning compared to the isolated form of trigonocephaly. This finding confirmed earlier findings concerning more developmental delay in the syndromal form of trigonocephaly compared to the isolated form (Bottero et al., 1998; Lajeunie et al., 1998).

No significant effects were found between different levels of SES and any domain of executive functioning. Bottero et al. (1998) found a significant relation between SES and developmental delay; however executive functions were not included in that study. No earlier studies concerning a trigonocephaly sample, examined the effects of SES on executive functions therefore no real comparison between studies could be made. A possible explanation no significant effects were found between different levels of SES and executive functioning domains is: no relation exists between SES and executive functioning. Only one study was found which investigated the relation between SES and executive functions in children (Kimberly, Noble, Norman & Farah, 2005). Kimberly et al. (2005) found that SES influenced the domains of executive functioning. Low SES children had more problems with executive functioning than high SES children. Therefore it was not assumable that no relation exists between SES and the executive functioning domains. Another explanation could be that SES was not reliable measured in this study which caused non significant findings between SES and executive functioning. Education level was the only variable used to assess SES; perhaps more variables should be taken into account (see also limitations paragraph SES) to make a reliable assessment.

The third hypothesis was: *the discussed potential risk factors (brain anomalies, Digital Impressions and ICP, severity of the stenosis, type of trigonocephaly and SES) can predict*

abnormalities of the executive functions in children with trigonocephaly.

This study included six risk factors, of which five could be used for analyses. All five risk factors were present in this sample. The type of trigonocephaly was the only risk factor that could significantly predict the outcomes of the executive functioning domains; working memory (Brief) inhibition (Brief-P father), emotional control (Brief-P father) and total executive functioning (Brief-P father). Therefore, this hypothesis was confirmed for type of trigonocephaly and these executive functioning domains. However, the other four risk factors (Digital Impressions, ICP, severity of the stenosis and SES) could not significantly predict the outcomes on any of the domains of executive functioning. For these risk factors this hypothesis must be rejected.

Limitations

An important limitation of this study was the small sample size. Of the 87 invited children, only 47 participated in this study. Because the great amount of different cognitive tests used in this study, the sample size decreased for some tests because of the different age ranges. The disadvantage of a small sample size is the possibility that the sample does not represent the children with trigonocephaly in general in this age range. Another disadvantage of a small sample size is the difficulty to find significant results, because of her limited power. For example the lack of cognitive problems found in the children of this sample (except motor coordination delays), although different studies reported significant more problems in speech, reading and/or writing, schooling and mental retardation (Bottero et al., 1998; Sidoti et al., 1996). Perhaps in a sample with more children diagnosed with trigonocephaly these cognitive difficulties would also be found.

Unfortunately it was not possible to get norm data for the SSRT and SOP tests. This lack of information made it more difficult to assess the domains of executive functioning of this sample compared to the normal population, because these two tests could not be included.

Further this study had incomplete medical information. Brain anomalies could not be assessed because of a lack of information and therefore this risk factor had to be excluded from the study. Digital Impressions and the severity of the stenosis could only be assessed for a part of this sample, because of missing scans and too little time to find them. Because of the missing information, this sample could have become less representative for the whole population consisting of children with trigonocephaly. To test this represenativeness, this sample could be compared to the sample with trigonocephaly in which Shimoji et al. (2004) measured the Digital Impressions. Shimoji et al. (2004) reported Digital Impressions in 75%

of these children. In this sample only 33% had Digital Impressions, which supports the concern that the prevalence of the data for this medical risk factor is less representative for the population with trigonocephaly. One the other hand the same could be true for the used sample of Shimoji et al. (2004) which also had a small sample size (56 children). The IPDICD could also be compared between this sample, which was 1.33, and that of Shimoji et al. (2002), which was 1.25. This difference (reaches significance) is another support for the concern for a possible less representative sample. Further, the chance to find any significant relations between these risk factors and other variables became smaller, because of the small number of children of which medical information could be retrieved.

The syndromal type of trigonocephaly was present in 30% of this sample, in stead of the 17% Lajeunie et al. (1998) reported. This difference in prevalence also supports the concern of a less representative sample.

Social Economic Status (SES) which is a multidimensional concept that takes material, social resources and the individual's position in the social hierarchy into account, was in this study only based on education level of the parents. Because SES is such a wide ranging definition, it was perhaps better to include more indicators to assess SES in stead of only education levels of parents.

The gender ratio in this sample was 6:1 (boys: girls) in stead of the earlier reported 3:1 (Lajeunie et al., 1998). If this sample would be comparable to the mean gender ratio reported by Lajuenie (1998), this sample should have 12 girls in stead of 7 girls to get a representative comparison of the population of children with trigonocephaly.

This study did not have a control group of children from the normal population. Comparisons were made by using norm data provided by the different manuals of the used tests. This is a very common way to compare results, but the study would be more valid and reliable if a control group was submitted.

Finally, there were some limitations to the procedure and materials used in this study. Children in this sample showed or said to find the executive functioning test (SSRT, SOP) difficult to persist. Fluctuations in concentration and motivation were obvious. This could have affected the reliability of these tests. Further, the test battery took approximately 2-3 hours, which was to long for some children. Because many children lived far from the hospital it was impossible to divide the tests over two visits. Logically, the tests administered at the end (DMT/Klepel/VMI) did not get the same concentration level from these children compared to the other tests. This could also have altered the results on these tests. The intelligence was measured by an IQ test, but only the short version of four subtests (except the

Mullen, which was always administered as a whole). For research purposes it is common to assess intelligence levels, but perhaps extreme scores have more influence on the total results when the sample size is smaller as in this study. Further, some tests (VMI, Mullen, Brief, Brief-P) were compared to American norms, this could also have altered the results on these tests. On the other hand, the United States is also a western country which has many different nationalities and cultures within the society, just as the Netherlands has, which favours the use of US norms.

Future research

Future research should attempt to conduct a longitudinal study of a sample that gives a good representation of the total population of children with trigonocephaly and include a control group (no psychological study yet concerning trigonocephaly was longitudinal and/or included a control group). Further, valid test instruments should be used which are complete and applicable for the whole sample, because this was an important limitation of this study. Perhaps a replication of this study for a larger sample would find more significant differences between children diagnosed with trigonocephaly and the normal population. Another potential fruitful avenue of research could be on the aetiology of this condition because no earlier study has yet found clear evidence concerning the aetiology.

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V References

Absher, J.R. & Cummings, J.L. (1995). Neuropsychological abilities and neurobehavioral assessment in frontal lobe dysfunction. *Aphasiology, 9 (2),* 181-192.

Achenbach, T.M. (1991). *Manual for the Child Behavior Checklist/ 4-18 and 1991 Profile.* Burlington, VT: University of Vermont, Department of Psychiatry.

Aman, C.J., Roberts, R.J. & Pennington, B.F. (1998). A neuropsychological examination of the underlying deficit in ADHD: The frontal lobe versus right parietal lobe theories. *Developmental Psychology, 34,* 956-969.

Anderson, V. (1998). Assessing executive functions in children: biological, psychological, and developmental considerations. *Neuropsychological Rehabilitation, 8 (3),* 319-349.

Anderson, F.M., Gwinn, J.L. & Todt, J.C. (1962). Trigonocephaly: identity and treatment. *Journal Neurosurgery, 19,* 723.

Anderson, V., Levin, H. & Jacobs, R. (2002). Executive functions after frontal lobe injury: A developmental perspective. *Principles of frontal lobe function (p.p. 504-527).* NY: US, Stuss, Donals (Ed.), Knight, Robert T. (Ed.).

Azimi, C., Kennedy, S.J., Chitayat, D., Chakraborty, P., Clarke, J.T.R., Forrest, C. & Teebi, A.S. (2003). Clinical and Genetic Aspects of Trigonocephaly: A study of 25 cases. *American Journal of Medical Genetics, 117A,* 127-135.

Barkley, R.A., Grodzinsky, G. & DuPaul, G.J. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: a review and research report. *Journal of Abnormal Child Psychology, 20,* 163-188.

Bates, T.C., Castles, A., Coltheart, M., Gillespie, N., Wright, M. & Martin, N.G. (2004). Behaviour genetic analyses of reading and spelling: A component processes approach. *Australian Journal of Psychology, 56 (2),* 115-126.

Bedard, A., Ickowicz, A., Logan, G.D., Hogg-Johnson, G.D., Schachar, R. & Tannock, R. (2003). Selective inhibition in children with attention-deficit hyperactivity disorder off and on stimulant education. *Journal of Abnormal Child Psychology, 31,* 315-327.

Beery, K.E. (1997). *The Beery-Buktenica Developmental Test of Visual-Motor Integration* (4th ed.). New Jersey: Modern Curriculum Press.

Bos, van den, K.P., Spelberg, H.C.L., Scheepstra, A.J.M. & de Vries, J.R. (1994). *DE KLEPEL, Vorm A en B, een test voor de leesvaardigheid van pseudo-woorden. Verantwoording, handleiding, diagnostiek en behandeling.* Groningen: Berkhout Nijmegen bv.

Bottero, L., Lajeunie, E., Arnaud, E., Marchac, D. & Renier, D. (1998). Functional Outcome after Surgery for Trigonocephaly. *American Society of Plastic Surgeons, 102 (4),* 952-958.

Corvalan, C., Amigo, H., Bustos, P. & Rona, R.J. (2005). Socioeconomic Risk Factors for Asthma in Chilean Young Adults. *American Journal of Public Health, 95 (8),* 1375-1381.

Center for psychological studies. (n.d.) *Weschler Preschool and Primary Scale of Intelligence.* Retrieved March 12, 2006, from http://www.cps.nova.edu.

Cogulua, O., Onaya, H., Ozgenca, F., Karacaa, E., Gunduzb, C., Tzetisc, M., Cankayaa, T., Kanavakisc, E. & Ozkinaya, F. (2005). Trigonocephaly and Wilson's disease in two siblings. *Clinical Dysmorphology, 14,*161–164.

Collman, II, Sorenson, N. & Krauss, J. (1996). Consensus on trigonocephaly. *Child's Nervous System, 12,* 664-668.

Diamond, A. & Goldman-Rakic, P.S. (1989). Comparison of human infants and rhesus monkeys on Piaget's AB task: Evidence for dependence on dorsolateral prefrontal cortex. *Experimental Brain Research, 74 (1),* 24-40.

Fernbach, S.K. & Feinstein, K.A. (1991). Radiologic evaluation of children with craniosynostosis. *Neurosurgery Clinics of North America, 2 (3),* 569-586.

Garth, J., Anderson, V. & Wrennall, J. (1997). Executive functions following moderate to severe frontal lobe injury: impact of injury and age at injury. *Pedriatric Rehabilitation, 1 (2),* 99-108.

Gerritsen, F.M.E. (1994). *VTO Taalscreenings-instrument voor 3-4-5 jarigen. Handleiding en verantwoording.* Lisse (Netherlands): Swets & Zeitlinger B.V

Geurts, H.M., Verté, S., Oosterlaan, J., Roeyers, H. & Sergeant, J.A. (2004). How specific are executive functions deficits in attention deficit hyperactivity disorder and autism? *Journal of Child Psychology and Psychiatry, 45 (4),* 836-854.

Geurts, H.M., Verté, S., Oosterlaan, J., Roeyers, H. & Sergeant, J.A. (2005). ADHD subtypes: do they differ in their executive functioning profile? *Archives of Clinical Neuropsychology, 20,* 457-477.

Gioia, G.A., Espy, K.A. & Isquith, P.K. (2003). *Brief-P Behavior Rating Inventory of Executive Function- Preschool version. Professional manual*. Odessa, FL: Psychological Assessment Resources, inc.

Gioia, G.A., Isquith, P.K., Guy, S.C. & Kenworthy, L. (2000). *Brief Behavior Rating Inventory of Executive Function. Professional manual*. Odessa, FL: Psychological Assessment Resources, inc.

Graham, J.M. jr. & Smith, D.W. (1980). Metopic craniosynostosis as a consequence of fetal head constraint: Two interesting experiments of nature. *Paediatrics, 65,* 1000-1002.

Honein, M.A. & Rasmussen, S.A. (2000). Further evidence for an association between maternal smoking and craniosynostosis. *Teratology, 62,* 145-146.

Kapp-Simon, K.A., Leroux, B., Cunningham, M. & Speltz, M.L.(2005). Multisite Study of Infants With Single-Suture Craniosynostosis: Preliminary Report of Presurgery

Development. *Cleft Palate-Craniofacial Journal, 42 (4),* 377-384.

Kimberly, G., Noble, M., Norman, F. & Farah, J.M. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science, 8(1),* pp 74–87.

Kraft, S. (1984). Cognitive Function and Women's Art. *Woman's Art Journal, 4 (2),* 5-9

Kuper, B.D. (2000). *Behavior patterns among children with a history of metopic synostosis.* Unpublished doctoral dissertation, University of North Texas.

Lajeunie, E., Le Merrer, M., Marchac, D. & Renier, D. (1998). Syndromal and nonsyndromal primary trigonocephaly: Analysis of a series of 237 patients. *American Journal of Medical Genetics, 75,* 211–215.

Logan, G.D. & Cowan, W.B. (1984). On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review, 91,* 295-327.

Marsh, J.L., Jenny, A., Garlic, M., Picker, S. & Vannier, M.W. (1991). Surgical management of sagittal synostosis: A quantitative evaluation of two techniques. *Neurosurgery Clinics of North America, 2,* 629-640.

Moelands, F., Kamphuis, F. & Verhoeven, L. (2004). *Verantwoording Drie-Minuten-Test.* Arnhem:Cito

Mullen, E.M. (1995). *Mullen Scales of Early Learning AFS Edition Manual.* Minnesota: American Guidance Service, Inc.

Nigg, J.T. (1999). The ADHD response-inhibition deficit as measured by the stop-signal task: Replication with DSM-IV combined type, extension and qualification. *Journal of Abnormal Child Psychology, 27,* 393-402.

Okkerse, J.M.E., Beemer, F.A., Mellenbergh, G.J., Wolters, W.H.G. & Heineman-de Boer, J.A.(in press). Risk factors for cognitive functioning in children with craniofacial anomalies. *Journal of Cranofacial Surgery.*

Oosterlaan, J., Scheres, A. & Sergeant, J.A. (2005). Which Executive Functioning Deficits Are Associated With AD/HD, ODD/CD and Co-morbid AD/HD + ODD/CD? *Journal of Abnormal Child Psychology, 33 (1),* 69-85.

Petrides, M. & Milner, B. (1982). Deficits on subject-ordered tasks after frontal- and temporal- lobe lesions in men. *Neuropsychologia, 20,* 249-262.

Petrides, M., Alivisatos, B., Evans, A.C. & Meyers, E. (1993). Dissociation of human mid-dorsolateral from posterior dorsolateral frontal cortex in memory processing. *Proceedings of the National Academy of Sciences, 90,* 873-877.

Piaget, J. (1954). *The construction of reality in the child.* New York: Basic Books.

Posnick, J.C., Lin, K.Y., Chen, P. & Armstrong (1994). Metopic synostosis: Quantitative assessment of presenting deformity and surgical results based on CT scans. *Plastic Reconstruction Surgery, 93 (16),* 16-24..

Psychological corporation, the. (n.d.) *Psychological Assessment CATALOGUE 2004*. Retrieved March 12, 2006, from www.tpc-international.com

Renier, D., Sainte-Rose, C., Marchac, D. & Hirsch, J.F., (1982). Intracranial pressure in craniosynostosis. *Journal of Neurosurgery, 57,* 370-377.

Scheres, A., Oosterlaan, J., Geurts, H., Morein-Zamir, S., Meiran, N., Schut, H., Vlasveld, L. & Sergeant, J.A. (2004). Executive functioning in boys with ADHD: primarily an inhibition deficit? *Archives of Clinical Neuropsychology, 19,* 569-594.

Shimoji, T., Shimabukuro, S., Sugama, S. & Ochiai, Y. (2002). Mild trigonocephaly with clinical symptoms: analysis of surgical results in 65 patients. *Child's Nervous System, 18,* 215-224.

Shimoji, T. & Tomiyama, N. (2004). Mild trigonocephaly and intracranial pressure: report of 56 patients. *Child's Nervous System, 20,* 749-756.

Shuper, A., Merlob, P., Grunebaum, M. & Reisner, S.H. (1985). The incidence of isolated craniosynostosis in the newborn infant. *American Journal of Diseases of Children, 139 (1),* 85-86.

Sidoti, E., March, J.L., Marty-Grames, L.M.A & Noetzel, M.J. (1996). Long-Term Studies of Metopic Synostosis: Frequency of Cognitive Impairment and Behavioral Disturbances. *Williams & Wilkins, 97 (2),* 276-281.

Speltz, M.L., Kapp- Simon, K.A., Cunningham, M., Marsh, J. & Dawson, G. (2004). Single-Suture Craniosynostosis: A Review of Neurobehavioral Research and Theory. *Journal of Pediatric Psychology, 29 (8),* 651-668.

Thompson, D.N.P., Harkness, W., Jones, B., Gonzalez, S. & Hayward, R. (1995). Subdural intracranial pressure in craniosynostosis: it's role in surgical management. *Child's Nervous System, 11,* 269-275.

Tuite, G.F., Evanson, J., Chong, W.K., Thompson, D.N.P., Harkness, W.F., Jones, B. & Hayward, R.D. (1996). The beaten copper cranium: a correlation between intracranial pressure, cranial radiographs, and computed tomographic scans in children with craniosynostosis. *Neurosurgery, 3,* 691–699.

Vaandrager, J.M., Prahl-Andersen, B., Niermeyer, M.F. & Heinemann-de Boer, J. (2005). *Van buiten een beetje anders maar van binnen wonderschoon.* Binnekom: Laposa.

Verhoeven, L. (1995) *Drie-Minuten-Toets*. Arnhem: CITO.

Wechsler, D. (1992). Wechsler *Preschool and Primary Scale of Intelligence*. New York: Psychological Corporation.

Wechsler, D. (1997). Wechsler *Preschool and Primary Scale of Intelligence*. New York: Psychological Corporation.

Zink, I. & Lejaegere, M. (2003). *N-CDIs Lijsten voor Communicatieve Ontwikkeling korte*

vormen. Handleiding. Acco: Leuven.

Appendix I

Glossary

Anomalies of the corpus callosum	deviation of the corpus callosum (bridge between left- and right hemisphere).
Arachnodyctyly	hands and fingers/ feet en toes are abnormally long and slender.
Calvarial	upper side skull or skull cap
Cardiac abnormalities	hart deviations
Clinodactyly	a congenital defect in which one or more toes or fingers are abnormally positioned
Craniosynostosis	premature fusion of one or more of the sutures that normally separate the bony plates of the infant skull.
Digital Impressions	the impressions of the brain on the skull.
Dorsolateral	the side of the backside
Ectopic kidney	abnormal positioned kidney
Frontal subdural space distention	frontal space beneath the hard outer side of the cerebral membrane is swollen up.
Hydrocephalus	a usually congenital condition in which an abnormal accumulation of fluid in the cerebral ventricles causes enlargement

	of the skull and compression of the brain, destroying much of the neural tissue.
Hydronephrosis	abnormal enlargement of the kidney
Hypoplasia of the frontal lobes	incomplete or less development of the frontal lobes.
Hypospadias	abnormality of the penis in which the urethra opens on the underside
Hypotelorisme	abnormal closeness of the eyes.
Hypovascularity	shortage of blood vessels
Intracranial pressure	pressure on the skull from the inside.
Maxillofacial abnormalities	abnormality of the jaw and face
Midline frontal ridge	the forehead is long narrow, or crested.
Multi-suture fusion	multiple sutures of the brain are closed.
Pulmonale	lungs
Schisis	slit palate
Single – suture fusions/ isolated synostosis	one of the sutures is closed prematurely.
Subarachnoid space	a space in the meninges beneath the arachnoid membrane and above the pia mater that contains the cerebrospinal fluid.

Sulci	any of the narrow fissures separating the twists of the brain.
Trigonocephaly	premature closure of the metopic suture (forehead) and is characterised by a triangular head shape.
Valproate Syndrome	fetal abnormalities due to the maternal use of medication for epilepsy.
Vault	an arched part of the body, especially the top part of the skull