1 Abstract

In the past decades much research has been performed to investigate the influence of music practice on cognitive performance. However, most of these studies have been performed in laboratory settings or in relative small experiments.
The present cross-sectional survey investigates the correlation between musical practice during childhood and cognitive performance in a large sample. Primary schools (N=33) co-operated in this study and 860 students received the questionnaire (appendix 1). The parents of these students were asked to complete the questionnaire (appendix 2). Within two weeks 366 questionnaires were returned. The response rate is 44.6%. Cognitive performance was measured with the CITO-eindtoets-score (a national assessment for final year primary school students).
Extra-curricular practice of music during the time of primary school led to a significant higher CITO-eindtoets-score for the students that had musical training during the time of primary school ($p = .002$). After adding socio-economic status to the model the effect of musical practice on CITO-eindtoets-score was still significant ($p = .023$). There was on interaction of musical practice and socioeconomic status.

2 Introduction

Speculations about possible benefits of musical training on academic performance have existed from the early 20th century (Earhart, 1920; Draper & Gayle, 1987). These speculations mainly stemmed from anecdotal observations about the fact that enhanced musical abilities frequently co-occurred with enhanced cognitive performance in domains other then music. It was suggested that musical training improved cognitive functions. Many correlational studies (Bilhartz, Bruhn, & Olson, 1999; Hetland, 2001; Jones, 2009; Southgate & Roscigno, 2009; Standley, 2008) reported an association between musical training and non-musical skills. Yet it is not possible to demonstrate a causal relationship from these observations. Causal relationships can best be revealed through experimental research designs (Črnčec, Wilson, & Prior, 2006).

2.1 Experimental Research

Hetland (2001) performed a meta-analysis of studies on the effect of musical training on spatio-temporal abilities. The meta-analysis included experiments (random samples), quasi experiments and pre-experiments. She reports an effect size of r = .39. According to Schellenberg (2006), music practice in childhood associates positively with IQ and academic performances. He reported that after 36 weeks of musical training a group of six-year olds improved 7 IQ points compared to a control group that improved only 4,3 IQ points. The effect size was medium (d = .35). Schellenberg (2004) hypothesised that musical training may improve IQ in a way that this provides students with additional educational experience in a combination of hours of individual practice, attention and concentration (Schellenberg, 2001), suggesting a causal relationship.

2.2 Theoretical Framework

There are two theories that dominate the research on cognitive performance and musical training. One theory is the neuroscientific Trion model (Leng, Shaw, & Wright, 1990). This model states that music resonates with neural firing patterns throughout the brain. Music listening and instruction primes the brian for enhanced performance on other cognitive tasks. Neural networks are trained and reinforced by their use, hereby changing the strength of connections between neurons (McLeod, Plunkett, & Rolls, 2007).

This suggests that training a network in one modality will benefit the performance of a different modality that relies partly on the same network.
The other cognitive theory is based on near transfer, which states that two modalities e.g. musical instruction and spatio-temporal reasoning, require similar and related cognitive skills (Hetland, 2000; Frances H. Rauscher, 2002; Schellenberg, 2001). This model describes the effect of emotional state on cognitive performance with music as a moderator. Moreover musical practice requires the development of orientation skills while reading, listening and performing music simultaneously. This multi-modal training lead to near transfer of similar requirements for spatio-temporal reasoning. There is also an effect of tonal attributions on phonemic awareness in language which will be discussed later in this study.

2.3 Neuro-imaging Studies

In the past decades the use of brain imaging and functional brain imaging techniques have contributed to the understanding of the influence of music on cognitive performance. Studies (Hyde, et al., 2009; Lappe, Herholz, Trainor, & Pantev, 2008) on the functioning as well as structure of the brain reveal significant differences between professional musicians and non-musicians. The structural differences are mainly found in the grey matter of the motor cortex. Differences in white matter are reported in the anterior part of the corpus callosum and the arcuate fasciculus bilaterally (Patston, Kirk, Rolfe, Corballis, & Tippett, 2007). It is suggested that infra-structural changes accompanying music practice may benefit performance in other domains, such as attention and working memory (Piro & Ortiz, 2009). It is not known which age windows and what instruments are most effective to enhance cognitive performance.

2.4 Effect of Music on Cognition

Most of the studies examining the effect of musical training on cognitive performance were performed in laboratory settings. They yielded significant positive correlations, supporting the transfer of extended brain-functioning associated with musical training to cognitive domains such as language processing, calculating and spatial-reasoning (Hetland, 2001; Schlaug, Jäncke, Huang, & Staiger, 1995).
From the above it is suggested that musical training has a positive influence on a wide

array of cognitive performance. The specific effect on language, spatio-temporal skills and the Mozart effect will be presented hereafter.

2.5 Music and Language

In language there are two major constructs that highly relate to music. The first is prosody, the pattern of stress and intonation in spoken language, very similar to pitch changes, intensity, duration and spectral characteristics in music (Moreno, et al., 2009). The second is phonemic awareness, the ability to recognise individual sounds or phonemes in spoken words, which is crucial for beginning readers (Gromko, 2005). The effect of music on prosody was investigated by Moreno et al. (2009) using EEG. Eight year old children were tested for pitch incongruities in language in a pre-test. One group was trained in music and an other group was trained in painting. This study revealed that after musical training, the late positive component resulting from strong incongruities was reduced, compared to the not musical trained group. Moreno et al. (2009) concluded that musical training positively influences the prosodic aspect of language processing .
Gromco (2005) investigated the influence of musical training on phonemic awareness in language, especially the phoneme-segmentation, in kindergarten children. This experiment showed significant gains in the development of phonemic awareness and segmentation after musical training. The results support a near transfer model stating that active music making and consequently training the association of sounds with appropriate symbols, may develop processes similar to segmentation of spoken words into phonemes in language.

2.6 Spatio-temporal Skills

Spatial tasks require mental manipulation (e.g. mentally putting shapes in order of size) of shapes without having the shapes physically present. Spatio-temporal tasks in particular require the ability to mentally rotate shapes without having the shape physically present. Music instruction improves spatio-temporal skills, not only at a limited time like described with the Mozart effect, but permanently. There is further evidence that music instruction started before the age of five is associated with larger effects (Bilhartz, et al., 1999; Frances H. Rauscher, 2002; F. H. Rauscher & LeMieux, 2003).

2.7 Mozart Effect

Listening to a part of a Mozart sonata or similar complex music, performance on spatio-temporal reasoning tasks may improve for 10-15 minutes. This is commonly known as the The Mozart effect (Frances H. Rauscher, 2002). Also Schellenberg (2007) reports enhanced performance on cognitive tests after exposure to different types of music. This can be explained by near transfer. The effects are mediated by the emotional state and can also be generalised across cultures (Schellenberg, 2001).

2.8 Hypothesis

The above findings (i.e. correlational studies, neuroimaging studies, experimental studies) suggest that musical training has a positive effect on a wide range of cognitive functions. In the Netherlands cognitive performance in the final year of primary school is measured with the CITO-score. The CITO-score not only provides a good representation of cognitive functions such as language and arithmetics but furthermore the CITO-score is a strong predictor of future academic achievements.
The experimental studies as well as most correlational studies focus on the effect of music practice on specific modalities (e.g. phonemic $ awareness language, prosody in language, spatio-temporal skills). Academic skills or cognitive performance are determined by a complex interaction of modalities. Being a strong predictor for future academic achievement, CITO-score is a reliable measurement for this interaction. In the present cross sectional survey, CITO-score is used as measurement for the effect of music on cognitive performance. In addition the survey investigates if previous experimental findings can be generalised when investigating a large sample without experimental manipulation.

3 Methods

3.1 Design and Procedure

To investigate the correlation between extra curricular musical education during primary school and cognitive performance in the final year, a crosssectional study using a questionnaire was performed. The CITO-eindtoets-score was used to measure the cognitive performance. CITO stands for "Centraal Instituut voor Toets Ontwikkeling", the central institution for the development of tests. Musical training and SES are used as variables in this thesis (see appendix 1 question 4, 29 and 36). The questionnaire investigates whether the student is musical trained and during which years the student has taken music lessons. In this research only the first option is added to the statistical model.

To control for possible influence of the socio-economic status (SES). The income of the father, mother and a possible attendant is measured and expressed in a four level ordinal scale. This scale contained the following levels:

1: gross income/year in Euro < 25,000,
2: 25,000 < gross income/year in Euro < 48,000,
3: 48,000 < gross income/year in Euro < 60,000,
4: 60,000 < gross income/year in Euro.

To control for gender and handedness of the participants, these factors were included in the investigation.

3.2 Participants

By targeting 35 of a total of 180 existing schools in the South Limburg area, 820 questionnaires were distributed among final year primary school students. The parents were asked to complete a questionnaire and return it to the school within two week (*see Figure 1 for a flowchart of the procedure*). The targeted schools are evenly distributed over the rural and urban areas.

To enhance the response, four VVV-vouchers with a value of five Euros and one "first prize" with a value of ten Euros, were raffled among the students who returned the questionnaire (VVV is the Dutch tourist bureau. Their gift vouchers are widely accepted in stores). After one week the schools were contacted by email to remind the students about

the questionnaire. After two weeks, the questionnaires were collected at the schools. Parents were requested to complete the questionnaire which was estimated to take approximately 15 minutes. The survey was approved by the Ethical Committee of the Maastricht University faculty of Psychology and Neuroscience (ECP) on april 12, 2010.

3.3 Materials

The parents of the students were presented with a questionnaire containing five fields to fill in the CITO scores (language, arithmetics, study skills, world knowledge, total score and standard score) and 37 questions. Question one to three are about age, gender and handedness. Then there are four sections containing questions about music training, sports training, training in dancing, training in arts and computer games. The final section contains eight questions about the social environment, the biological background (e.g if one of the biological parents is a professional musician), family income and postal code.
With the questionnaire two flyers were distributed. One flyer contained the information to the parents. This explained the research, gave information about consent and anonymity and gave information of the approval of the ECP. The second flyer explained the raffle.
For the school an information flyer was added containing all the necessary information needed to understand the nature of the research and what steps the school would have to take for distributing and collecting the questionnaires.

3.4 Analysis

First, a one-way analysis of variance (ANOVA) is used to compare the musical trained group with the not musical trained group. The dependent variable is CITO-eindtoets-score. The Cito-standard-scores are constructed from the scores on 3 sub-tests: verbal/language, arithmetic and study skills. A fourth subtest “world knowledge” is not mandatory and many schools don%t take this subtest. The language sub-test consists of 100 four option multiple choice questions, the arithmetic sub-test consists of 60 four option multiple choice questions, the study skills sub-test consists of 40 four option multiple choice questions. The maximum total score is 200. The total is converted into a standard score on a 50 point scale, ranging from 501 to 550. This has been done to prevent any similarity with IQ scaling.

Second, general linear model (GLM) univariate analysis is used to control for confounding of SES. Both main effects (musical training and SES) as well the interaction (musical training * SES) are examined. ! The total family income was calculated in a four level ordinal scale by combining the separate incomes given in the method section, controlling for the overlap in the combined scales. The numbers in the combinations below refer to the levels of income for the father, mother and attendant given in the method section. If there is only one income in the family, this is indicated as sole income. A combination of three incomes in one family never occurred. The levels for family income were constructed as follows:

1: 1 (sole income), 2 (sole income)
2: 1 and 1, 1 and 2, 3 (sole income), 4 (sole income),
3: 2 and 2, 1 and 3, 1 and 4,
4: 2 and 3, 2 and 4, 3 and 3, 3 and 4, 4 and 4.

The level of education of the parents also contributes to the SES. Because of strong correlation with the total family income (*all correlations were significant at a .001 level*), this measure is not included in the statistical model.

SPSS1[61] 18 software was used on a Macintosh MacBookPro computer to perform the statistical analysis.

61 SPSS Inc. 233 S. Wacker Drive, 11th floor, Chicago, Il 60606

4 Results

4.1 Response Rate

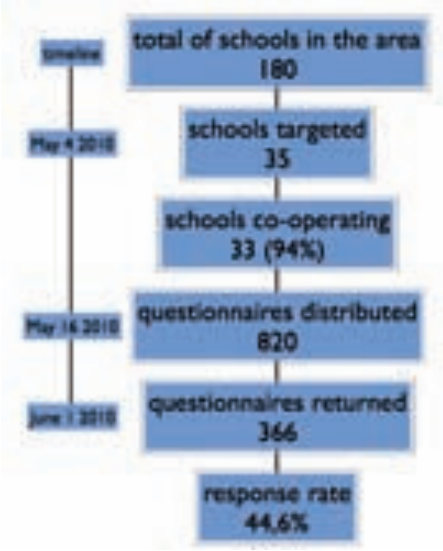

Figure 1 Flowchart of the datacollection and response rate

Of the 35 schools that were targeted 2 schools decided not to co-operate in the research so 94% of the schools fully co-operated. Of the 820 questionnaires that were distributed through the 33 school, 366 were returned. This leads to a response rate of 44,6% (*Figure 1 illustrates this process*).

4.2 Composition of the Sample

The males (N=184) and females were evenly distributed in the the groups, X^2 (1,394) = 1.822, p = .18, V = .7. Participants mean age was 11.7 (range 10-13; SD= .57).

Of the females 45% was musical trained, of the males 38% was musical trained. There was no significant effect of gender on CITO-score F (1, 328) = 0.12, p = .4, η^2, .002. There were 46 left-handed participants and 347 right-handed participants. The handedness was not evenly distributed X^2 (1,393)= 5.083, p = .024, V = .1, however there was no effect of handedness on the CITO-score, F (1, 397) = 0.12, p = .73, η^2 , .001. Gender and handedness of the participants were controlled for in the analysis. SES was not evenly distributed in the musical training and non-musical traing group, X^2 (3,325)= 23.168, p < .001, V = .27.

4.3 ANOVA

The first analysis compared the musical trained group and the not musical trained group. This was done by a one-way ANOVA with musical training as a factor and CITO-score as dependent variable. There was a significant difference in CITO-score F(1, 323) = 9.787, p = 0.002, η^2 = 0.029 between musical trained and non-musical trained children. (Table 1). Figure 2 shows the difference in mean CITO-score with the 95% CI.

Table 1

Mean, SD, CI, SE and groupsizes of the musical trained and non-musical trained group

	mean	SD	CI	SE	Groupsize (N)
musical trained	541.67	6.575	[540.15, 542.33]	0.552	142
not musical trained	538.45	8.890	[537.16, 539.75]	0.657	183

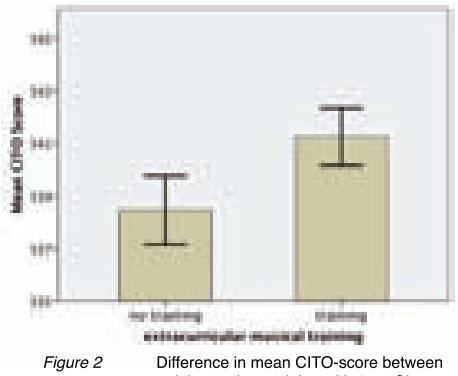

Figure 2 Difference in mean CITO-score between training and no training with 95% CI

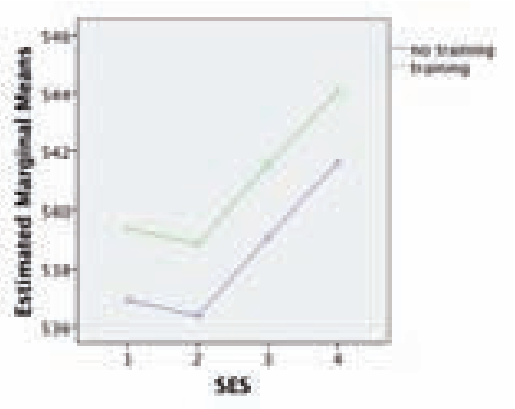

Figure 3 Main effects of musical training and SES on CITO-score

4.4 GLM Univariate

To control for the expected confounding of SES on the CITOscore a GLM univariate analysis was performed with CITO-score as dependent var iable and musical training and SES as independent variables (factors). First the full-factorial model is tested. This yields no significant interaction for musical training * SES * CITO-score $F(3,368) = 1,9$, $p = 0,13$, $\eta^2 = 0.021$. Second the model is tested without the interaction term.

This yields two significant main effects namely: Musical training $F(1,268) = 6,212$, $p = 0,013$, $\eta^2 = 0.023$ and SES $F(3,268) = 5,547$, $p = 0,001$, $\eta^2 = 0.06$ (*Figure 3*) suggesting that musical training has a significant effect on the CITO-score when controlled for the influence of SES. The effect is small to medium. SES has an even more significant influence in the CITO-score when controlled for the effect on musical training. Higher SES correlates positive with higher CITO-scores. The effect is medium.

5 Discussion

The present study investigates the correlation between extra-curricular musical training during the time of primary school and cognitive performance by performing a cross-sectional study in a large sample of final year primary school students of primary schools in South Limburg (NL). The cognitive performance was measured by the CITO-eindtoets-score. It reveals that students with extracurricular training in music score significantly higher on the CITO-eindtoets compared to not musical trained students.
Socio-economic status (SES) of the students is a second important predictor of CITO-eindtoets-score. However when controlled for SES the extracurricular musical training still results in a significant higher score on the CITOeindtoets.
This is in line with prior research (i.e. correlational studies, neuro-imaging studies, experimental studies) performed on the effect of musical training on a wide range of cognitive skills like language (Gromko, 2005; Moreno, et al., 2009) and spatio-temporal skills (Bilhartz, et al., 1999; Hetland, 2000; Frances H. Rauscher, 2002).
One limitation of the experimental studies, neuro-imaging studies, as well as most correlational studies is the fact that they focus on the effect of music practice on specific modalities (e.g. phonemic awareness in language, prosody in language, spatio-temporal skills). However, the positive effect of musical training on academic skills or cognitive performance is determined by a complex interaction of cognitive constructs.

This Study

In the Netherlands cognitive performance in the final year of primary school is measured with the CITO-score. The CITO-score not only provides a good representation of cognitive functions such as language and arithmetics, but furthermore the CITO-score is a strong predictor of future academic achievements. As such, the CITO-score is a reliable measurement for this interaction. In the present cross sectional survey, CITO score is used as measurement for$the effect of music on cognitive performance.
The aim of this study is to investigate the influence of extra-curricular musical training on the total of the 3 subtests in the CITO-eindtoets in a large part of the population without challenging one construct. Furthermore the sample in the study is a strong representation of the populations final year primary school students. The targeted schools are evenly distributed over the rural and urban areas. Although SES was not evenly distributed in

the musical training and nonmusical training group, this had no influence on the results because there is no interaction of SES and musical training. Given the response rate of 44,6% the results of this study are robust.

5.1 Limitations of this Study

Limitations of this study are firstly the fact that this is a cross-sectional study. No causal relations can be drawn from these results. Secondly, in this study only SES is controlled for by using the total family income as predictor, leaving out the parental educational level. This because of the high correlation between SES and parental education. Furthermore, gender and handedness are not included in the model because neither a main effect of gender and handedness, nor interaction was observed.

5.2 Future Research

Although the questionnaire measures the involvement in sports, dancing, arts and computer games as well as social involvement, these factors are not included in this study. The effect of duration, intention, motivation and kind of instrument played is also measured in the questionnaire and will be investigated in future studies. Furthermore the effect of a time window is of importance.

5.3 Implications

Musical training and education can broaden the development of cognitive performance in many ways. The results of this study reveal a significant positive effect of musical training on cognitive performance even when controlled for SES. A caveat is to administer effect sizes to this phenomenon in daily practice that are beyond reality. The reported effect sizes here are small to medium.

Nonetheless, music is of great value as a vehicle for emotional expression and communication. The participation in musical activity is always joyful and not restricted to a certain age. These joyful experiences in involvement in, and mastery of music can have a positive influence on the child's development (Southgate & Roscigno, 2009). It is difficult to investigate such multi factorial effects scientifically but at the same time it is giving drive for future exploration.

6 Acknowledgements

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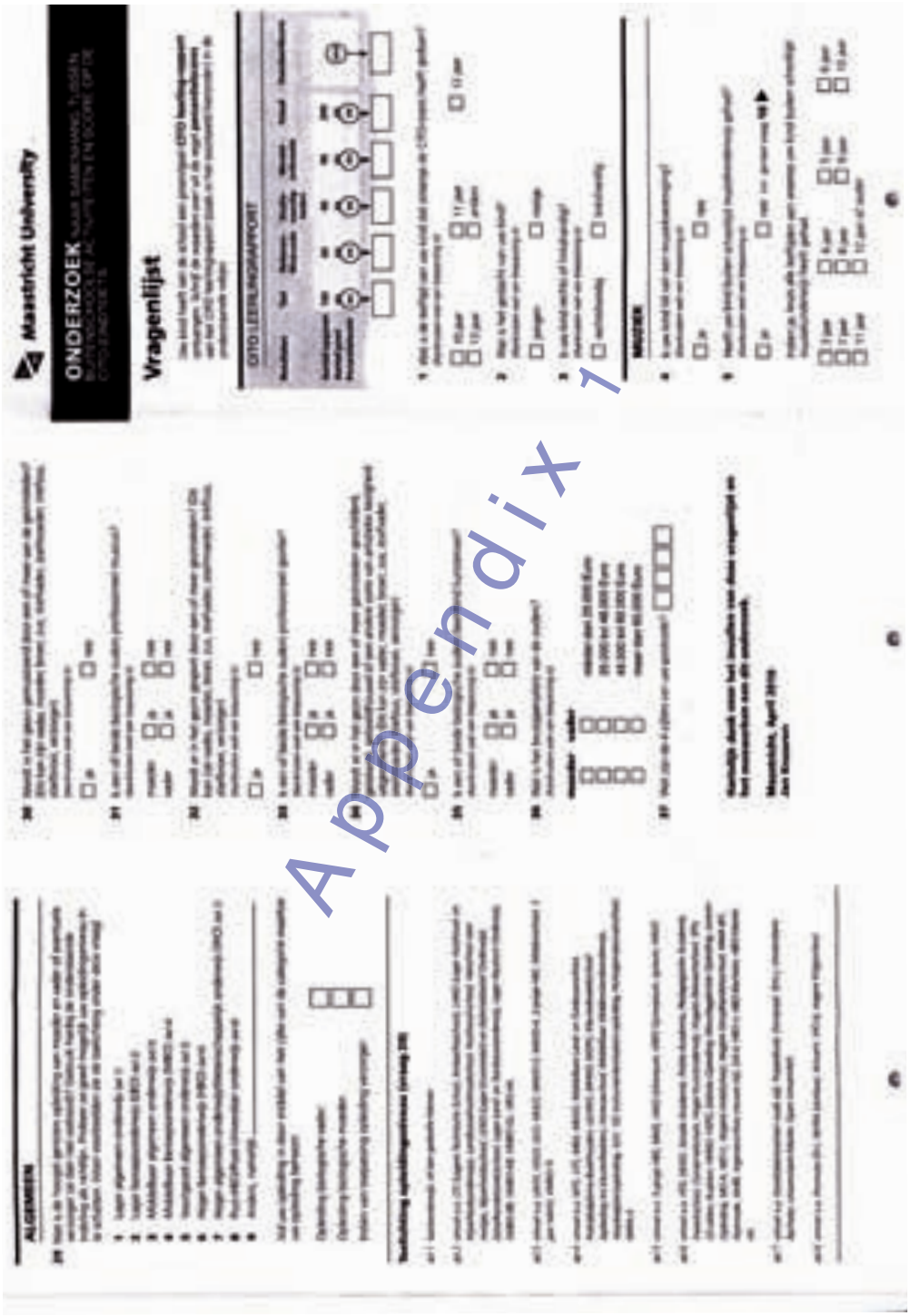
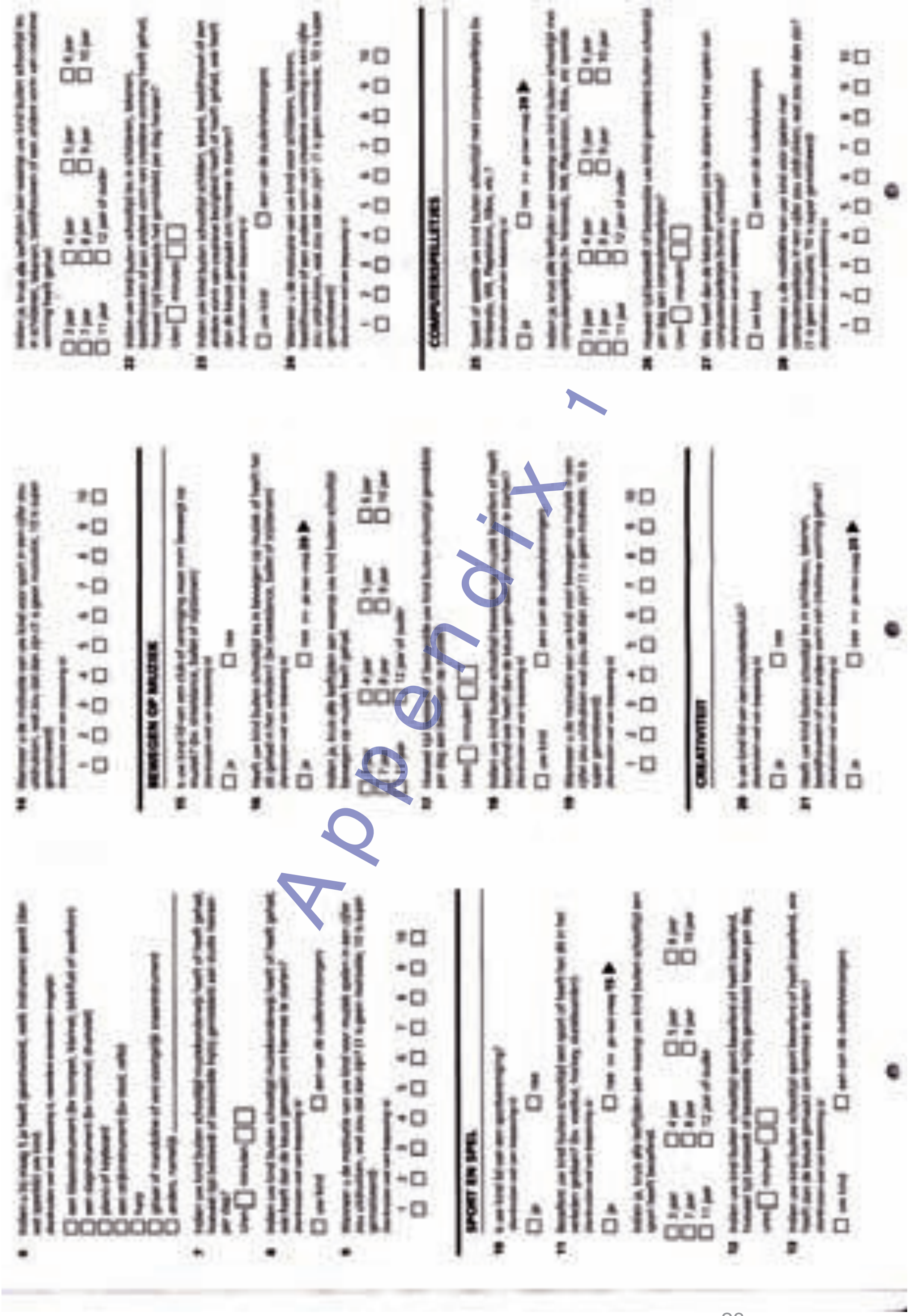
8 Appendices

Appendix I: Questionnaire



Appendix 1



The influence of music practice during primary school on congitive performance. Jan Knooren i521593 Maastricht University 23

Appendix II: Flyer distributed with the questionnaire to inform the parents about the survey

Onderzoek naar de samenhang tussen buitenschoolse activiteiten en CITO-score

In de wetenschap wordt steeds duidelijker dat ons brein verantwoordelijk is voor alles wat wij ervaren. Andersom dragen alle ervaringen uit ons dagelijks leven bij aan de vorming van ons brein. Buitenschoolse activiteiten zoals muziekbeoefening, sport, dansen of het spelen van computerspelletjes kunnen zodoende invloed hebben op de vorming van het brein. Dit kan weer invloed hebben op andere vaardigheden, zoals rekenen en taal.

Dit onderzoek richt zich op het verband tussen het beoefenen van buitenschoolse activiteiten en basisvaardigheden zoals rekenen en taal bij kinderen. We onderzoeken dit door informatie in te winnen over de score op de CITO-eindtoets van scholieren en de hoeveelheid tijd die deze hebben besteed aan buitenschoolse activiteiten. Verder worden een aantal algemene vragen gesteld.

Het is van groot belang dat we informatie van zoveel mogelijk scholieren ontvangen, dus ook wanneer uw kind volgens uw mening naast school geen enkele buitenschoolse activiteit heeft of heeft gehad, is deze informatie van groot belang. We willen benadrukken dat alle gegevens anoniem verwerkt worden. Bent u bereid mee te doen aan dit onderzoek; vul dan de bijgevoegde vragenlijst in (ongeveer 10 minuten tijd) en laat uw kind deze binnen een week inleveren bij de leerkracht van groep 8. Wanneer er dit jaar binnen uw gezin meer dan een kind de CITO-eindtoets heeft gemaakt, vul dan voor ieder kind een vragenlijst in.
Wilt u meer informatie over het onderzoek, lees dan verder op de achterzijde.

Wij bedanken u, mede namens het onderzoeksteam, voor uw medewerking aan dit onderzoek.

Jan Knooren (tel: 06 1922 0611)

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Faculty of Psychology and Neuroscience
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Vraag en antwoord.

Wat wordt er met mijn gegevens gedaan?
Deze gegevens worden anoniem verwerkt door de onderzoeker. Het doel hiervan is om naar de samenhang tussen buitenschoolse activiteiten en CITO score te kijken.

Waarom worden er vragen over het inkomen gesteld?
We willen vertekening van resultaten voorkomen en door bepaalde informatie mee te nemen in ons onderzoek kunnen we voor sommige dingen corrigeren; bijvoorbeeld, de kans bestaat dat mensen met hogere inkomens eerder hun kinderen muziekles laten volgen of op een sportclub laten gaan dan mensen met lagere inkomens. Als dat zo is kunnen we daar in de statistische bewerking rekening me houden.

Wie kan mijn gegevens inzien?
Alleen de medewerkers aan dit onderzoek kunnen de gegevens inzien. Uw vragenlijst wordt anoniem geretourneerd waardoor uw anonimiteit is gewaarborgd.

Over welke van mijn kinderen gaat dit onderzoek?
Dit onderzoek heeft betrekking op uw kind in groep 8 dat onlangs de CITO toets heeft gemaakt. Indien er meerdere kinderen uit uw gezin deze toets hebben gemaakt graag voor ieder kind een aparte vragenlijst invullen

Wat doe ik met de vragenlijst als hij ingevuld is?
De ingevulde vragenlijsten kunt u aan uw kind meegeven naar school. De leerkracht uit groep 8 zal de vragenlijsten verzamelen.

Voor meer vragen kunt u bellen met Jan Knooren,

06 1922 0611 of mail naar info@knooren.nl.