UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Reliability of the Functional Auditory Performance Indicators (FÁPI) to monitor progress in five-year-old children with Autism Spectrum Disorder

by

Carlien Müller

A dissertation submitted in fulfilment of the requirements of the degree

MCommunication Pathology

in the Department of Speech-Language Pathology and Audiology at

the

UNIVERSITY OF PRETORIA

FACULTY OF HUMANITIES

SUPERVISOR: Professor A. Kritzinger

CO-SUPERVISOR: Dr L. Pottas

August 2016

Table of content

Declaration of originality v

Abstract vi

List of abbreviations vii

List of tables viii

List of figures viii

Chapter 1 9

Introduction 9

1.1 Introduction and literature overview 9

1.2 Problem statement and research question 17

1.3 Terminology as used in the dissertation 17

1.4 Outline of chapters in the dissertation 18

Chapter 2 19

Interventions for young children with ASD 19

2.1 Background information 19

2.2 Intervention programmes and approaches for preschool children with ASD ... 21

2.2.1. “Bottom-Up” and “Top-Down” therapies 21

2.2.2 Applied Behavioural Analysis (ABA) 22

2.2.3 Picture exchange intervention 24

2.2.4 Verbal Behaviour Therapy (VBT) 25

2.2.5 Treatment and Education of Autistic and Communication Related Handicapped Children (TEACCH) 26

2.2.6 Makaton Language Programme 27

2.2.7 Early Start Denver Model (ESDM) 28

2.2.8 Therapeutic Listening 29

2.3 The value of a monitoring instrument to track progress in children with ASD 30

Chapter 3 32

Methodology 32

3.1 Aim and objectives 32

3.2 Research design 32

3.3 Ethical issues 33

3.3.1 Confidentiality and anonymity 33
3.3.2 Informed consent 34
3.3.3 Protection from harm 34
3.3.4 Honesty with professional colleagues 35
3.3.5 Non-discrimination 35
3.3.6 Competence and practices of the researcher 35
3.4 Participants 35
3.4.1 School selection criteria 35
3.4.2 Participant selection criteria 35
3.4.3 Participant selection procedures 36
3.4.4 Participant description 37
3.5 Materials and Apparatus 38
3.5.1 Material 38
3.5.2 Apparatus 41
3.6 Research procedures 43
3.6.1 Pilot study 43
3.6.2 Data collection for the main study 44
3.6.3 Video analysis 44
3.6.4 Data analysis 47
3.7 Reliability and validity 48
3.7.1 Reliability 48
3.7.2 Validity 49
Chapter 4 51
Article: Reliability of the Functional Auditory Performance Indicators (FÁPI) to monitor progress in five-year-old children with Autism Spectrum Disorder 51
Introduction 52
Method 55
Aims and Design 55
Participants 55
Material and apparatus 56
Procedures 58
Data analysis 59
Results 60
Overall performance of the participants on the seven categories of the FÁPI 60

Test-retest (intra-rater) reliability of the FÁPI 62
Inter-rater reliability of the FÁPI 66
Discussion 69
Conclusion 71
Chapter 5 76
Contributions, implications and conclusion 76
5.1 Contributions, theoretical and clinical implications of the study 76
5.2 Critical evaluation of the strengths and limitations of the study 79
5.3 Recommendations for further research 80
Reference list 81
Appendices A 88
Appendices B 103
Appendices C 128
Appendices D 139

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Declaration of originality

UNIVERSITY OF PRETORIA

The Department of Speech-Language Pathology and Audiology places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

Full names of student: **Carlien Müller**

Student number: **29026319**

Topic of work: **Reliability of the Functional Auditory Performance Indicators (FÁPI) to monitor progress in five-year-old children with Autism Spectrum Disorder.**

Declaration

1. I understand what plagiarism is and am aware of the University's policy in this regard.

2. I declare that this dissertation is my own original work. Where other people's work has been used (either from a printed source, Internet or any other source), this has been properly acknowledged and referenced in accordance with departmental requirements.

3. I have not used work previously produced by another student or any other person to hand in as my own.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Carlien Müller   Date

Abstract

Background: Atypical processing of auditory information in children with autism spectrum disorder (ASD) can be observed at a neurological as well as at a behavioural level. The Functional Auditory Performance Indicators (FÁPI) is an observational monitoring tool for pre-school children with hearing loss, but has not yet been described in children with ASD. A reliable instrument to monitor progress of functional auditory performance in young children with ASD may contribute to evidence-based practice during intervention.

Method: The aim was to describe the overall performance of five-year-old children with ASD on the FÁPI; to determine the test-retest reliability and inter-rater reliability of the tool. The study was exploratory with a descriptive design incorporating repeated measures. Twelve participants with ASD were purposely selected. The mean age was 65 months and all were exposed to English as additional language. Ten of the 12 participants had very little speech as reported by their parents. Pre-recorded sound and speech stimuli were used to elicit responses from participants in their familiar therapy rooms. For test-retest reliability three data collection sessions per participant were conducted over a two-week period. Video recordings were provided in randomised order and analysed by two independent raters. The raters were blind to the order of data sets.

***Results and conclusion*:** With an increase in complexity of auditory stimuli a marked decrease in response was observed in the participants. Category seven, the highest level of auditory responses, demonstrating the child's ability to process linguistic information, showed the least responses The test-retest reliability was good, with a single difference in the category 'Awareness and meaning of sound'. Inter-rater reliability indicated a significant difference in two of the seven categories of the FÁPI, 'Awareness and meaning of sound' and 'Sound localisation' with p-values of 0,006 and 0,003. These categories may be the most subjective in the tool. Despite some subjectivity in two of the seven categories the FÁPI was reliable to plot functional auditory performance in the sample group. Since the instrument relies on direct observation with very few demands to participate on a social level, it has potential for use in five-year-old children with ASD. Further research is required to determine the tool's performance using natural sound conditions to monitor the progress of children with ASD longitudinally, against themselves during intervention.

Keywords
Auditory performance, Autism Spectrum Disorder (ASD), Functional Auditory Performance Indicators (FÁPI), Inter-rater Reliability, Monitor progress, Test-retest Reliability.

List of abbreviations

AAC: Augmentative and Alternative Communication

ABA: Applied Behaviour Analysis

ABA-DTT: Applied Behaviour Analysis-Discrete Trail Therapy

AIT: Auditory Integration Training

APA: American Psychological Association

APD: Auditory Processing Disorder

ASD: Autism Spectrum Disorder

ASHA: American Speech-Language-Hearing Association

(C)APD: Central Auditory Processing Disorder

CHIP: Colorado Home Intervention Program

CNS: Central Nervous System

DSM: Diagnostic and Statistical Manual of Mental Disorders

DVD: Digital Video Disc

EAL: English Additional Language

EO: Establishing Operation

ERP: Event Related Potentials

ESDM: Early Start Denver Model

FÁPI: Functional Auditory Performance Indicators

HPCSA: Health Professions Council of South Africa

HPP: Head-turn Preference Procedure

LoLT: Language of Learning and Teaching

MMN: Mismatch Negativity

PEACH: Parent's Evaluation of Aural/Oral Performance of Children

PECS: Picture Exchange Communication System

PET: Positron Emission Tomography

SI: Sensory Integration

SPD: Sensory Processing Disorder

TEACCH: Treatment and Education of Autistic and Communication Related Handicapped Children

TEACH: Teacher Evaluation of Aural/Oral Performance of Children

VBT: Verbal Behaviour Therapy

List of tables

Table 1: Participant characteristics	37
Table 2: FÁPI scoring criteria	40
Table 3: Content of the pre-recorded stimuli	41
Table 4: Total scores for each category of the FÁPI	45
Table 1 (Article): Participant characteristics	55
Table 2 (Article): FÁPI scoring criteria	57
Table 3 (Article): **Table 3:** Intra-rater reliability; Rater 1	62
Table 4 (Article): **Table 4:** Intra-rater reliability; Rater 2	63
Table 5 (Article): **Table 5:** Inter-rater reliability for each category of the FÁPI.	66

List of figures

Figure 1: Therapy attributes of “Top-Down” and “Bottom-Up” therapies	22
Figure 1 (Article): Average FÁPI scores per category (n=12)	61
Figure 2 (Article): Rater 1 Intra-rater reliability depicting significant differences in scores for recording 1,2 and 3 for Category 1: Awareness and meaning of sound	65
Figure 3 (Article): Inter-rater reliability for Category 1: Awareness and meaning of sounds	67
Figure 4 (Article): The inter-rater reliability form Category 2: Auditory feedback and integration	68

Chapter 1

Introduction

The aim of this chapter is to introduce the issues relating to the functional auditory performance of preschool children diagnosed with Autism Spectrum Disorder (ASD); to critically discuss related literature and the monitoring of functional auditory performance in this specific population; to describe the problem statement and rationale, and to conclude with the research question and the terminology as used in the dissertation.

1.1 Introduction and literature overview

Neurodevelopmental disorders are described as a group of conditions with its onset during the early stages of development and may be characterised by deficits that cause impairments of social, personal, academic or occupational functioning (American Psychiatric Association [APA], 2013); one such disorder includes Autism Spectrum Disorder (ASD) which comprises of two domains in the new diagnostic criteria (APA, 2013). The first domain includes deficits in social communication and social interaction across contexts, as well as deficits in nonverbal communicative behaviours. The second domain includes stereotyped motor movements, speech or use of objects, insistence on sameness and highly restricted, fixated interests in focus and hyper- or hypo-reactivity to sensory input or activities. Sensory impairments were added to the DSM-5 diagnostic criteria for ASD which place new emphasis on an area of difficulty that might have been neglected in research in the past.

Sensory impairments, in particular auditory processing disorder and auditory functioning deficits, may be defined as difficulties in the processing of auditory information in the central nervous system (CNS) as demonstrated by poor performance (American Speech-Language-Hearing Association [ASHA], 2005). The specific skills that might be affected include sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal discrimination, temporal integration, temporal masking, and temporal ordering; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals (ASHA, 2005). The question is whether these functional auditory skills are indeed affected in children with ASD, and whether hyper- and hypo-reactivity to sound as described by APA (2013) fully address the auditory deficits the children may present with. It is therefore necessary to consider what is currently understood by auditory processing disorder.

The position statement on (Central) auditory processing disorder [CAPD] (ASHA, 2005) maintains that there is sufficient evidence to support the existence of (C)APD as a diagnostic entity. It is thus possible to assess and diagnose the condition, thereby informing the development of customised treatment and management plans. (C)APD is an auditory deficit and is thus part of the scope of practice of an audiologist (ASHA, 2005). Audiologists collaborate with speech-language therapists in the overall screening and assessment process, differential diagnosis, and development and implementation of intervention plans where there is evidence of speech-language and/or cognitive-communicative disorders (ASHA, 2005). Part of the speech-language therapist's qualification and scope is to define, describe and treat the cognitive-communicative and/or language factors that may be associated with (C)APD (ASHA, 2005). Thorough understanding of the disorder requires a multidisciplinary assessment to determine the functional impact of the difficulties and to guide treatment and management of the condition and deficits (ASHA, 2005). (C)APD is therefore a complex condition, requiring the attention of both audiologists and speech-language therapists. When the disorder is suspected in a child with ASD, the question is whether the same practice guidelines for assessment and intervention can be followed.

According to Pottas (2011) children with ASD have unique auditory processing difficulties which support the recent inclusion of sensory impairments as criteria for diagnosis of the condition. O'Connor (2012) reports that evidence for atypical processing of auditory information in ASD can be observed at a neurological as well as on a behavioural level. Additionally, it is indicated that accurate processing and interpretation of auditory information is often difficult for this population (O'Connor, 2012). O'Connor (2012) continues describing the characteristics of auditory processing disorder in children with ASD as diverse, ranging from low-level perceptual features, such as loudness and pitch of input, to processing of complex auditory information such as prosody. Deficits in children with ASD occur frequently when processing complex auditory input, with more severe difficulties for speech than non-speech stimuli (O'Connor, 2012).

A number of studies regarding the functional auditory skills of individuals with ASD have been conducted (Alcantara, Weisblatt, Moore & Bolton 2004; Azouz, Kozou, Khalil, Abdou & Sakr 2014; Ferguson & Moore 2014). The majority of the studies were conducted in the field of Neurophysiology and were executed within controlled environments. A study conducted by Boddaert *et al.* (2003) in the field of neurophysiology ascribes the language impairment and inadequate response to sound, observed in individuals with ASD, to abnormal cortical processing (Boddaert *et al.*, 2003). The objective of the study was to investigate the auditory cortical processing in ASD by means of positron emission tomography (PET) activation studies. The researchers found that typical adults present with bilateral activation of the superior temporal gyrus when exposed to speech-like sounds. Participants with ASD also presented with bilateral activation, but greater evidence of activation was observed in the right hemisphere at the right mid frontal gyrus with less activation in the left hemisphere (Boddaert *et al.*, 2003). These findings provide evidence that there are neurological differences in functional auditory skills of individuals with ASD and those without the condition which contributes to the idea of unique auditory skills.

The concept of unique auditory processing difficulties in children with ASD is further supported by studies using neuro-imaging and other experimental techniques (Bruneau, Bonnet-Brilhault, Gomot & Barthélémy, 2003; Ceponiene *et al.*, 2003; Kuhl, Coffey-Corina, Padden, & Dawson, 2005). Kuhl *et al.* (2005) conducted a study including behavioural and electrophysiological measurements to investigate the links between social and linguistic processing of speech in preschool children with ASD. The goals of the study were to examine the auditory preference in preschool children with ASD and match their performance to typically developing children by opposing motherese speech samples to non-speech analogue signals; to evaluate the basic speech discrimination abilities of the groups by comparing the data obtained from mismatch negativity (MMN) studies. Finally, the study examined the potential association between social and linguistic measures and investigate a possible link between these measures and the severity of ASD in a child (Kuhl *et al.*, 2005).

The study included 29 participants formally diagnosed with ASD, aged from 14 to 36 months; 29 typically developing children with the same mental age (for the behavioural section of the study) and 15 typically developing children, matched for chronological age (Kuhl *et al*., 2005). The study was divided into two main sections.

The first section included neurophysiological procedures using event related potentials (ERP), resulting in MMN. This procedure included passive listening to the different types of stimuli, while the participants were wearing an Electro-cap. The second part included a behavioural analysis approach, with the participant on the parent's lap while the different types of stimuli were presented and reactions were recorded. The behavioural component of the experiment included a head-turn preference procedure (HPP).

When comparing the results for both procedures and varied groups, the following results were described: The typically developing chronologically aged matched participants showed general significant effects to the auditory input, while the group with ASD did not show a statistically significant effect. With the auditory preference test the participants with ASD presented with a strong preference for non-speech analogue signals while the typically developing mentally matched peers did not show a specific preference. Upon further analysis an interesting finding emerged. Participants with ASD were divided into sub-groups based on their listening preference observed during the MMN procedure (a response that reflects automatic neural reaction to changes in auditory stimulation). The group was divided into participants with ASD presenting with a preference for child directed speech and participants with ASD who preferred non-speech analogue signals with comparative supra-segmental aspects to the motherese sample. A clear difference in waveforms was observed with ERP. Participants with ASD who presented with a preference for speech had waveforms similar to their typical developing peers. Additionally, the researchers found a significant positive correlation between the preference for non-speech analogues and the number of ASD related symptoms in participants (Kuhl *et al.,* 2005). The greater the number of ASD symptoms, and therefore the severity of

ASD, the greater the preference for non-speech signals in the participants. Significant negative correlations were observed between the participants' preference for non-speech analogues, the measure of frequency of initiation of joint attention, and expressive language abilities. Participants preferring non-speech analogue input scored lower on measures of initiating joint attention and expressive language abilities than those who preferred speech. Kuhl *et al.* (2005) concluded that participants with ASD differ significantly from their typically developing peers in their neural and behavioural responses to speech. The researchers found a definite preference for specific sound stimuli in participants with ASD and that the preferences were aligned with the severity of ASD. There was a strong correlation between the social and linguistic measures of the participants. Atypical speech processing scores were positively associated with the severity of ASD which had an effect on language acquisition (Kuhl *et al.*, 2005). It was remarkable that the findings were already observed in children as young as one to three years old.

Following on the study by Kuhl *et al.* (2005), Paul, Chawarska, Fowler, Cicchetti and Volkmar (2007) conducted a study using behavioural observation to investigate the auditory preference of toddlers with ASD. This study included paradigms that replicated studies of typical developing children's speech preference. Paul *et al.* (2007) hypothesised that pre-school children with ASD fail to "tune-in" to auditory input, an essential skill which allow typically developing children to develop a specific preference for sound patterns of their native language. Failing to "tune-in" to ambient language, results in limited language experience as well as limited social interaction (Paul *et al*., 2007). Kuhl *et al.* (2005) found similar results with an objective study approach.

In the study by Paul *et al.* (2007) the participants were divided into four groups of 14-36 month-old children. The groups included children diagnosed with ASD, an age matched control group with significant developmental delays, a typically developing group matched on language ability and a typically developing group as an age match. The HPP protocol was also used in the study. Similar to Kuhl *et al.* (2005) participants were positioned on the parent's lap facing a light in the centre, with two peripheral lights. Once the participant's attention was focused on the centre light one of the peripheral lights started flickering to draw attention. After the participant turned his/her head to focus on the flickering light, auditory stimuli were presented when the flickering light was switched off. The initial localisation of the auditory stimulus was therefore prompted.

Paul *et al.* (2007) found that all four groups of participants orientated longer to child directed speech than contrast speech samples. The strongest preferences were observed in typically developing participants and the weakest preference was observed in participants with ASD. The results did not show a significant overall difference in auditory preference between children with ASD and neurotypical children as in the study conducted by Kuhl *et al.* (2005). A possible reason offered by the researchers was that the modification of the motherese input to produce the non-target patterns may have presented a greater electronic sound than intended. Paul *et al.* (2007) found that participants with ASD presented with a decreased preference for child directed speech, and suggested that the pattern of limited auditory attention may have an influence on language development. In this study only the typically developing age matched participants presented with an increased preference for pauses inserted at grammatical boundaries. Typically developing participants who were matched with participants with ASD based on language abilities, did not show preference for pauses inserted at grammatical boundaries, but significant preferences for English stress patterns were observed. All the groups thus preferred child directed speech rather than the contrast stimuli, but the participants with ASD paid significantly less attention to child directed speech.

The findings of the studies by Kuhl *et al.* (2005) and Paul *et al.* (2007) provide evidence that very young children with ASD show difficulty to listen and attend to complex sound, i.e. speech, and that the listening difficulties may impact on their language acquisition. The different approaches followed in the studies emphasised different aspects of auditory deficits experienced by participants with ASD, which again stresses the difference between auditory processing of typically developing pre-school children and those with ASD. Other characteristics of unique responses to sound in children with ASD include inconsistent response to their name, sound aversion, decreased awareness or recognition of a caregiver’s voice, neglect to pay attention to speech yet presenting with an awareness of environmental sounds, and a lack of interest or response to neutral statements (Johnson & Myers, 2007).

Both neurophysiological and behavioural studies therefore highlight the difference between the functional auditory performance of typically developing individuals and those with ASD. Similar to the study of Kuhl *et al.* (2005) Carpenter, Estrem, Crowell and Edrisinha (2014) found a heterogeneity in auditory behaviour within a sample of participants with ASD when within-group comparisons are made. The study (Carpenter *et al.,* 2014) examined the relationship between ASD and central auditory processing in a group of young adults diagnosed with ASD and a control group matched for age and gender. Carpenter *et al.* (2014) investigated whether certain patterns of response in a group of young adults with ASD for subtests on typical behavioural tests for (C)APD could be observed. A second goal of the study was to determine the association between (C)APD subtests and composite scores for participants with ASD and a control group. The subtests included six auditory processing skills: localisation, discrimination, pattern recognition, temporal aspects, performance with competing signals, and performance with degraded signals. The researchers hypothesised that similar within-group patterns would be observed but that a significant difference would be evident when the two groups were matched (Carpenter *et al.*, 2014). Participants were seated in a sound proof booth while different auditory stimuli with primary acoustic characteristics were presented at a loudness level of 50 dB, while competing background noise was presented.

The results of the within-group variability showed a general low mean and median for the ASD participants. The participants with ASD scored within the borderline or disordered ranges and failed the screening. The findings confirmed that the majority of participants with ASD presented with (C)APD. The greatest between-group differences were observed in words-free recall while a competing signal was presented. Carpenter *et al.* (2014) did not find different responses in participants with ASD, but heterogeneity within the group was apparent in the different subtests. The researchers concluded that individuals with ASD may present with co-morbid auditory processing difficulties and questioned whether possible subgroups can be identified in individuals with ASD presenting with specific auditory processing difficulties.

In summary, neurophysiological studies and some behavioural studies increasingly ascribe auditory deficits in children with ASD to auditory processing difficulties, although there are some differences in terminology used (Boddaert *et al.*, 2003; Haesen, Boets, & Wagemans, 2011; Kuhl *et al.*, 2005). However, neurophysiological tests are not accessible to practising speech-language therapists to assess, understand and monitor the functional auditory skills of their young clients with ASD. Evidence of the auditory processing deficits in this population is mostly based on neurophysiological studies (Tomchek & Dunn, 2007; Ceponiene *et al.*, 2003; Haesen *et al.,* 2011; O'Connor, 2012; Kuhl *et al.*, 2005) and direct observation during experiments (Carpenter *et al*., 2014; Kuhl *et al.,* 2005; Paul *et al.,* 2007) but limited research relating to the behavioural response to speech and sound in clinical contexts is available.

To date, no known studies have examined central auditory processing skills in individuals with ASD, using tools designed to identify and plot auditory processing disorders (Carpenter *et al.*, 2014). Carpenter *et al.* (2014) remarked that multiple neurophysiological studies have investigated auditory processing in individuals with ASD, but the diagnosis of (C)APD in typically developing individuals is usually based on behavioural tests and tools. There appears to be a lack of behavioural data of the functional auditory performance of children with ASD. (C)APD tests may be used to assess the auditory processing difficulties of children with ASD with different degrees of success. Children with ASD typically do not comply well when tested and direct demands for performance are made (Coplan, 2010). Clinical observational tools to monitor the effectiveness of auditory processing intervention in children with ASD may be a useful alternative. The identification of a reliable clinical tool to plot and monitor progress may thus assist in describing and understanding the functional auditory performance of children with ASD in a natural environment, allowing speech-language therapists to plan intervention and monitor progress.

The field of audiology offers multiple sources for children with hearing loss and auditory processing deficits that might be applicable for individuals with ASD. A number of standardised clinical and monitoring tools are available to investigate the functional auditory skills and performance of children with hearing loss, but most are not applicable to preschool children. The Functional Auditory Performance Indicators (FÁPI), developed by Stredler-Brown and Johnson (2004) is an integrated approach to monitor the auditory skill development of children with hearing loss. The FÁPI

(Stredler-Brown & Johnson, 2004) is used to assist teachers, therapists and parents to create a comprehensive profile of the child's auditory skills and performance in a hierarchical order, based on a scale of skill development. The FÁPI is scored by means of direct observation of the child's functional auditory skills in a familiar environment without controlling background sound or placing many demands on the child to perform. The FÁPI was designed to track the natural auditory functioning development of preschool children with hearing loss and can be administered multiple times to evaluate a child's progress against him/herself during the course of intervention.

1.2 Problem statement and research question

Based on research evidence children with ASD present with auditory processing difficulties, which are also described in the latest ASD diagnostic criteria (APA, 2013) as hyper- and hypo-reactivity to sound. A reliable instrument to monitor progress of functional auditory performance in young children with ASD may contribute to evidence-based practice during intervention. The following research question was posed: Would the FÁPI (Stredler-Brown & Johnson, 2004) be an appropriate and reliable tool to describe and monitor the auditory performance of young children with ASD?

1.3 Terminology as used in the dissertation

Autism spectrum disorder (ASD): A neurodevelopmental disorder which comprises of two domains in the new diagnostic criteria (APA, 2013). The first domain in individuals with ASD is characterised by continuous deficits in social interaction and social communication across various settings, including deficits in nonverbal communication behaviours used for social interaction, social reciprocity, and skills in developing, maintaining as well as understanding relationships. Additionally, the social communication deficits require the presence of restricted, repetitive patterns of behaviour, interests or activities in order to make a diagnosis of ASD. The second domain includes hypo- or hyperactivity to sensory input or unusual interest in sensory aspects of the environment. The deficits result in functional limitation in effective communication, social participation, social relationships and academic achievement. In order to make a diagnosis of ASD these disturbances should not be better explained by intellectual disability or global developmental delay. ASD and intellectual disability is frequently co-occurring. In order to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below the expected general developmental level (APA, 2013).

Auditory processing disorder (APD): In this study auditory processing refers to what the brain does with the auditory input it receives. Auditory processing disorder refers to difficulties in the processing of auditory information in the central nervous system (CNS) as demonstrated by poor performance (ASHA, 2005). The specific skills that may be affected include sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal discrimination, temporal integration, temporal masking, and temporal ordering; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals (ASHA, 2005).

Functional auditory performance: The performance refers to the auditory skill level on which a child is functioning based on the hierarchical structure provided by Stredler-Brown and Johnson (2004). The levels of development include: awareness and meaning of sounds, auditory feedback and integration, localising sound source, auditory discrimination, auditory comprehension, short-term auditory memory, linguistic auditory processing. Functional auditory performance thus refers to the level on which a child is functioning when observing his/her auditory skills directly.

1.4 Outline of chapters in the dissertation

Chapter 1: Introduction to the topic, problems statement, research question and rationale
Chapter 2: Literature overview of ASD interventions
Chapter 3: Methodology used in the research study
Chapter 4: Article submitted to a scientific journal
Chapter 5: Implications, recommendations and conclusion

Chapter 2

Interventions for young children with ASD

The aim of this chapter is to provide an overview of the intervention programmes and outcomes for preschool children with ASD. The purpose is to describe to which extent functional auditory performance is targeted in intervention and thereby indicate the need for a monitoring instrument to measure progress in auditory skill development.

2.1 Background information

In brief, the description of ASD according to the DSM-5 (APA, 2013) includes deficits in social skills, communication, repetitive behaviour, and sensorimotor processing. Although the most recent diagnostic criteria (APA, 2013) do not include different subtypes of autism under the term "pervasive developmental disorders" anymore, and the criteria are differently arranged from the DSM-IV-TR (APA, 2000), the content of the descriptors remained almost the same. The comprehensive list of priorities for intervention compiled by Coplan (2010) still embodies the essence of difficulties experienced by children with ASD. According to Coplan (2010) the following aspects should be considered when setting therapy goals for preschoolers with ASD:

- A prerequisite in the social realm is that the child should acknowledge the presence of other people and give a reliable response to social offers for interaction.

- The initial communication goal should be to teach a child the existence of language. The use of objects and activities may be implemented with arbitrary sounds, gestures or visual symbols. According to ASHA (2006) speech-language therapist have an important role in the screening, diagnosing and improvement of the social communication development and the child' with ASD life. To address the enhancement of social communication development, ASHA (2006) provides detailed and specific communication goals.

- The initial behaviour modification goal should be to decrease mental and behavioural rigidity, replacing the behaviour with more appropriate play activities and increasing tolerance to change.

- Sensorimotor processing is typically included in the scope of an occupational therapist. Pfeiffer, Koenig, Kinnealey, Sheppard and Henderson (2011) report that Sensory Processing Disorder (SPD) is rather common in children diagnosed with ASD. Pfeiffer *et al*. (2011) explain that children with SPD often experience difficulty with the regulation of responses to specific stimuli, which might result in the use of self-stimulation to compensate for the lack of stimuli, or may be easily overstimulated. Sensory Integration (SI) treatment is designed to elicit an adaptive motor response with the presentation of a controlled sensory environment (Pfeiffer *et al*., 2011). Coplan (2010) discusses sensory impairments as an integral component of an ASD diagnosis, but does not make specific reference to auditory hyper- or hypo-reactivity. Auditory processing and functional auditory performance is considered as being part of the scope of practice of the speech-language therapist (ASHA, 2007), although the deficits can be categorised under SPD.

Since the proposed goals (Coplan, 2010) include creating of awareness of language to facilitate interaction and communication, the question arises what the prerequisites of language development are. According to Owens (2008) language is a social tool that is a complex system of symbols and rules for using those symbols. An individual, in this case a preschool child, must become knowledgeable about the symbols and the acceptable use of rules, concepts and word combinations. Bailey and Snowling (2002) state that although children make use of visual cues when learning language, audition is of utmost importance for language acquisition. In the case of children with ASD, audition appears to be a particular area of difficulty (Kuhl *et al*., 2005). Toddlers with ASD show a significantly reduced preference for natural speech, in particular motherese. According to Paul *et al*. (2007) basic language learning mechanisms may be intact in children with ASD, but the development thereof continues to be affected by auditory inattention. Paul *et al*. (2007) explain that inconsistent orientation of attention to auditory stimuli in the environment (language), results in reduced input. Reduced language input causes a decline in the potential learning experiences of interaction and joint attention with another person. As discussed in Chapter 1 Kuhl *et al*. (2005) found that young children with ASD differ greatly in their neural and behavioural response to speech, with a greater preference for non-speech stimuli. It is therefore clear that orientation to and sustained attention to speech should be targeted as intervention goals to improve language and communication in children with ASD.

The field of ASD intervention includes a wide range of different treatment approaches (models of intervention) (Leaf *et al*., 2016). It is not unusual to hear that a child is receiving intervention based upon Skinner's Analysis of Verbal Behavior (or Applied Verbal Behavior) (Coplan, 2010), or the Early Start Denver Model (Dawson *et al*., 2010). In view of the importance of functional auditory performance in language acquisition and the difficulties experienced by preschool children with ASD in this regard, different intervention programmes will now be critically discussed.

2.2 Intervention programmes and approaches for preschool children with ASD

2.2.1. "Bottom-Up" and "Top-Down" therapies

Coplan (2010) refers to the "Bottom-Up" and "Top-Down" patterns of brain activities used by psychologists to describe neural functioning in two directions, from low level functions to high level functions, and vice versa. These two patterns are used to differentiate between intervention approaches for preschoolers with ASD. Top-down attention refers to a referred focusing of attention on a location and/or an object based on current behavioural goals, whereas bottom-up attention is prompted automatically by the aspects of stimuli (Ciaramelli, Grady, & Moscovitch, 2008).

"Bottom-Up" therapies focus on foundation skills, are therapist-directed and stimulus driven (Coplan, 2010). With "Bottom-Up" approaches, the child is not required to understand or articulate the therapy goal; the child is just required to perform the action, according to fixed response patterns. Mastery of skills is assumed to result in progression to a higher level of functioning. In contrast, the "Top-Down" approaches to intervention for children with ASD are learner-directed and concept-driven. The learner should have an explicit understanding of the learning material and the focus is on complex social and linguistic skills including reasoning, making judgements and planning. Depending on the age of the child with ASD, the explicit training of auditory skills to focus on speech may be viewed as a Top-Down therapy approach. In the early stages of auditory training with very young children, the approach may be purely Bottom-Up. The cognitive orientation and therapy attributes of the two approaches are presented in Figure 1.

Top-Down	Child-driven Works directly on target skills Explicit understanding is a goal Strategising by child is required
	Therapist and child work as partners Works on foundation and target skills Explicit understanding may be a goal Strategising by child may be required
Bottom-Up	Therapist-driven Works on foundation skills Explicit understanding is not a goal Strategising by child is not required

Figure 1: Therapy attributes of “Top-Down” and “Bottom-Up” therapies (Coplan, 2010)

There are still many debates about which intervention approach addresses the deficits of children with ASD best, as both “Bottom-Up” and “Top-Down” patterns of activities are included in various intervention programmes and have a role to play depending on the natural development and level of functioning of the child (Coplan, 2010). The most prominent intervention programmes currently used for children with ASD currently are as follows:

2.2.2 Applied Behavioural Analysis (ABA)

Applied behaviour analysis (ABA) refers to the method used by behaviourists to manipulate and describe behaviour (Coplan, 2010). Formal training in ABA is required to become a licensed member at the board of certified behaviour analysts (Behavior Analyst Certification Board® Inc, n.d). ABA has successfully been used with thousands of individuals to address unwanted behaviours such as self-injury (Coplan, 2010). ABA has also been used to promote positive behaviours which include language, adaptive skills and outward forms of social behaviour in children with ASD (Coplan, 2010). This approach is purely “Bottom-up” in nature, with the therapist in control of the session and the child responding to the input received.

Although there are multiple models of ABA intervention for children with ASD, all programmes share a common set of core features (Virués-Ortega, 2010). Specific strategies and techniques which focus on the principles of learning are used (Coplan, 2010). The strategies and techniques include shaping, prompting and fading, chaining and reverse chaining, generalisation and discrete trails. Shaping refers to the systematic manipulation of experiences and the consequences thereof to either increase or decrease the presence of a specified behaviour. Prompting and fading include verbal or physical clues which increase the chance that the child will produce the desired behaviour. With the desired response increasing, prompts are systematically decreased or faded. Chaining and reverse chaining involves the breaking down of a complex task into smaller units that are easier to shape. Depending on circumstances, an activity may start at the beginning and progress towards the end or vice versa. Generalisation refers to the ability of the child to perform a learnt task in any given setting or condition. Prompts and tasks are varied, presented in different environments and facilitated by different therapists (Coplan, 2010; Virués-Ortega, 2010).

Applied behaviour analysis - discrete trails (ABA-DTT) is typically used in therapy with children with ASD entering therapy (Coplan, 2010). ABA-DTT includes defined interactions between a facilitator and the learner in an attempt to follow a typical pattern during therapy. The therapy session is typically one-on-one and includes physical prompts (Coplan, 2010). ABA-DTT requires the trainer to present a stimulus, the learner responds and the trainer then delivers a consequence. The consequences included in ABA-DTT are positive reinforcement, negative reinforcement, punishments and ignoring, as well as time-out. This approach is purely “Bottom-Up” and is solely controlled by the therapist with the child’s response to the physical input combined with verbal input. No strategising by the child is required, and conscious understanding is not set as a therapy goal (see Figure 1).

It is apparent that the child’s functional auditory performance is not targeted with this therapy approach, even though listening behaviour is used as a means to an end. The physical prompt is combined with the spoken instruction, which implies that the therapist assumes that the necessary auditory skills have been acquired prior to the ABA-DTT therapy sessions.

Behaviourists support the notion that ASD can be cured by ABA, but according to Coplan (2010) there are two flaws in their logic. In the first place behaviourists disregard development and ascribe all progress to behavioural intervention. It is now known that development occurs along with the behavioural intervention (Coplan, 2010). Intervention enhances development, but a degree of the progress made is ascribed to development. The second flaw described by Coplan (2010) is the disregard of the child's understanding or insight. ABA does not consider abstract thinking and reasoning and works from the supposition that actions must be taught to the child and are not executed based on reasoning. Following a "Bottom-Up" approach it appears that the majority of time is spent on physical prompts and external rewards given to the child with ASD, with little to no attention given to working directly on a target goal or skill such as functional auditory performance. Verbal instructions are provided in addition to the physical prompt but the degree of understanding expected from the child is debatable (Leaf *et al*., 2016). It may thus be concluded that ABA as used in ASD intervention does not include functional auditory performance as a goal or directly addresses the development of auditory skills in a child.

2.2.3 Picture exchange intervention

Research literature on the possible benefits of augmentative and alternative communication (AAC) for individuals with autism is a growing field (Ganz *et al*., 2013). Picture exchange intervention is usually used in combination with ABA-DTT (Coplan, 2010). Although AAC has shown to be successful in controlled contexts, minimal research has investigated its implementation within a natural environment (Ganz *et al*., 2013).

The Picture Exchange Communication System (PECS) is in particular recommended as a form of communication exchange for children with ASD. According to Preis (2006) the goal of PECS is to shape the child's behaviour by exchanging a picture card for the corresponding object. With the progression of intervention the learner's picture exchange repertoire is broadened to include cards representing many food types, objects or activities that the child finds rewarding. While the picture card is presented, the therapist or teacher models the spoken word as the object is presented. In most cases the child needs to grasp the symbolic communication first before the spoken language is added (Coplan, 2010). Picture exchange was designed as a means of communication, not to elicit speech even though speech may be a consequence of the intervention (Coplan, 2010). Coplan (2010) describes the picture exchange method as a "Bottom-Up" approach, as there appears to be little or no eye contact, no functional language and it is used for nonverbal children. It is clear that the picture exchange method does not focus on high levels of functioning such as functional auditory performance. Eventually, a Top-Down functioning can be achieved when the child learns to control communication interactions with a partner by using picture cards.

In a meta-analysis conducted by Flippen, Reszka, and Watson (2010), PECS is described as a popular communication-training programme for young children with ASD. The meta-analysis found that PECS is a promising intervention approach, but that it is not yet an established form of evidence-based intervention for children with ASD (Flippen *et al*., 2010). There appears to be moderate to small gains evident in a child's communication interactions during PECS training, but little to no gains were observed in language (Flippen *et al*., 2010). Ganz *et al*. (2012) state that multiple studies have demonstrated that PECS is effective within the research contexts. According to Ganz *et al*. (2012) PECS results in improved functional communication, play, speech, and behavioural skills in individuals with ASD in a controlled environment. The strong focus on visual input characteristic of PECS reduces the value of the verbal stimuli which further reduces the focus on language. The child's auditory skills are therefore used as a supplementary means to an end, but no specific attention is paid to functional auditory performance and the hierarchical development thereof during PECS intervention.

2.2.4 Verbal Behaviour Therapy (VBT)

Verbal Behaviour Therapy (VBT) was derived from the book by B. F. Skinner in 1957 (Coplan, 2010), with the main focus of the treatment approach on the development of language skills (Sundberg & Michael, 2001). Sundberg and Michael (2001) describe the approach as teaching communication using the principles of ABA and the theories of the behaviourist B.F. Skinner. VBT motivates a child, adolescent or adult with ASD to learn language by connecting words with their purposes. The student learns that words can help obtain desired objects or other results. Skinner identified seven types of verbal operants including echoic, mand, tact, intraverbal, textual, transcriptive, and copying a text (Sundberg & Michael, 2001). The authors explain that the seven types of verbal operants function as components of advanced forms of language (Sundberg & Michael, 2001). For example, manding, which is synonymous to requesting, is taught by using activities or objects of desire that are highly motivating (Coplan, 2010). If a child experiences difficulty, partial prompts may be provided, fading the prompt as quickly as possible. As the child's verbal behaviours expand, the programme may progress to /wh/-questions. With VBT comprehensive verbal prompting is initially included. VBT starts with a "Bottom-Up" approach, and as the child progresses through the levels of verbal behaviour, the approach gradually changes to a "Top-Down" approach (Coplan, 2010) (see Figure 1).

Coplan (2010) comments that the eclectic approach followed by VBT is favourable as the required stimulation is included to achieve success. Verbal instructions in combination with picture exchange or signing are used.

Common features are apparent when VBT and PECS are compared. In both approaches a desired item is presented as the antecedent. The child then responds with a specific behaviour, either prompted or spontaneous. Prompting includes hand-over-hand, verbal phrases or a subtle gesture, but is faded as soon as possible, with a reward if the appropriate behaviour is observed. The emphasis of VBT is on the verbal operant with little to no attention on auditory skills and the development thereof. It appears that VBT, similar to previous approaches discussed, implement auditory skills as a means to an end, but with no special emphasis on training auditory skills underlying language learning.

2.2.5 Treatment and Education of Autistic and Communication Related Handicapped Children (TEACCH)

According to Virués-Ortega, Julio and Barriuso (2013) TEACCH is an emerging successful practice in the field of ASD. TEACCH was initially developed for individuals with significant disability. This approach is flexible to adapt according to needs and abilities of a specific child. Every TEACCH programme is characterised by the following three components (Coplan, 2010):

1. Structured therapy environment: The physical layout of the working station or classroom is organised in such a manner that the child knows exactly what the goal of the activity is, how much time is allocated and what the progression on the specific activity should be (Coplan, 2010; Virtués-Ortega *et al*., 2013). The structured

environment is based on the idea that individuals with ASD are stronger visual learners (Coplan, 2010) which is why TEACCH relies on visual cues to transform the environment into a comprehendible place for the child. The structure minimises possible distractions (Virtués-Ortega *et al*., 2013). Daily schedules are included in routines and multimodal language intervention emphasises visual modalities in addition to verbal instructions.

2. Strengths and interests are considered as the child's desired activity is included to become the focus of the therapeutic interaction. The therapist playfully sabotages the child's stereotypical behaviour to engage the child in therapy. Visual and/or written information is provided to supplement verbal communication.

3. Organisation of the tasks and materials promote independence from prompts or directions (Virtués-Ortega *et al*., 2013).

With TEACCH verbal communication is used, but little to no consideration of functional auditory skills training is evident. The TEACCH approach targets specific skills in activities of daily living, communication, social skills, language, executive functioning, attention, and engagement (Schopler, 2005). As with other intervention approaches for children with ASD it appears that the assumption is made that the functional auditory performance does not pose a problem for the child and that it is not a topic to address during intervention.

In the meta-analysis, conducted by Virués-Ortega *et al*. (2013) it became evident that the clinical effects of TEACCH on perceptual, motor, verbal and cognitive skills of children with ASD were small. Many studies report an increase in learning behaviours when using TEACCH, but it is not clear exactly what children are learning and why (Howley, 2015). According to Howley (2015) existing research evidence demonstrates that TEACCH fails to capture a holistic intervention approach for children with ASD, as recommended by Schopler (2005). TEACCH starts out as a "Bottom-up" approach but evolves into a "Top-Down" approach as the child's level of functioning improves.

2.2.6 Makaton Language Programme

Since functional communication is a major goal in intervention for children with ASD (Lal, 2010) the Makaton programme can be adapted for this purpose. Makaton is a language programme that uses signs and symbols to assist in communication (Watson, 2012). The programme is designed to support spoken language with signs presented in the same word order of a sentence. As the child's language acquisition develops, the use of signs decreases and the use of spoken language increases if the child has the ability to talk (Watson, 2012). Makaton, like TEACCH, may initially be described as using a "Bottom-up" approach, but as the child's functioning improves the learning pattern changes to become "Top-down" in nature.

When a child uses a combination of signs, symbols (line drawings) and speech the listener receives an abundance of communication clues, thereby assisting successful interactions. The Makaton programme can be personalised and adapted according to the specific needs of the child (Lal, 2010). Lal (2010) conducted a study to determine the effectiveness of the Makaton Language Programme to enhance language and social behaviour in children with ASD. Pre- and post-test mean scores indicated a positive effect on the receptive and expressive language development of children with ASD using Makaton signing and symbols (Lal, 2010). According to Lal (2010) it appears that the Makaton programme facilitated pragmatic skills in children with ASD. During Makaton language intervention no additional attention is given to a child's functional auditory development. It appears that the developers of Makaton, similar to other intervention programme developers, focus on language acquisition by means of multimodal input, but does not focus on the hierarchical development of functional auditory skills.

2.2.7 Early Start Denver Model (ESDM)

The Early Start Denver Model (ESDM) is a comprehensive and intensive early intervention programme that uses a naturalistic developmental behavioural approach to address early symptoms of ASD (Dawson *et al*., 2010; Vivanti, Dissanayke & The Victorian ASELCC Team, 2016). The programme is used for toddlers and preschool children with ASD, but is currently recommended for children between 12-48 months (Vivanti *et al., 2016*). The ESDM integrates ABA principles with developmental and relationship-based approaches (Dawson *et al*., 2010) and may be the most effective intervention programme for young children with ASD yet. The focus of the ESDM is on social learning and social-cognitive development to increase communication, imitation, sharing, joint attention and play in a child with ASD. The child's strengths and weaknesses are used to determine the goals. Intervention is conducted two hours per day, five days a week in the child's natural environment at home by trained therapists (Dawson *et al*., 2010). The teaching strategies used in the ESDM include shared engagement with real-life materials and activities, interpersonal exchange and positive affect, adult responsivity and sensitivity to the child's cues and a focus on verbal and nonverbal communication, all based on an informed curriculum that addresses all developmental domains (Dawson *et al*., 2010)

The results of a randomised trial (Dawson *et al*., 2010) showed that the ESDM is an effective intervention programme in comparison to less intensive community interventions for children with ASD. Children in the programme show a significant increase in cognitive ability, expressive and receptive language and in adaptive behaviour (Dawson *et al*., 2010). Similar to all the previous approaches and programmes the intervention relies on auditory skills, but does not address these skills in a direct manner. ESDM is child directed, but it remains therapist-driven thus including a "Bottom-up" therapy pattern.

2.2.8 Therapeutic Listening

An approach that appears to target the auditory deficits of children with ASD is Therapeutic Listening. There are multiple testimonials for the effectiveness of Auditory Integration Training (AIT) on the internet but research evidence of the training is rare (Coplan, 2010). Most research reports do not include control groups but claims that improvement in children with ASD is evident (Coplan, 2010). Therapeutic Listening, a registered trademark of Vital Links, is a specific sound-based intervention embedded within a developmental and sensory integration perspective. The auditory stimuli in Therapeutic Listening provide the listener with unique and accurately controlled sensory information (Vital Links, n.d). Music is electronically adapted to highlight those parts of the sound spectrum that naturally capture attention and activate body movement, while the stimuli are synchronised with the environment. Therapeutic Listening uses electronic modifications, along with organised, rhythmical sound patterns inherent to music, to reportedly trigger the self-organising capacities of the nervous system.

Coplan (2010) reports on a study with a control group using AIT. There was no improvement in the participants and some showed poorer outcomes than before the intervention. There appears to be different opinions regarding the effectiveness of AIT. Bazyk, Cimino, Hayes, Goodman and Farrell (2010) found that index scores of participants showed an accelerated rate of development in fine-motor, visual-motor, nonverbal ability, and language skills. The 2002 ASHA Work Group on AIT concluded that AIT has not met the necessary scientific standards for efficacy. The practice of AIT is thus not justified in the position statement on Auditory Integration Therapy (ASHA, 2004).

No attention is given on auditory skill development and functional auditory performance in AIT. It is a method that trains an individual to listen to sound patterns, not speech. Areas such as auditory discrimination and localisation may be addressed in an indirect and asocial way, but these skills are not targeted as intervention goals.

All intervention approaches discussed thus far include audition to some extent, but it appears that the programmes assume that auditory performance of the child is intact and functioning similar to typically developing individuals. It appears that limited attention is paid to the difficulties preschool children with ASD may be encountered with functional auditory performance and auditory processing in current intervention programmes for children with ASD. The need for an intervention programme that directly targets functional auditory performance in children with ASD is apparent. In order to track auditory skill development in intervention, a monitoring instrument may be valuable.

2.3 The value of a monitoring instrument to track progress in children with ASD

It is known that children with ASD display inconsistent responses to stimuli which are often observed in assessment results (Coplan, 2010). Towgood, Meuwese, Gilbert, Turner and Burgess (2009) suggested possible reasons for the inconsistency of assessment results. Towgood *et al*. (2009) explain that an ASD diagnosis may include individuals with highly variable abilities and disabilities. ASD is composed of multiple subgroups, which in itself may have an impact on research results. The second explanation is that the diagnosis of ASD defines a specific group of individuals. The definition of the group is according to a distinct pattern of deficits and strengths, but the nature of the deficit may manifest in various ways. Social cues followed by typically developing individuals are often not understood by individuals with ASD, which can prompt different responses depending on the child's understanding. The third reason why inconsistent research results are obtained in studies with individuals with ASD may be the presence of sensory and other processing impairments. Sensory processing impairments may cause unpredictable behaviours in participants with ASD during tests aimed at measuring difficult tasks such as reasoning.

The authors therefore recommend the use multiple single-case series as research methodology when investigating children with ASD. Using single-case studies Towgood *et al*. (2009) could consider the relative levels of performance across different tasks within the same individual with ASD. In comparison to a control group the results clearly showed that a defining feature of the group with ASD was considerable variation in performance. In addition, the authors found considerable variation between participants with ASD, and also within individual participants. Towgood *et al*. (2009) found the pattern of marked variability of individual performance was not apparent when data were analysed for the group. Towgood *et al*. (2009) highlighted the importance of measuring the skill level of an individual with ASD with his/her own performance and not by comparing skills with the performance of other individuals with ASD.

The findings by Towgood *et al*. (2009) highlight the need for a monitoring instrument to track functional auditory performance in children with ASD. According to Pena, Iglesias, and Lidz (2001) dynamic plotting of skills also reduces test bias. The FÁPI (Stredler-Brown & Johnson, 2004) is an example of such a monitoring instrument and was identified as an appropriate instrument to test for reliability for use with children with ASD in the current study.

Chapter 3

Methodology

The purpose of the chapter is to provide a comprehensive description of the research methodology followed in the study in order to determine the reliability of the FÁPI as an appropriate monitoring instrument of auditory performance for preschool children with ASD. The aims and objectives of the study will be outlined as well as the research design, ethical considerations, participants, material and apparatus and all the procedures. The chapter provides further description and justification of selected research procedures than the method stated in the article (Chapter 4).

3.1 Aim and objectives

The main aim of the study was to determine whether the Functional Auditory Performance Indicators [FÁPI] (Stredler-Brown & Johnson, 2004) is an appropriate and reliable monitoring instrument of functional auditory skills in five-year-old children diagnosed with ASD.

The following objectives were formulated in order to achieve the main aim:

- To describe the overall functional auditory skills of five-year-old English Additional Language (EAL) children with ASD, using the FÁPI;
- To determine the test-retest or intra-rater reliability of the FÁPI;
- To determine the inter-rater reliability of the FÁPI when administered to the participants.

3.2 Research design

The study was exploratory in nature using a descriptive design (Leedy & Ormrod, 2005) with repeated measures. According to Bless and Higson-Smith (2004) exploratory research is conducted to gain a comprehensive understanding of a phenomenon. This study therefore attempted to gain a comprehensive understanding of the reliability of the FÁPI as used in children with ASD. The need for an exploratory study arises from a lack of basic information in a new area of interest (Bless & Higson-Smith, 2004).

The design allowed comparison of the same participants' performance, based on direct observation, across three similar administrations of the tool on each participant. The intention was not to trace development in the participants, but to determine the test-retest reliability or stability of the FÁPI as an appropriate intervention tool for monitoring progress of children with ASD, known for inconsistent behaviours. According to Bless and Higson-Smith (2004) it is possible to determine the test-retest reliability with repetition of the same measurement procedure on the same group of people. High test-retest reliability ought to produce similar results with each repetition (Bless & Higson-Smith, 2004).

A quantitative research approach was used as it is more appropriate to compare the performance on quantitative achievement scores and time-on-task behaviours, than that of qualitative accounts (Leedy & Ormrod, 2005). Bless and Higson-Smith (2004) describe quantitative research as methods which implement measurements to record and investigate aspects of social reality. The FÁPI allows the observer to score participant performance on each skill in a certain category by means of direct observation.

3.3 Ethical issues

The development and results of research require strict ethical choices and cautious thought on the part of the social researcher (Bless & Higson-Smith, 2004). For a researcher in the field of social sciences, ethical issues are described as complex and pervasive (Strydom, 2011).

Ethical clearance was granted by the Research Ethics Committee of the Faculty of Humanities (See Appendix A) at the University of Pretoria. Permission was granted by the principals of participating private schools to conduct the study on their premises and recruit participants from their classes (See Appendix A). The following research ethical principles were adhered to:

3.3.1 Confidentiality and anonymity

The participants' parents were informed that personal and other information revealed during the video recordings and observations would be kept strictly confidential (See Appendix B). The parents were informed that the data would be described anonymously in the dissertation and research article. The only parties who had access to the data were the researcher, the study leaders and the raters. Data are now securely stored at the Department of Speech-Language Pathology and Audiology at the University of Pretoria for the next 15 years.

3.3.2 Informed consent

Participation in this study was strictly voluntary and all parents of participants and the two independent raters gave informed consent (Bless & Higson-Smith, 2004). Informed consent refers to the disclosing of all information about the goal of the investigation, procedures that will be followed, possible disadvantages and dangers a participant might be exposed to (Strydom, 2011). The participants' parents and the raters received letters disclosing the following information: (See Appendix B)

- A description of the nature of the research study and aims
- A description of the procedures and duration of the data collection
- Contact details of the researcher and of the Department of Speech-Language Pathology and Audiology at the University of Pretoria. If any concerns or enquiries arose, the parents of the participants could contact the researcher.
- An allocated place was provided in the letter where the participants' parents and the raters signed and dated the letter, indicating informed consent to participate.

3.3.3 Protection from harm

The researcher was obligated to ensure that no physical harm, physical discomfort, psychological distress and loss of privacy could occur. The precaution is necessary since social research is intrusive and may create distress and embarrassment (Alderson & Morrow, 2011). The researcher attempted to avoid all possible risks by ensuring that the child participants were accompanied by a familiar person such as their teacher. The researcher is trained to provide intervention to children with ASD and to apply play-based procedures. Interaction with the participants was conducted on an informal level. Observable behaviours were elicited without pressurizing the child (Rossetti, 2001).

3.3.4 Honesty with professional colleagues

The research report and article is transparent, honest and complete, without deceiving others about the nature of the findings or by misrepresenting the procedures which were followed to obtain the data.

3.3.5 Non-discrimination

No discriminatory practices were applied through the course of the research. The children who participated in the study were treated equally and with respect *(*Strydom, 2011).

3.3.6 Competence and practices of the researcher

The researcher is registered as an independent speech therapist at the Health Professions Council of South Africa (HPCSA). The researcher has three years clinical experience assessing and treating young children with ASD.

3.4 Participants

Participants were purposely selected as they illustrated some features of interest which linked with the clear selection criteria for the study (Strydom, 2011).

3.4.1 School selection criteria

Since the aim of the study was to identify a reliable progress monitoring instrument in five-year-old children with ASD, preschools accepting children with ASD in Pretoria were approached for participant selection. As the education level of the participants' mothers and the language of learning and teaching (LoLT) in the school had to be consistent, it was more appropriate to approach private schools than government-funded schools for participant selection. Additionally the school had to have a separate therapy room equipped with a table and chairs where data could be collected.

3.4.2 Participant selection criteria

Child participant inclusion criteria were as follows:

- When preschools were approached for participant selection, it appeared that most children with ASD in the schools were approximately five years old. Therefore participants had to be 60 to 71 months of age. The density of children with ASD in the specific age group may relate to the typical late diagnosis of ASD in South Africa (Autism SA, n.d).

- Participants of any gender were included, as the study was not gender specific. It was expected that more boys will participate in the study as a result of a male gender bias in ASD (Centre for Disease Control and Prevention, 2012).
- Participants had to be formally diagnosed with ASD only, as co-morbid disorders and other neurodevelopmental disorders might present similarly or have an impact on the individual's functioning (APA, 2013)
- Normal hearing was part of the inclusion criteria as the study focussed on functional auditory performance which is influenced by hearing ability (Stredler-Brown, & Johnson, 2004).
- School attendance of longer than six months was a prerequisite to exclude adjustment variables.
- The maternal level of education had to be similar. A mother's education level is closely associated with her children's language proficiency (Pan, Rowe, Singer & Snow, 2005)
- Since the LoLT was English in the participating schools, and South African children are characterised by many different home languages, with minimum exposure to English, all participants had to be EAL learners.

The only exclusion criterion was that English first language speaking children were not included in the study.

Adult participant inclusion criteria were as follows: The two raters had to be qualified speech-language therapists, and registered with the HPCSA.

3.4.3 Participant selection procedures

The researcher contacted private pre-schools who are known for accommodating children diagnosed with ASD. After the principal agreed that the researcher may visit the school and signed a consent form which allowed access to the children and their information files, the researcher was able to identify possible participants. The identification and selection of the participants were based on the inclusion criteria where after the preliminary participants' parents provided consent. The participants were thus purposely selected according to the inclusion and exclusion criteria but the availability of the specific population played an important role.

Two speech-language therapists working in private practice in Pretoria were approached to participate in the research as raters of the video recordings.

3.4.4 Participant description

The final sample group of participants presented with the following characteristics:

Table 1: Participant characteristics (n=12)

Characteristic	Description
Age	Average: 65 months; Range: 60-71 months
Gender	Male: 10; Female: 2
Language of instruction	English
Home languages	Afrikaans: 5; Sepedi: 3; Setswana: 2; isiZulu: 2
Hearing test results	Air conduction thresholds between 0dB and 20dB
Duration of school attendance	Average: 14 months; Range: 7-22 months
Maternal education	All mothers had Bachelor's degrees

All participants were five-year-old EAL learners, with four different home languages commonly spoken in the city where the research was conducted. According to parental report, ten of the participants were non-verbal and communicated mainly by using gestures, with limited spontaneous verbal utterances. The participants had been in their schools long enough to have acquired some basic interactive communication skills in English. They all displayed normal hearing based on a formal tests conducted by private audiologists prior to the study. All had been formally diagnosed with ASD according to the DSM-IV (APA, 2000), as they were diagnosed before the DSM-5 was used in South Africa. The participants' mothers had a high education level.

The two independent raters included in the study were both qualified professionals. The one rater is qualified and registered at the HPCSA as a speech-language therapist and audiologist and the other is qualified as a speech-language therapist. Both the raters were working in the private practice setting. The dually qualified rater has 22 years of experience as a speech-language therapist and the other had two years of experience. Both raters have worked with children with autism. The raters are both English second language speakers.

3.5 Materials and Apparatus

3.5.1 Material

The FÁPI, a progress monitoring instrument of functional auditory performance, developed by Stredler-Brown and Johnson, was formally revised in 2001, 2003 and 2004. The FÁPI has been translated from English into Spanish, and is now mostly used in the USA (Stredler-Brown & Johnson, 2004). The instrument is currently mostly used in the Colorado Home Intervention Program (CHIP) for children with hearing impairment to compare their progress in intervention with themselves (Johnson & Stredler-Brown, personal communication, 7 April, 2016). In the personal email communication Dr Johnson mentioned that she is currently using the 2010 version, but has not yet been published. According to Dr Johnson (personal communication, 9 June, 2016) the difference between the 2004 and 2010 version is an expanded explanation of the categories, but the content remained the same.

The FÁPI describes functional auditory performance based on observation of a child's natural behaviour in the following seven hierarchical auditory developmental areas:

1. Awareness and meaning of sounds: The child is aware of a specific sound and can associate a variety of sounds with a specific sound source. This demonstrates that the sound is meaningful to the child. The stimuli presented to prompt a response in the present study included environmental sounds, such as a doorbell, music, vocalisations (non-true words), speech and discourse. Expected responses included looking up when the doorbell rings. The observer considered different aspects while observing responses included a response that is visually cued for example pointing to your ear to focus the participant's attention.

2. Auditory feedback and integration: The child adapts, notices and monitors his/her own vocalisations based on auditory input received. The behavioural responses expected when a child demonstrates this skill are to respond to the sound by vocalising in an attempt to monitor auditory feedback and imitate a spoken stimulus.

3. Localise sound sources: The child actively looks for the sound source as searching is a prerequisite for localising. For this category an expected response

included that the child was searching for the sound source and localising the specific source by looking at it or even vocalising in the direction of the sound source.

4. Auditory discrimination: The child differentiates between characteristics such as the intensity, pitch and duration of different sounds as well as different environmental sounds, non-words and true words. The child may discriminate between communicative intentions such as statements, questions and exclamations. Expected responses included production of sounds on the same pitch or with the same pitch variation when hearing the different sounds, following an instruction or responding to a question.

5. Auditory comprehension: The child demonstrates understanding of spoken language, may identify important ideas or critical elements of the message, and follow instructions. In this category the expected responses included identification of single words, common objects or pictures, following directions with increased progression in difficulty, and responding to complex abstract questions about a story.

6. Short-term auditory memory: The child perceives, remembers, restates and recalls a sequence of numbers. This skill is developmentally appropriate for neurotypical children at the age of two years and older (Stredler-Brown & Johnson, 2004). Numbers are used to isolate the skill as auditory memory only is being monitored.

7. Linguistic auditory processing: The child uses auditory information to make sense of language, such as understanding an instruction and executing it correctly, or making use of syntactic language in response to information received. The responses ranged from the correct identification of objects to short utterances such as “in the fridge” (Stredler-Brown & Johnson, 2004).

It is clear that the FÁPI is comprehensive, including items from basic sounds to complex language. A total of 33 auditory skills are plotted within the seven areas in the FÁPI. In order to obtain baseline data a four-point Likert scale is used to score the child’s level of attainment of auditory performance, from 1). ‘not present’ with a score value of 0, 2). ‘emerging’ with a score value of 1, 3). ‘in process’ to acquire with a score value of 2 and 4). ‘acquired’ with a score value of 3’, as indicated in Table 2.

Table 2: FÁPI scoring criteria (Stredler-Brown & Johnson, 2004)

Level of skill attainment	Criteria	Score value
a) The skill is not present	(NP) = 0-10% occurrence	0
b) The skill is emerging	(E) = 11-35% occurrence	1
c) The skill is in process	(P) = 36-79% occurrence	2
d) The skill is acquired	(A) = 80-100% occurrence	3

The tool is hierarchical in structure (Stredler-Brown & Johnson, 2004) organised from the least complex to the most complex with the integration of response to sound, speech and language. This FÁPI was developed for children with a hearing loss, to monitor how a child progresses through these specified developmental skills and to assist with planning for skill development (Stredler-Brown & Johnson, personal communication, 7 April, 2016). The tool may thus be used to plot and monitor progress of the development of functional auditory skills of young children within a comprehensive framework. According to the authors there is limited published literature available that demonstrates norm-referenced stages of functional auditory skill development. The PEACH (Parent's Evaluation of Aural/Oral Performance of Children) and TEACH (Teacher Evaluation of Aural/Oral Performance of Children) scales (Ching & Hill, 2007) are an exception (Brown, personal communication, 7 April, 2016). Norm-referenced data are available for these parent- and teacher completed scales.

The FÁPI appears to be applicable to use for children with ASD as it is based on functional auditory skills development of typically developing children and can be completed by means of direct observation of the child, while making very few demands to respond. Additionally, the instrument was deemed appropriate for the study as children with ASD present with different auditory preferences as their neurotypical peers (Kuhl *et al.*, 2005). The FÁPI was selected for the current study with participants with ASD as the scoring is conducted by means of observation, with limited social interaction required between the child and researcher. A number of studies indicated that direct interaction and participation with the children diagnosed with ASD resulted in incomplete data collection due to participants not willing to interact on a direct basis (Kuhl *et al.,* 2005; Paul *et al.,* 2007). It was thus necessary to consider the impact of challenges relating to social communication in children with ASD as well as the difficulty experienced by individuals with ASD to generalise specific skills during formal assessments (APA, 2013). According to the ASHA (2006) guidelines for assessment and treatment of children with ASD, the focus should be on holistic learning and functioning within a natural learning environment, which is consistent with the natural observational approach of functional auditory performance of the FÁPI. Natural learning environments support higher rates of interaction and generalization, and support progress in children with ASD (ASHA, 2006). The question was just whether the FÁPI is a reliable instrument to use with children with ASD, giving replicable results with every administration.

3.5.2 Apparatus

For the present study pre-recorded sound stimuli were used to ensure a standard presentation format for each child, and across three data collection sessions. A 20 minute recording was made inside an audiometric sound-proof booth and with the assistance of a qualified audiologist. Movement and interruptions during the recording were avoided. An Olympus digital voice recorder, VN-5500PC was used to record the stimuli. The prerecording ensured that the auditory input remained consistent for all data collection sessions. The same device was used for presenting the stimuli. The stimuli followed the hierarchy of items in the assessment tool starting with basic sounds such as noisemakers (rattles and whistles), contemporary and classical music, and environmental sounds such as a fire engine driving by (See Table 3).

Table 3: Content of the pre-recorded stimuli

Approximate recording time in minutes	Sound stimuli
0:30	Aeroplane noise
1:00-1:15	Music
1:30	Speech : “Hallo”, repeated every 3 to 5 seconds for 20 seconds
2:00	Noise maker: drum
2:30	Vocalisation of single vowels
3:30	Vocalisation of syllables. Initially single, progressing to multiple syllables
4:45	Vocalisation of non-true words
6:00	Production of single words
7:00	Production of sounds, syllables or words with varying intensity
800	Production of sounds, syllables or words with varying pace e.g. slow or fast
9:00	Production of sounds including continuous production vs abrupt production
10:00	Production of sounds with varying frequency e.g. high vs low
11:00	Production of meaningful environmental sounds e.g. fire engine noise

Approximate recording time in minutes	Sound stimuli
11:30	Varying intent of message: e.g. “sit down.” Vs “sit down!” Continuous communication e.g. asking a question, making a statement such as “look at the book”
13:30	Onomatopoeia: Presentation of animals sounds with 20 second intervals. Animals included cows and sheep. The sound of a train was also included.
15:30	Familiar commands: “stop!”, “look!” and “listen!”
16:30	Production of syllables example: ham/hammer
17:00	Vowel differences e.g. cat/cut; mad, mud
17:30	Consonant differences e.g. hen/pen
18:00	Story of the monkey and the banana
19:30	Barney’s theme song

The recording ended with speech prompts to elicit verbal responses from the child (the child could imitate sounds or react vocally) and a short story about a monkey collecting yellow bananas from the forest across the river. The speech sample was in South African English by a female EAL speaker and included typical supra-segmental characteristics (intensity, duration and pitch variations). The recorded voice named objects, gave directions and prompted the child to communicate, by asking questions such as “what is that? Where is the big book?” The intensity of the sound stimuli varied between 40-55dB which was regulated by means of the “Talk forward” function on an audiometer. The recording device was placed inside the booth, while the stimuli were produced. The sound could be heard inside the booth via the “Talk forward” function. The intensity of the “Talk forward” feature was adjusted to record intensity levels between 40-55dB. The settings on the voice recorder were kept constant for the initial recording and for data analyses.

Additional apparatus included the following:

- An electronic Tablet was used to show pictures and simple matching tasks to the child while the recording was played.
- Additional table top activities were: blowing bubbles, building blocks and puzzles and paging through developmentally appropriate books.
- A digital video camera (Canon, Legria HFR506) was used to record the child’s responses so that two raters could score the auditory performance at a later stage. Three sessions were recorded for each child.

3.6 Research procedures

3.6.1 Pilot study

A pilot study was conducted to determine whether relevant data could be obtained from the participants and the context (Strydom, 2011). The pilot allows a researcher to focus on specific areas that might not have been well-planned or to test certain conditions (Strydom, 2011). The pilot study offered the researcher the opportunity to manage interfering variables in the environment, thereby increasing the reliability of the data. Confounding variables that were controlled to remain consistent across repetition of the procedures and which promoted internal validity, included the following: room setup; intensity of the auditory stimuli presented; duration of the session; and the same facilitator was used to interact with the participant by looking at pictures on a tablet, building puzzles, blowing bubbles and interacting naturally during the activities, without verbal interaction. The room setup was organised in such a manner that the positioning of the furniture, camera and auditory playback device remained constant. The participant's chair in relation to the facilitator's chair also remained constant for all participants. The intensity of the auditory stimuli was easily controlled as stimuli were pre-recorded. Care was taken to place the playback device at the same distance from the participants.

The pilot study included three data-collection sessions at the school in the pilot participant's familiar therapy room over a two-week period. The pre-recorded stimuli, placement of the table and two chairs and table-top activities to keep the participant busy, were tested. Changes to improve the sound presentation and the quality of the voice recording were made after the pilot study. The reason for this being that the stimuli appeared to be soft in relation to the environmental noise, decreasing the signal-to-noise ratio. The intensity of the recording was changed to the average intensity of speech production (40-75dB) and the playback device was placed at a higher level than before, but still within one metre from the participant. The changes made were to prevent the participants from reaching for the device, thus changing the distance and intensity of the sound that the participant hears, and to ensure that the input received was as close as possible to the natural sound environment.

3.6.2 Data collection for the main study

Data were collected during observation of the participants' auditory functioning by means of the FÁPI. Before the formal recording and sound stimuli presentation, the researcher spent time with the participant in his/her classroom, where after the child willingly accompanied the researcher to a familiar therapy room, where data collection took place. The camera was already positioned on a table two metres away from the participant, with the participant's chair facing the camera. The playback device was placed behind the participant, one meter away, but elevated to prevent the participants from reaching for the device. The researcher explained to participants that they were going to hear different sounds and a lady talking while playing with the researcher. After about five minutes in the data collection room the sound playback and video recording commenced. The researcher did not draw attention to the camera, but if a participant enquired about it, the researcher responded that they were going to make a movie. The researcher interacted quietly with the child by paging through a book, blowing bubbles, building puzzles and playing with the electronic tablet to mimic the natural environment in the school, while the pre-recorded stimuli were played-back. The activities prevented the child from leaving the room.

To collect data for test-retest reliability, each participant's data were collected over a two-week period, with a time lapse of three days or more between the three recordings. The time lapse decreased the familiarity with the recorded stimuli, thereby preventing a practice effect. In order to prevent interference with the pre-recorded stimuli, no verbal interaction took place between the researcher and participant during playback of the recorded stimuli.

3.6.3 Video analysis

The data of the main study were scored by two independent raters after they had received training on how to score the FÁPI. The pilot study video recordings were used to train the raters. The raters scored the pilot participant's performance with the assistance of the researcher. The researcher facilitated the scoring by identifying and analysing certain aspects of the child's performance. The initial scoring session was interactive in nature, where the raters asked questions and queried certain scores. With the remainder of the pilot video recordings, the raters were requested to score the recordings on their own.

The two independent raters contributed to data triangulation. According to Delport and Fouché (2011) triangulation allows the researcher to be confident of the results. Utilising two raters added alternative perspectives and objectivity which may have reduced the limitations of the study (Delport & Fouché, 2011). The raters had to view the complete video recordings several times before rating the participants' auditory responses. The video recordings were provided to them on a DVD. The recordings were arranged in random order so that raters could not predict the performance of a particular participant in subsequent ratings (Leedy & Ormrod, 2005). To further enhance the reliability of the scoring, the raters were blinded to the scores of the previous sessions of the same child by the use of the freeze frame function of Excel. This function ensures that a rater cannot keep track of the actual chronological sequence of each participant's scores.

The data were processed by using the FÁPI's weighted scoring methods so that each child obtained a total score for each category as set out in Table 4. Percentages of participant responses were calculated for each category.

Table 4: Total scores for each category of the FÁPI

Sub categories and indicators (test items)	Total score
1.Awareness and meaning of sound • Responds to loud environmental sounds or noisemakers • Responds to music • Responds to speech • Associates loud environmental sounds or noisemakers with their source • Associates vocalizations with speaker • Associates discourse with speaker	144

2.Auditory feedback and integration
• Changes vocalizations
• Notices own vocal productions
• Monitors status of amplification by making noises or vocalizing
• Takes vocal/spoken turns
• Imitates spoken stimulus, e.g.
  • vowels
  • number syllables
  • non-true words
  • words
	132

Sub categories and indicators (test items)	Total score
3. Localizing sound source • Searches for loud environmental sounds or noisemakers • Searches for source of music • Searches for source of vocalizations • Searches for source of discourse • Localizes source of loud environmental sounds or noisemakers • Localizes source of music source • Localizes source of speaker making vocalizations • Localizes source of speaker using discourse	240

4. Auditory discrimination
• Discriminates non-linguistic information:
    • Loud versus soft sounds
    • Fast versus slow
    • Continuous versus abrupt
    • High versus low pitch
    • Meaningful environmental sounds
    • Intent of utterance based on supra-segmental features
    • Mom's versus dad's voice
    • Discriminates oral utterances – non-true word productions
• Discriminates oral utterances – non-true word productions:
    • Vowels
    • Number of syllables
• Discriminates oral utterances- true word productions:
    • Onomatopoeic sounds
    • Child's own name
    • Familiar commands
    • Number of syllables of words in utterances
    • Familiar words based on vowel differences
    • Familiar words based on consonant differences
    • Familiar words based on syllable differences
	306

5. Auditory comprehension
• Identifies single words:
    • Points to body parts when named
    • Points to common objects or pictures when named
• Identifies critical elements in short phrases:
    • Identifies picture or object with one critical element
    • Identifies picture or object with two critical elements
• Follows directions:
    • Follows simple one-step directions
    • Follows two-step directions
    • Follows three-step directions
• Identifies critical elements in short stories:
    • Responds to simple concrete questions about story
    • Responds to complex abstract questions about story
	162

6. Short-term auditory memory
• Memory: Recalls digits that are heard as demonstrated by a response within moments of the stimulus
    • 1-2 digits
    • 3-4 digits
    • 5-6 digits
	54

7. Linguistic auditory processing • Linguistic auditory processing: higher level auditory skills demonstrating the child's ability to process linguistic information • Sequencing • Closure	234

- Syntactic and morphological analysis
- Suprasegmental analysis using auditory feedback
- Application of auditory information

Each rater captured the scores directly onto an Excel spread sheet. The duration of the analyses depended on the rater. Uninterrupted viewing of a single recording took approximately 20 minutes. Analysis and scoring of a single recording took a further 30-35 minutes. Each rater analysed a total of 36 recordings.

3.6.4 Data analysis

The FÁPI allowed the raters to score a participant's performance on each skill (item) in a sub category by means of video recordings. As already indicated, the FÁPI uses a four-point Likert scale to rate skills as not present, emerging, in process or acquired. The level of performance was scored by using the criteria presented in Table 2 (Stredler-Brown & Johnson, 2004).

The score for each skill was computed in the scoring column by multiplying each skill with the relevant factor provided on the instrument. The score for each category was thus computed by adding the weighted score of all the skills in the specific category. The scores were calculated and transferred to the profile page. The scored profile provided information regarding the strengths and deficits of the participant's auditory performance. A percentage score for each of the seven categories was obtained.

Data were analysed using Statistica version 12 to describe the overall performance of the participants for their auditory functioning, and to determine the test-retest reliability (which is the inclusive term for intra-rater reliability) and the inter-rater reliability. The test-retest reliability, in this case the intra-rater reliability, measured the degree of agreement when multiple repetitions of a test are performed (Banach, 2012). Nonparametric statistics were used due to the small sample size of the study, the uneven distribution of the data and the unpredictability and possible inconsistency of the participants' behaviour. Average scores for each category were determined. The Friedman Two-way Analysis, which is the nonparametric equivalent of the parametric repeated measures ANOVA, was conducted to determine the test-retest reliability. Inter-rater reliability was determined with the Wilcoxon Matched

Pairs Test, which is the nonparametric equivalent of the parametric matched t-test (Whitely & Ball, 2002).

3.7 Reliability and validity

3.7.1 Reliability

Reliability is concerned with the consistency of a specific measure (Bless & Higson-Smith, 2004). Low reliability is observed when an instrument is conducted with repeated measures, but the scores vary with each repetition. An instrument is described as being reliable when it consistently scores unchanging values with repeated measures (Bless & Higson-Smith, 2004).

Bless and Higson-Smith (2004) describe the test-retest reliability of an instrument as the application of the same measurement procedure to the same group of people on two or more occasions. In the current study the second aim was to determine whether the FÁPI presented with high test-retest reliability, which would imply that very similar results were obtained at each scoring of the instrument.

Reactivity is one of the potential problems that should be considered when using the test-retest reliability method (Bless & Higson-Smith, 2004). This phenomenon occurs with multiple exposures to the same stimuli. The participants may find the first time interesting, but with the second or third presentation they may get bored or agitated. Reactivity or the practice effect may lead to a discrepancy between the repeated measures which are not due to the instrument's lack of reliability. For the current study the stimuli remained consistent, as well as the order of the table top activities. The same activities were used each time, but the order in which they were executed varied.

According to Bless and Higson-Smith (2004) reliability in general refers to the extent to which independent administration of the same instrument consistently yields the same results under comparable conditions. Thus, the study aimed to achieve high inter-rater reliability. The independent raters' scores were thus compared with each participant's over the three recordings.

3.7.2 Validity

A valid measuring instrument has been described as executing what it is intended to do, as measuring the intended measure, and as providing scores whose difference reflect the true differences of the variable being measured, and not random or constant mistakes (Bless & Higson-Smith, 2004).

The FÁPI has been revised twice and was translated into Spanish in 2011 by Ferreira, Moret, Bevilacqua and Jacob. The instrument is now mostly used in the Colorado Home Intervention Program (CHIP) in the US for children with hearing loss to compare progress in intervention with themselves (Johnson & Stredler-Brown, personal communication, April 7, 2016). The FÁPI is recommended as a clinical monitoring tool in the 2nd edition of the Educational Audiology Handbook (Johnson & Seaton, 2012). This tool is designed for use with children with hearing loss from infancy to school age, and therefore applicable to the present study population. The use of the FÁPI with children with ASD has been discussed with the second author of the tool, Dr DeConde Johnson (email correspondence, May 2014). According to Johnson the FÁPI has primarily been designed to track an individual's progress while developing functional auditory skills. According to Johnson, Yoshinaga-Itano (associated with the University of Colorado, Boulder), was collecting data on the FÁPI at the time of correspondence, and found that the tool differentiated certain functional auditory skills better than other available tools.

The following steps were taken during the collection and analyses of the data to improve the validity and reliability of the research study:

- A pilot study was performed to test the measurement instrument, procedures, and the participants with ASD's behavioural responses to the new situation, and the recording of auditory stimuli.
- A natural environment was used at the school, where no attempt was made to manipulate the background environmental noise. A natural data collection environment is a requirement for the administration of the FÁPI.
- Pre-recorded auditory stimuli were used to ensure that the intensity of the auditory input (different noise makers and a voice) remained constant across all the sessions.
- The duration of the recordings was consistent.

- The data collection sessions were conducted in the morning to avoid fatigue in the participants.
- The recordings were analysed by two independent raters. To avoid bias, the researcher did not rate the participants' responses.
- The participant group was as homogenous as possible regarding age, language of learning and instruction, maternal education, diagnosis and normal hearing.

Chapter 4

Article: Reliability of the Functional Auditory Performance Indicators to monitor progress in 5-year-old children with autism spectrum disorder

The article was submitted to the South African Journal of Childhood Education for review and accepted for publication. The formatting of the article differs from that of the dissertation, as it was prepared according to the journal's specifications.

Abstract

Background: There is a need to monitor progress of functional auditory performance in young children with Autism Spectrum Disorder (ASD). The Functional Auditory Performance Indicators (FÁPI) is a monitoring tool for children with hearing loss, but has not yet been described in children with ASD.

Method: The aim was to describe the overall performance of five-year-old children with ASD on the FÁPI; to determine the test-retest reliability and inter-rater reliability of the tool. The study was exploratory with a descriptive design incorporating repeated measures. Twelve participants with ASD were purposely selected. Ten of the 12 participants were non-verbal. They were 60-71 months old and all were English additional language learners. Pre-recorded sound and speech stimuli were used to elicit responses from participants in their familiar therapy rooms. For test-retest reliability three data collection sessions per participant were conducted over a two-week period. Video recordings were analysed by two independent raters, who were blind to the order of data sets.

***Results and conclusion*:** With an increase in complexity of auditory stimuli on the FÁPI a marked decrease in participant responses was observed. The test-retest reliability was good, with a single difference in ratings in one category. Inter-rater reliability indicated a significant difference in two of the seven categories. These categories may be the most subjective in the tool. Despite subjectivity the FÁPI was reliable to plot functional auditory difficulties in the sample group. Since the instrument relies on direct observation with limited demands to participate, it has potential for use in children with ASD. Thorough training of raters is required. Further research is required to determine the tool's performance using natural sound conditions to monitor children's progress against themselves during intervention.

Keywords

Auditory skills, Autism Spectrum Disorder (ASD), Functional Auditory Performance Indicators (FÁPI), Inter-rater Reliability, Monitor progress, Test-retest Reliability.

Introduction

The autism spectrum disorder (ASD) diagnostic criteria now divide the typical characteristics of the condition into two psychopathological domains (American Psychiatric Association [APA], 2013). The first domain includes deficits in social communication and social interaction across contexts, as well as deficits in nonverbal communicative behaviours. The second domain includes stereotyped motor movements, speech or use of objects, insistence on sameness and highly restricted, fixated interests in focus and hyper- or hypo-reactivity to sensory input or activities. The description of variable reactivity to sensory input and activities, which includes 'Adverse response to specific sounds' (APA, 2013), places a new emphasis on an area of impairment in ASD that might have been underreported in the past. The auditory processing difficulties in this population are described as unique because of heterogeneous patterns observed in response to sound and speech (Carpenter, Estrem, Crowell & Edrisinha, 2014; Kargas & Lo, 2015). Siegal and Blades (2003) state that difficulties with auditory processing in children with ASD may limit their participation in conversations, which may contribute to social isolation. In addition Paul, Chawarska, Fowler, Cicchetti and Volkmar (2007) found that children with ASD show reduced responses to child-directed speech in comparison to neurotypical peers and that time spent listening to child-directed speech were related to the participants' current and later receptive language development. In pursuit of evidence-based practice, it is therefore important that speech-language therapists participate in research relating to the auditory behaviour of children with ASD and remain informed about the heterogeneous group of individuals (American Speech-Language-Hearing Association [ASHA], 2007).

A number of studies regarding auditory performance in individuals with ASD have been conducted (Alcantara, Weisblatt, Moore & Bolton, 2004; Azouz, Kozou, Khalil, Abdou & Sakr, 2014; Ferguson & Moore, 2014). Most studies were conducted in the field of neurophysiology and were executed in controlled environments. The concept of unique listening skills, behaviours and difficulties in the population of children with ASD is supported by studies using neuroimaging and other experimental techniques (Kuhl, Coffey-Corina, Padden & Dawson, 2005; Haesen, Boets & Wagemans, 2011; Ceponiene *et al.,* 2003; Bruneau, Bonnet-Brilhault, Gomot, Adrien & Barthelemy, 2003). Using mismatch negativity and event-related potentials, Kuhl *et al.* (2005) found that neurotypical children and those diagnosed with ASD presented with different neural and behavioural reactions to speech. The majority of participants with ASD in this study preferred non-speech analogue signals, characterised by continuous non-speech electronic input. Based on their listening preferences, the participants were divided into two groups. Participants who presented with a preference for speech also presented with less severe symptoms of ASD and were thus considered high functioning. Those who did not attend to speech were participants with severe ASD. The findings not only support the notion that autism represents a spectrum of impairments and cannot be described as a homogenous category, but also reflect the children's difficulty with listening and attending to complex sound, i.e. speech. Other characteristics of peculiar responses to sound in children with ASD include inconsistent response to their name, sound aversion, decreased awareness or recognition of a caregiver's voice, neglect to pay attention to speech yet presenting with an awareness of environmental sounds, and a lack of interest or response to neutral statements (Johnson & Myers, 2007).

There appears to be different interpretations of the atypical responses of children with ASD to speech. Paul *et al.* (2007) ascribe the problems that children with ASD experience with understanding sounds, especially speech directed at them, to pervasive difficulties in regulating responses, problems with paying attention to a range of stimuli and lack of motivation to participate in social interaction, rather than to auditory processing difficulties. It becomes increasingly evident that neurophysiological studies ascribe atypical listening behaviour in children with ASD to auditory processing difficulties (Carpenter *et al.*, 2014; Kuhl *et al.,* 2005). However, neurophysiological tests are not accessible to practising speech-language therapists to understand and monitor the auditory skills of their young clients with ASD. Evidence of the auditory processing deficits in this population is therefore mostly based on neurophysiological studies, but limited research relating to the behavioural response to speech and sound in clinical contexts is available. The identification of a reliable clinical monitoring tool may thus assist in describing and understanding the functional auditory skills of children with ASD in a natural environment, allowing speech-language therapists to plan intervention and monitor progress.

The field of audiology offers investigative tools for children with hearing loss and their auditory skills (Johnson & Seaton, 2012; Zhang, Barry, Moore & Amitay, 2012). A limited number of clinical tools are available to describe the functional auditory skills and performance of children with hearing loss, but most are not applicable to preschool children. The Functional Auditory Performance Indicators (FÁPI), developed by Stredler-Brown and Johnson (2004) is an integrated approach to plot and monitor the auditory skill development of children with hearing loss. The FÁPI (Stredler-Brown & Johnson, 2004) is used to assist teachers, therapists and parents to create a comprehensive profile of the child's auditory skills and performance in a hierarchical order, based on a scale of skill development. The FÁPI is scored by means of direct observation of the child's behaviour in a familiar environment without controlling background sound or placing many demands on the child to perform. Since the FÁPI was designed for use with children with a hearing loss, it is not known how consistently children with ASD with normal hearing, but with inconsistent listening behaviour and auditory skill deficits, will perform on the monitoring tool over consecutive data collection sessions.

Method

Aims and Design

The main aim of the study was to determine whether the FÁPI is an appropriate and reliable monitoring tool to describe the auditory performance of young children with ASD, regardless of the heterogeneity of the participants or their level of interaction. The aim was not to describe the instrument's intervention monitoring properties, but to determine reliability for use with children with ASD. The objectives were to describe the overall performance of five-year-old children with ASD on the instrument and to determine the test-retest reliability and the inter-rater reliability of the FÁPI. The study was exploratory in nature as a relatively new and emerging subject was investigated (Fouché & De Vos, 2011). The method was observational, using repeated measures (Leedy & Ormrod, 2005). The design allowed comparison of the same participants' performance, based on direct observation, over three sessions. The intention was not to trace or monitor development, but to determine the test-retest reliability of the FÁPI as a tool for children with ASD.

Participants

The principals of three participating private preschools for learners with special needs gave permission to use their facilities for data collection. Parents of all participants gave informed consent. Participants were purposely selected according to the following inclusion criteria: Five-year-old children, any gender, formally diagnosed with ASD, with normal hearing, school attendance of longer than six months to exclude adjustment variables, and with mothers who had a homogeneous education level. Since the language of learning and teaching was English in the participating schools and South African children are characterised by many different home languages, all participants had to be English Additional Language (EAL) learners. Participant characteristics are described in Table 1.

Table 1: Participant characteristics (n=12)

Characteristic	Description
Age	Average: 65 months; Range: 60 months-71 months
Gender	Male: 10; Female: 2
Language of instruction	English
Home languages	Afrikaans: 5; Sepedi: 3; Setswana: 2; isiZulu: 2

Hearing	Air conduction thresholds between 0dB and 20dB
Duration of school attendance	Average: 14 months; Range: 7 months-22 months
Maternal education	All mothers had bachelor's degrees

According to Table 1 all the participants were five-year-old EAL learners, with four different home languages, all commonly spoken in the city where the research was conducted. According to parental report, ten of the participants were non-verbal and communicated only by using gestures. The participants had been in their schools long enough to have acquired some basic interactive communication skills in English. They all displayed normal hearing based on a formal screening test. All had been formally diagnosed with ASD according to the DSM-IV (APA, 2000), as they were diagnosed before the DSM-5 was used in South Africa. The participants' mothers had a high education level.

Two speech-language therapists working in private practice in Pretoria were approached to participate in the research as raters of the video recordings. The two raters were qualified speech-language therapists with respectively 22 years (Rater 1) and two years of clinical experience (Rater 2).

Material and apparatus

The FÁPI, a progress monitoring tool of functional auditory skills, developed by Stredler-Brown and Johnson, was formally revised in 2001, 2003 and 2004, translated into Spanish (Ferreira, Moret, Bevilacqua & Jacob, 2011). The instrument is now mostly used in the Colorado Home Intervention Program (CHIP) in the US for children with hearing impairment to compare their progress in intervention with themselves (Johnson and Stredler-Brown, personal communication, 7 April, 2016). The tool describes auditory performance based on observation of a child's behaviour in seven auditory developmental areas: 1. Awareness and meaning of sounds: the child is aware of a specific sound and can associate a variety of sounds with a specific sound source. Stimuli that the child should respond to include: environmental sounds, music, vocalisations and discourse. 2. Auditory feedback and integration: the child reacts and adapts his/her own vocalisations based on auditory input received, such as responding to sounds with the production of own vocalisations. 3. Localise sound sources: the child actively looks for the sound source. 4. Auditory discrimination: the child distinguishes between characteristics such as intensity, pitch and duration of different sounds, vocally producing sounds in reaction on the same pitch or with the same variation in pitch. 5. Auditory comprehension: the child understands spoken language and can identify important ideas of the message. 6. Short-term auditory memory: the child perceives, remembers, restates and recalls a sequence of numbers and 7. Linguistic auditory processing: the child uses auditory information to process language, such as understanding an instruction and executing it correctly, or making use of syntactic language in response to the information received. A total of 33 skills are described within the seven areas. As the aim of the FÁPI is to monitor a child's progress with him- or herself over time, no norms are used to interpret the data. A four-point Likert scale is used to score the child's level of attainment of auditory performance, from 1. 'not present' with a score value of 0, 2. 'emerging' with a score value of 1, 3. 'in process' with a score value of 2 to 4. 'acquired' with a score value of 3, as indicated in Table 2.

Table 2: FÁPI scoring criteria (Stredler-Brown & Johnson, 2004)

Level of skill attainment	Criteria	Score value
a) The skill is not present	(NP) = 0-10% occurrence	0
b) The skill is emerging	(E) = 11-35% occurrence	1
c) The skill is in process	(P) = 36-79% occurrence	2
d) The skill is acquired	(A) = 80-100% occurrence	3

For the present study pre-recorded sound stimuli were used to ensure a standard presentation format for each child, and across three data-collection sessions. A 20 minute recording was made inside an audiometric sound-proof booth. An Olympus digital voice recorder, VN-5500PC was used to record the stimuli. The stimuli followed the hierarchy of the monitoring tool, starting with basic sounds such as noisemakers (rattles and whistles), contemporary and classical music, environmental sounds, such as a fire engine driving by and ending with speech prompts to elicit verbal responses from the child, such as imitation of sounds perceived or vocal reactions and a short story about a monkey collecting yellow bananas from the forest across the river. The speech sample was in South African English by a female EAL speaker and included typical supra-segmental characteristics (intensity, duration and pitch variations). The recorded voice named objects, gave directions and prompted the child to communicate. The intensity of the sound stimuli varied between 40-55dB which was regulated by means of the "Talk forward" function of the audiometer. Material to keep the child busy but not overly engaged while the pre-recorded stimuli were presented, included age-appropriate books, bubbles, puzzles and an electronic tablet. All sessions were recorded with a Canon video camera.

Procedures

Ethical clearance was granted by the university's Research Ethics Committee. A pilot study offered the opportunity to test the positioning of the camera and the placement of a playback device. Three data-collection sessions with a pilot participant were conducted at school in a familiar therapy room over a two week period. The pre-recorded stimuli, placement of the table and two chairs and table-top activities to keep the child busy were tested. Changes to improve the sound presentation and the quality of the video recording were made after the pilot study. The intensity of the playback was changed to the average intensity of speech production (40-75dB) and the playback device was placed at a higher level, but within one meter from the participant.

For the main study, data collection took place at the participants' preschools. Prior to the formal recording and sound stimuli presentation, the researcher spent time with the participant in his/her classroom, where after the child willingly accompanied the researcher to a familiar therapy-room, where data collection took place. The camera was already positioned on a table two metres away from the participant, with the participant's chair facing the camera. The playback device was placed behind the participant, one meter away, but elevated to prevent the participants from reaching for the apparatus. The researcher explained to a participant that he/she is going to hear different sounds and a lady talking while playing with the researcher. After five minutes in the data collection room the sound playback and video recording commenced. The researcher did not draw attention to the camera, but if a participant enquired about it, the researcher responded that they were going to make a movie. The researcher interacted quietly with the child by paging through a book, building puzzles and playing with an electronic tablet to mimic the natural environment in the school, while the pre-recorded stimuli were played-back.

Each participant was recorded three times within a two-week period. The dependent variable in this study was the functional auditory performance of the participant. The independent variables, which were kept consistent throughout the recordings, included the positioning of the furniture, video camera and the playback device, intensity of the pre-recorded stimuli, the duration of a session, the same facilitator and table-top activities. The only variable that could not be controlled was environmental noise. Occasionally a child shouted outside or an ambulance siren could be heard, but it was found that the participants did not react to the sounds from the external environment.

Each participant's data were collected over a two-week period, with a time lapse of three days or more between recordings. The time lapse decreased the familiarity with the recorded stimuli, prohibiting the practice effect. In order to prevent interference with the pre-recorded stimuli, no verbal interaction took place between the researcher and participant during playback of the recorded stimuli.

Data analysis

The data of the main study were scored by two independent raters after they had received training on how to score the FÁPI (Stredler-Brown & Johnson, 2004). Data obtained from the pilot study were used to train the raters. The raters had to watch the complete video recordings several times before rating the participants' auditory responses. The video recordings were provided on DVD. The recordings were arranged in random order so that raters could not predict the performance of a particular participant in subsequent ratings (Bless & Higson-Smith, 2004; Leedy & Ormrod, 2005). To enhance the reliability of the scoring further, the raters were blinded to the scores of the previous sessions by the use of the freeze frame function of Excel. This function ensures that a rater cannot keep track of the actual chronological sequence of each participant's scores.

Each rater captured the scores directly onto an Excel spread sheet. The duration of the analyses depended on the rater. Uninterrupted viewing of a single recording took approximately 20 minutes. Analysis and scoring of a single recording took a further 30-35 minutes. Each rater analysed a total of 36 recordings.

Data were analysed using Statistica version 12 to describe the overall performance of the participants for their auditory functioning, and to determine the test-retest reliability and the inter-rater reliability. The test-retest reliability, in this case the intra-rater reliability, measured the degree of agreement when multiple repetitions of a tool are performed (Banach, 2012). Nonparametric statistics were used owing to the small sample size of the study, the distribution of the data and the unpredictability and inconsistency of the participants' behaviour. Average scores for each category were determined. The Friedman Two-way Analysis, which is the nonparametric equivalent of the parametric repeated measures ANOVA, was conducted to determine the test-retest reliability (Leedy & Ormrod 2005). The Wilcoxon signed-rank test was used to compare the scores obtained from the raters to determine the inter-rater reliability. The Kendall Coefficient of concordance was used to determine the test-retest reliability of the raters performance.

Results

Overall performance of the participants on the seven categories of the FÁPI

Averages of the three recordings of each participant were calculated to obtain the mean group scores on the seven categories of the FÁPI. The results are presented in Figure 1.

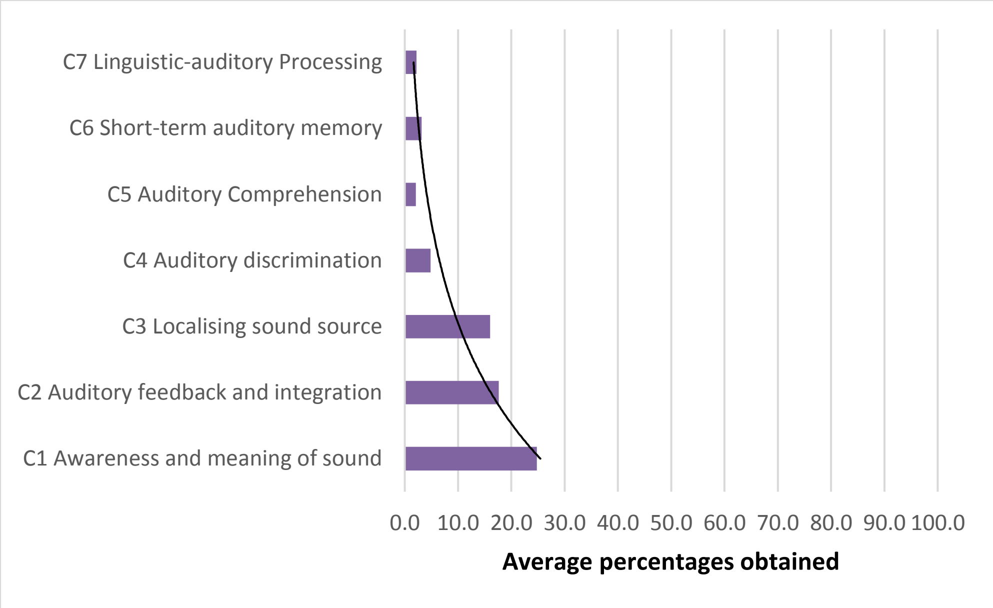


Figure 1: Average FÁPI scores per category (n=12)

According to Figure 1 the results indicate that participants showed a decrease in responses to the pre-recorded auditory stimuli with an increase in the complexity of the stimuli. The participants showed limited awareness of the sound (24.8% for Category 1), but even poorer responses for discrimination, comprehension, memory and linguistic-auditory processing were noted. A sharp decline in reaction and participation was clearly noted from Category 4 onwards. An average of only 2,2% responses was observed in Category 7.

Category 1 represents the ability to identify the presence of sound and matching the sound to its source in order to attach meaning to it. Typical responses of the participants were looking up or stopping an activity and in some cases, pausing momentarily without looking up. Typical responses to Category 2 (auditory feedback and integration) were imitating the sounds. In some cases participants covered their ears in reaction to the sound; some were startled with the initial presentation of the sound. Another response included imitation of the sounds more loudly than those of the recording, possibly in an attempt to block out the incoming stimuli. The average score decreased from 24,8% for Category 1 to only 17,6% for Category 2. With localisation of the sound source (Category 3) the participants turned their heads or looked in the general direction of the sound source 16% of the time. Very few responses were observed for Categories 4 to 7, which include language, and discriminating between sounds, words and instruction. Discrimination of sounds was observed when a participant imitated minimally paired words such as cat – hat. Observable comprehension of a word or utterance occurred only 2,1% of the time, such as when a participant identified a correct object. With short-term auditory memory (Category 6) a slight increase was observed with an average of 3,2%. Being a monitoring tool, the FÁPI compares the scores obtained by an individual over time and does not rely on standard norms. It is, however, clear that the group of participants showed limited and unusual responses to the sound stimuli and that an obvious pattern of decline could be observed when stimuli became complex. The poorest responses were recorded for understanding of continuous speech, i.e. Category 5 and 7.

Test-retest (intra-rater) reliability of the FÁPI

To determine the test-retest or intra-rater reliability each rater's three scores for the same participant were compared. The repeated measures for each of the seven categories of the FÁPI for Rater 1 and 2 are indicated in Table 3 and 4.

Table 3: Intra-rater reliability; Rater 1

	Score	Mean	Median	Standard deviation	Skewness	ANOVA p-value	Kendall Coefficient of concordance
Category 1	1	46,18	46,18	23,07	-0,67	0,00365*	0,46780
	2	24,36	25,00	20,27	0,48		
	3	27,03	29,17	20,49	0.17		
Category 2	1	28,60	21,60	20,73	0,93	0,39315	0,09946
	2	20,27	13,64	20,79	2,34		
	3	24,50	13,64	25,34	1,30		
Category 3	1	24,50	13,66	24,02	0,28	0,62709	0,03889
	2	15,24	7,18	19,16	0,99		
	3	13,73	10,19	13,72	1,09		

	Score	Mean	Median	Standard deviation	Skewness	ANOVA p-value	Kendall Coefficient of concordance
Category 4	1	6,13	2,94	7,57	1,18	0,40130	0,07609
	2	6,23	0,00	13,05	2,17		
	3	6,70	0,00	14,04	2,34		
Category 5	1	4,43	0,00	6,85	1,21	0,17378	0,14583
	2	1,55	0,00	4,62	3,32		
	3	1,60	0,00	4,63	3,24		
Category 6	1	1,85	0,00	6,42	3,46	0.49659	0,05833
	2	3,24	0,00	7,66	2,441		
	3	1,70	0,00	5,88	3,46		
Category 7	1	2,81	0,00	6,15	2,57	0,36788	0,08333
	2	3,38	0,00	7,54	2,25		
	3	2,96	0,00	7,00	2,18		

*** Statistically significant difference p≤0,05**

Table 4: Intra-rater reliability; Rater 2

	Score	Mean	Median	Standard deviation	Skewness	ANOVA p-value	Kendall Coefficient of concordance
Category 1	1	20,43	18,40	19,32	0,80	0,33591	0,09091
	2	16,55	15,28	11,78	0,20		
	3	14,30	6,25	16,30	1,02		
Category 2	1	7,45	1,89	10,47	1,44	0,79787	0,1882
	2	11,87	3,03	22,52	2,78		
	3	13,01	0,38	22,07	1,79		
Category 3	1	16,82	13,66	16,45	0,58	0,97468	0,00214
	2	13,15	12,50	13,37	1,19		
	3	12,65	9,72	10,55	1,83		
Category 4	1	3,60	0,49	6,12	1,55	0,43171	0,0700
	2	3,57	0,00	7,23	2,50		
	3	2,72	0,00	4,24	1,14		

	Score	Mean	Median	Standard deviation	Skewness	ANOVA p-value	Kendall Coefficient of concordance
Category 5	1	1,55	0,00	4,98	3,43	0,92596	0,00641
	2	1,76	0,00	4,60	3,20		
	3	1,60	0,00	4,63	3,25		
Category 6	1	2,78	0,00	9,62	3,46	0,52579	0,05357
	2	4,94	0,00	9,12	1,47		
	3	4,48	0,00	10,81	2,34		
Category 7	1	0,78	0,00	1,87	2,23	0,09902	0,19271
	2	2,03	0,00	4,23	3,03		
	3	1,25	0,00	4,32	3,46		

According to Table 3 and Table 4 the only category that presented with a significant difference in scoring was Category 1 scored by Rater 1. The statistically significant differences in the ratings of Rater 1 with a median of 46,18% for rating 1 and medians of 24, 36% and 27,02% for ratings 2 and 3. The median score allocated for recording 1 showed an outlier. The differences between the three ratings were statistically significant with a p-value <0.05 at 0,003. Table 4 indicates that the consistency of Rater 2's scoring of Category 7 is within the 10% level of significance, therefore marginally inconsistent. The results of Rater 1 Category 1 are also depicted in Figure 2.

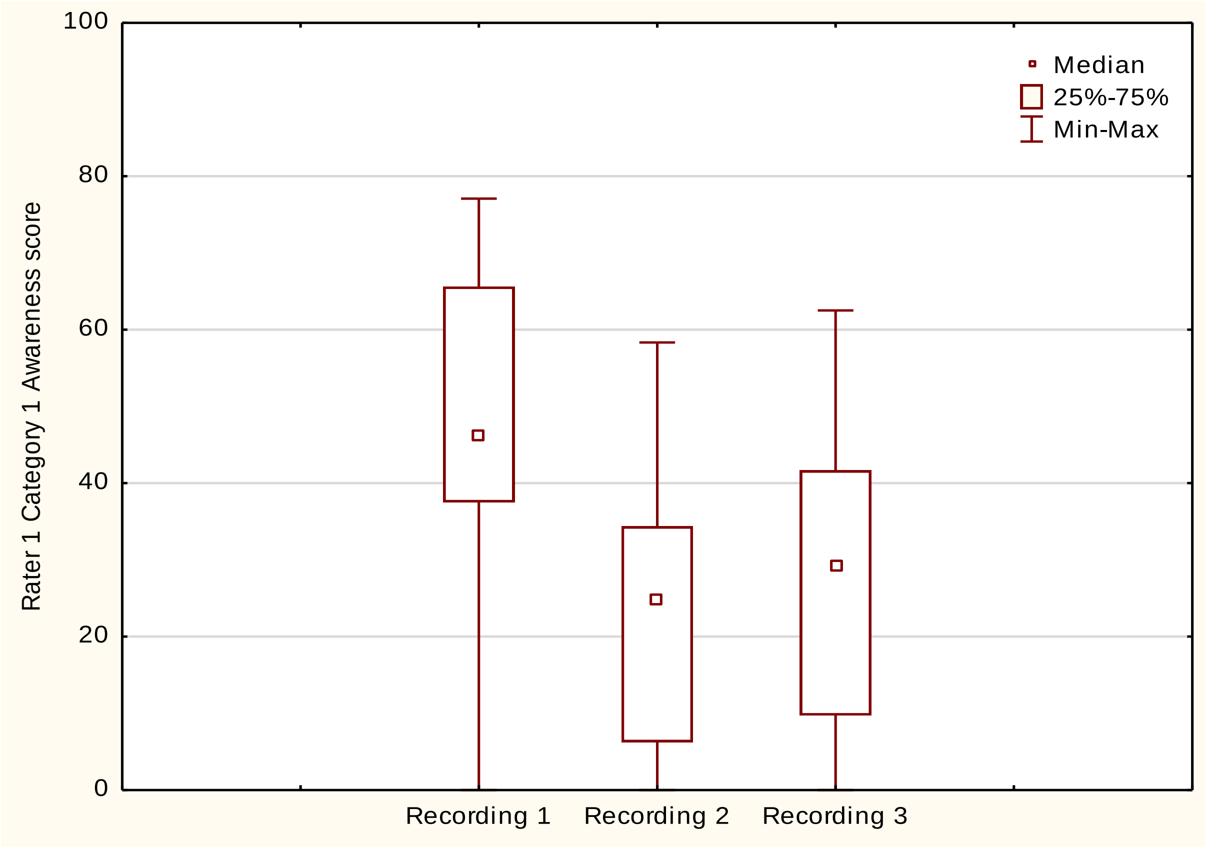


Figure 2: Rater 1 Intra-rater reliability depicting significant differences in scores for recordings 1, 2 and 3 for Category 1: Awareness and meaning of sound.

A possible explanation for the variation in scoring of the two raters could be that Rater 1 had 20 years more clinical experience and possibly paid closer attention while scoring the recordings. Subtle differences in participants' behaviours across the three recordings would be noticed by an experienced rater. It could also be that the variations in scoring represent true variations in the participants' responses over the three data-recording sessions. Tomchek and Dunn (2007) reported that sensory processing of children with ASD varies significantly from typically developing peers especially when considering emotional reactivity, low endurance, inattention and poor registration. The variation leads to a lack of consistency among sensory studies. The test-retest reliability of the FÁPI was therefore high, as only one test category showed a significant difference across the three recordings. Since the video recordings were placed in random order, the raters could not establish a routine following the chronological order of the data collections. The random order would have prevented that a rater was more attentive during the first video recording than during subsequent recordings. Since there was only one category that presented with a significant difference the conclusion is that the test-retest or intra-rater reliability for the FÁPI, for this specific sample was high.

Inter-rater reliability of the FÁPI

Table 5 provides the standard deviation for each category of the FÁPI , indicating whether there were similarities or differences between the two raters' scores.

Table 5: Inter-rater reliability for each category of the FÁPI.

FÀPI Category	Rater 1 (p-values: Intra-rater reliability)	Rater 2 (p-values: Intra-rater reliability)	T-Value	Z-Score	Wilcoxon Matched Pairs Tests Standard deviation (p-value)
1. Awareness and meaning of sounds	0,00365	0,33591	4,000	2,745626	0.006040 *
2. Auditory feedback and integration	0,30315	0,79787	0,000	2,934058	0,003346*
3. Localising sound source	0,62709	0,97468	25,000	1,098250	0,272096
4. Auditory discrimination	0.40130	0,43171	8,000	1,400280	0,161430
5. Auditory comprehension	0,17378	0.92596	3,000	1,752427	0,115852
6. Short-term auditory memory	0,49659	0,52579	1,000	1,069045	0,285050
7. Linguistic auditory processing	0,36788	0.09902	6,000	0,40452	0,685831

*** Statistically significant difference p≤0,05. The complete data sets are included in Appendix D.**

According to Table 5 there were significant differences between the scoring of the two raters for Categories 1 and 2 of the FÀPI. No significant differences were found between the scoring of the two raters for categories 3 to 7. The data of the inter-rater reliability between the two raters for Category 1 are also depicted in Figure 3.

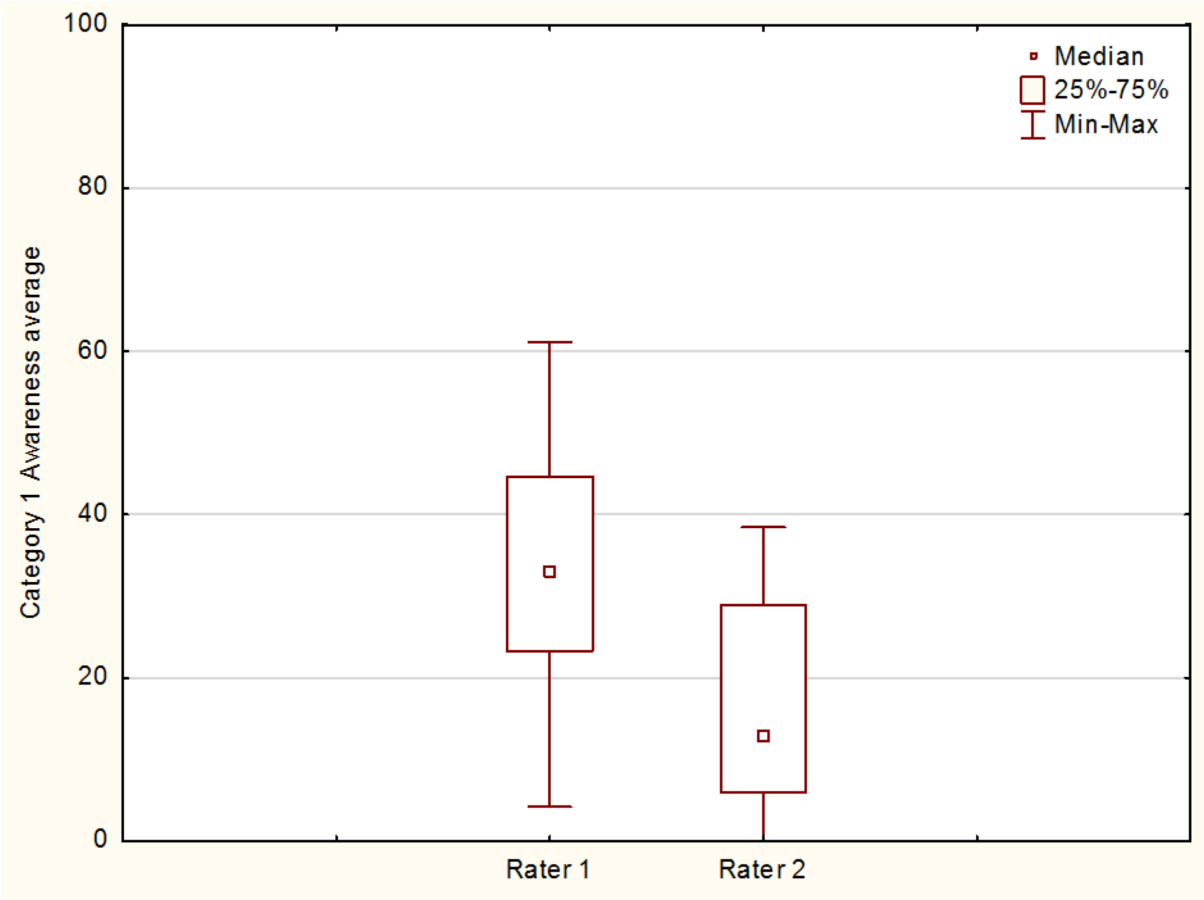


Figure 3: Inter-rater reliability for Category 1: Awareness and meaning of sound.

Figure 3 presents the average scores allocated for Category 1 by the two raters. The results clearly demonstrate the difference between the ratings of Rater 1 and Rater 2 for Category 1. Significant differences in scores were noted when comparing the weighted scores of Rater 1 with scoring a maximum of 61% and Rater 2 a maximum score of 39% (p-value of 0.006). A possible reason for the difference is the subjectivity of the items in this category. Similar differences were found between ratings of Category 2 as depicted in Figure 4.

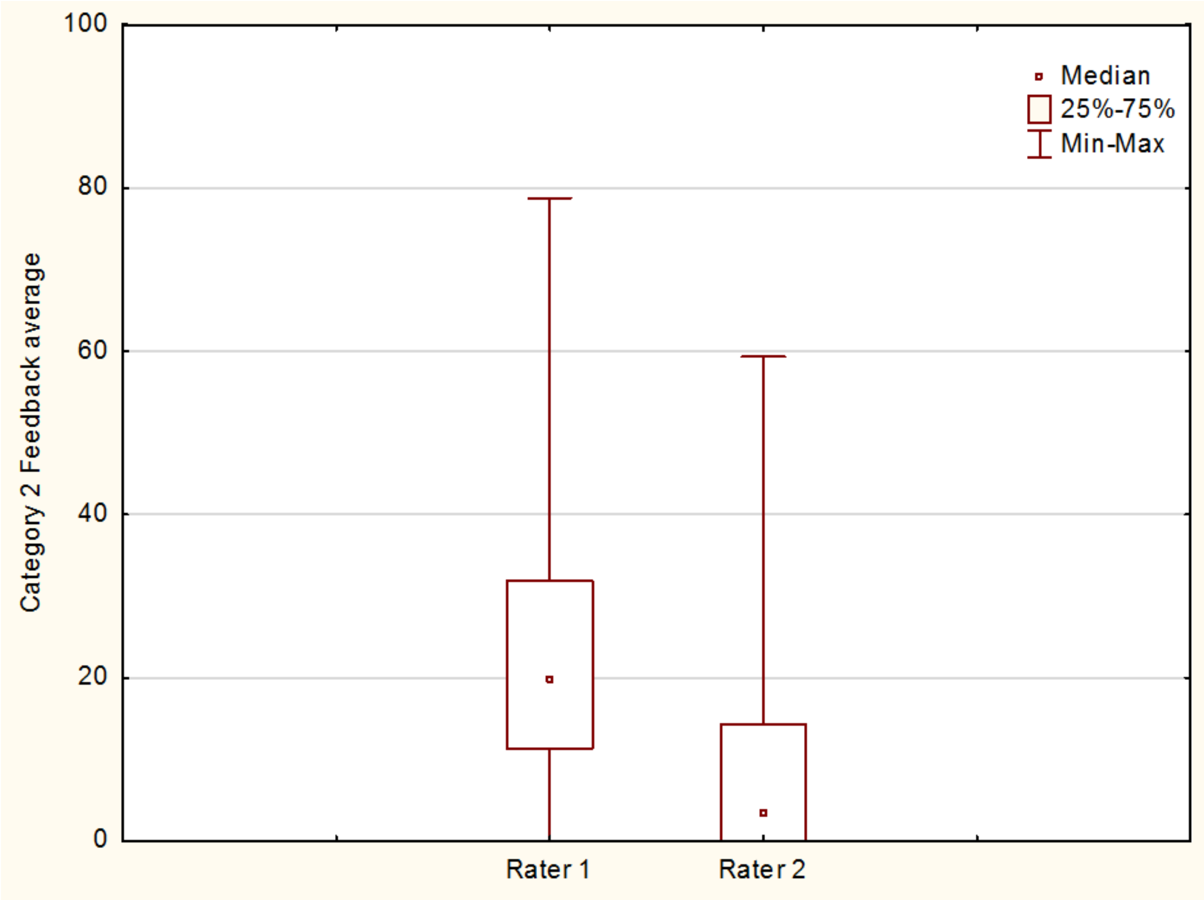


Figure 4: The inter-rater reliability for Category 2: Auditory feedback and integration.

In Figure 4 both raters' lowest weighted scores converged at 0%. The score was given when no response could be observed with Category 2, Auditory feedback and integration. The more complex the auditory stimuli became the fewer responses were observed in the participants. The maximum weighted scores of the two raters showed a 20% difference, with a p-value of 0.006, indicating a statistically significant difference.

The first two categories of the FÁPI, 'Awareness and meaning of sounds' and 'Auditory feedback and integration', rely on subjective scoring as there may be subtle variation in responses. An experienced rater may distinguish between a child pausing or ending an activity and looking up, or actually searching for the sound source. An experienced rater may therefore identify subtle differences, which can explain why the scores are more varied than an inexperienced rater. For both

Categories 1 and 2, subjectivity may have influenced the scoring. Category 3 to 7 include distinct responses and actions, such as repetition of a sequence of numbers where the participant either responds or fails to respond, which makes it easier to score. It may thus be concluded that with thorough training in the scoring of this tool consistent scoring may be achieved.

Discussion

The general observation in the results of the seven categories of the FÁPI was that an increase in the complexity of the auditory stimuli showed a decrease in involvement and reaction in the participants. The poorest responses were seen in understanding of variations of speech, which included single words to continuous speech. There are different explanations for poor auditory responses in children with ASD in the literature. Boddaert *et al.* (2003) found evidence of abnormal cortical processing in a neurophysiological study of adults diagnosed with ASD. According to O'Connor (2012) trends across studies suggest that auditory processing impairments in individuals with ASD are most likely to present during processing of complex auditory information and are more severe for speech than for non-speech stimuli. Kuhl *et al. (2005)* indicated that children with ASD, who lack social interest in communication, might be greatly disadvantaged in language learning which typically depends on social factors. The findings of the current study are in agreement with Kuhl *et al.* (2005) who observed that non-verbal participants exhibited little to no concern to auditory stimuli which included vocalisations and language. The participants in the current study were mainly non-verbal, and those who had some verbal skills presented with increased observable responses to the sound stimuli.

Other possible explanations for the lack of interest in sound and speech or low response scores observed in participants, specifically in Categories 5 and 7, may be related to the unusual auditory preferences observed in children with ASD (Paul *et al.*, 2007). According to Paul *et al.* (2007), reduced responses to sound may be associated with inattention, characterised by not being "tuned-in" to language, or the sound patterns of language. Failure to tune in to language has a negative impact on auditory functioning, social interaction and language learning (Johnson & Myers, 2007; Paul *et al.*, 2007). Additionally, Ludlow *et al.* (2014) noted that children with ASD experience difficulty when automatic attention is required, presenting with an inability to automatically shift their attention to the variation in sounds that do not fall within their attentional focus. Abnormal automatic processing may also be related to multiple key characteristics associated with ASD, such as failing to notice important auditory information (Marco, Hinkley, Hill & Nagarajan, 2011). The idea of automatic processing is specifically connected to language development (Ludlow *et al.*, 2014). In children with ASD the inability to automatically process auditory information outside their attentional focus may result in the memorisation of specific facts, but poor arrangement of the semantic material results in weak understanding of the connection between concepts (Ludlow *et al*., 2014). O'Connor (2012) introduces another idea when stating that children with ASD are able to match pitch contours of a sentence better than their typically developing peers, but present with far less comprehension of the content.

The participants in the study were all EAL speakers, busy acquiring English for the past 7-22 months in their nursery schools (See Table 1). According to Shipley and McAfee (2016) basic interactive communication skills in a second language develop over a two year period when circumstances are ideal. The role of EAL acquisition in addition to language impairment associated with ASD in the participants was not investigated in the study. Further research, utilising children who are English first language learners, may show the effect of EAL in the present study.

In this study, variables such as room setup, intensity of auditory stimuli presented and duration of the session, were kept consistent. Pre-recorded auditory stimuli were used and generally consistent responses were found in the participants across three successive data collection sessions. When additional variables could not be controlled, such as a participant's behaviour, responses to sound were influenced. It happened that a participant had an emotional outburst in class prior to the recording session which resulted in minimal to no reaction to the auditory stimuli presented.

With a clear pattern of responses emerging from the data of the present study, the FÁPI was therefore a useful tool to plot and describe the functional auditory skills of a group of five-year-old children with ASD. The inter-rater reliability of the FÁPI was found to be acceptable in this study, despite variations in Categories 1 and 2. The areas of poorest performance in the participants were Categories 5 and 7, therefore not the categories where significant inter-rater differences were found. The poor performance in understanding of continuous speech and a story (Categories 5 and 7) in the participants appear to be a reliable finding. Differences in ratings by the two independent raters were not significant enough to describe the intra-rater reliability as not reliable (Leedy & Ormrod, 2005).

Conclusion

Despite relying on subjective scoring for certain categories, heterogeneity in participants and variations in their levels of interaction, the FÁPI (Stredler-Brown & Johnson, 2004) was found to be a reliable instrument to plot and possibly monitor the functional auditory skills of five-year-old children with ASD. Video recordings of participants' overt responses to recorded sound and speech stimuli and using an instrument that relies on direct observation of participant responses to sound made it possible to describe the participants' functional auditory performance. Even though most of the participants were non-verbal, responses could still be recorded. The hierarchical structure of listening skill development of the FÁPI allowed a holistic view of the auditory difficulties of the participants. The results clearly showed that with an increase in complexity of the auditory stimuli, in particular speech, a decrease in behavioural responses was observed. Further research is required to determine the tool's performance using natural sound conditions to monitor children with ASD's progress against themselves during intervention. Further research is required to monitor and compare the auditory performance of children with ASD over time. The participants, who were non-verbal and suspected to have a severe form of ASD, presented with lower scores in comparison with the verbal participants, who responded to some extent to complex language stimuli. The nature of functional auditory skills found in the participants clearly showed deficits which may be addressed in intervention. The current research positively indicates that the FÁPI is a valuable and reliable instrument for the plotting of functional auditory performance of five-year-old children diagnosed with ASD, possibly monitor their skill development.

References

Alcantara, E., Weisblatt, B., Moore, B.C.J., & Bolton, P.F. (2004). Speech-in-noise perception in high-functioning individuals with autism or Asperger's syndrome. *Journal of Child Psychology and Psychiatry, 45*(6), 1107-1114. doi: 10.111/j.1469-7610.2004.t01-1-00303.

American Psychiatric Association. [APA]. (2000). *Diagnostic and Statistical Manual of mental disorders* (4th ed.). Arlington: American Psychiatric Publishing.

American Psychiatric Association. [APA]. (2013). *Diagnostic and Statistical Manual of mental disorders* (5th ed.). Arlington: United States of America: American Psychiatric Publishing.

American Speech-Language-Hearing Association. [ASHA]. (2007). *Scope of practice in speech-language pathology [Scope of practice].* Retrieved from www.asha.org/policy.

Azouz, H., Kozou, M., Khalil, M., Abdou, R.M., Sakr, M. (2014). The correlation between central auditory processing in autistic children and their language processing abilities. *International Journal of Pediatric Otorhinolaryngology, 78*(12), 2297-2300. doi:10.1016/j.ijporl.2014.10.039.

Banach, M. (2012). Reliability. Retrieved January 2016, from: https://www.ctspedia.org/do/view/CTSpedia.

Bless, C., & Higson-Smith, C. (2004). *Fundamentals of social research methods.* (3rd ed.). Cape Town: Juta & Company Ltd.

Boddaert, N., Belin, P., Chabane, N., Poline, J., Barthélémy, C., Mouren-Simeoni, M., Brunelle, F., Samson, Y., & Zilbovicius, M. (2003). Perception of complex sounds:

Abnormal pattern of cortical activation in autism. *Autism Journal of Psychiatry, 160(11),* 2057-2060. doi: 10.1176/appi.ajp.160.11.2057.

Bruneau, N., Bonnet-Brilhault, F., Gomot, M., Adrien, J.L., & Barthélémy, C. (2003). Cortical auditory processing and communication in children with autism: Electrophysiological/behavioural relations. *International Journal of Psychophysiology, 51*(1), 17-25. doi: 10.1016/S0167.8760(03)00149-1.

Carpenter, M., Estrem, R., Crowell, R.L., & Edrisinha, C.D. (2014). (Central) auditory processing skills in young adults with autism spectrum disorder. *Journal of Communication Disorders, Deaf Studies & Hearing Aids, 2*(2), 1-8. doi: 10.4172/2375-4427,1000112.

Ceponiene, R., Lepitsö, T., Shestakova, A., Vanhala, R., Alku, P., Näätänen, R., & Yaguchi, K. (2003). Speech-sound-selective auditory impairment in children with autism: They can perceive but do not attend. Proceedings of the *National Academy of Sciences of the United States of America, 100*(9), 5567-5572. doi:10.1073/Pnas.0835631100.

Ferguson, M., & Moore, D. (2014). Auditory processing performance and nonsensory factors in children with specific language impairment or auditory processing disorder. *Seminars in Hearing, 35*(1), 1-14. doi:10.1055/s-0033-1363520.

Ferreira, K., Moret, A.L.M., Bevilacqua, M.C., & Jacob, R.T. (2011). Translation and adaptation of functional auditory performance indicators (FAPI). *Journal of Applied Oral Science, 19*(6), 586-598. ISSN:16787757.

Fouché, C.B., & De Vos, A.S. (2011). Formal formulations, In De Vos, A.S., Delport, C.S.L., Fouche, C.B., & Strydom, H. *Research at grass roots: A primer for the social science and human professions* (pp 89-99). South Africa: Van Schaik Publishers.

Haesen, B., Boets, B., & Wagemans, J. (2011). A review of behavioural and electrophysiological studies on auditory processing and speech perception in autism spectrum disorder. *Research in Autism Spectrum Disorders, 5(2),* 701-714. doi: 10.1016/j.rasd.2010.11.006.

Johnson, C., & Myers, S. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics,120*(5), 1183-1215. doi:10.1542/peds.2007-2361.

Johnson, C., & Seaton, J. (2012). *Educational Audiology Handbook.* San Diego: Singular Publishing group.

Kargas, N., & Lo, B. (2015). The relationship between auditory processing and restricted, repetitive behaviours in adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 45*, 658–668. doi: 10.1007/s10803-014-2219-2.

Kuhl, P.K., Coffey-Corina, S., Padden, D., & Dawson, G. (2005). Links between social and linguistic processing of speech in children with autism: Behavioural and electrophysiological measures. *Developmental Science, 8,* 1-12.

Leedy, P., & Ormrod, J. (2005). *Practical research: Planning research: Planning and design*. (8th ed.). New Jersey: Upper Saddle River.

Ludlow, A., Mohr, B., Whitmor, A., Garagnani, M., Pulvermuller, F., & Gutierrez, R. (2014). Auditory processing and sensory behaviours in children with autism spectrum disorders as revealed by mismatch negativity. *Brain and Cognition, 86,* 55-63. doi: 10.1016/j.bandc.2014.01.016.

Marco, E., Hinkley, S., Hill, S.S., & Nagarajan, S.S. (2011). Sensory processing in autism: A review of neurophysiologic findings. *Pediatric Research, 69*(5), 48-54. doi: 10.1203/PDR.0b013e3182130c54.

O'Connor, K. (2012). Auditory processing in autism spectrum disorder: A review. *Neuroscience & Biobehavioural Reviews, 36*(2), 836-854. doi: 10.1016/j.neubiorev.2011.11.008.

Paul, R., Chawarska, C., Fowler, C., Cicchetti, D., & Volkmar, F. (2007). "Listen my child and you shall hear": Auditory preferences in toddlers with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research, 50*(10), 1350-1364. doi: 10.1044/1092-4388(2007/094).

Shipley, K., & McAfee, J. (2016). *Assessment in speech-language pathology: A resource manual* (5th ed.). N.Y: Delmar Cengage Learning.

Siegal, M., & Blades, M. (2003). Language and auditory processing in autism. *Trends in Cognitive Sciences, 7*(9), 378-380. doi: 10.1016/S1364-6613(03)00194-3.

Stredler-Brown, A., & Johnson, C. (2004). Functional auditory performance indicators. Retrieved April, 2014, from http://www.tsbvi.edu/attachments/Functional Auditory Performance Indicators.pdf.

Tomchek, S., & Dunn, W. (2007). Sensory processing in children with and without autism: A comparative study using the short sensory profile. *American Journal of Occupational Therapy, 61*(2), 190-200. 10.5014/ajot.61.2.190.

Zhang, Y., Barry, D., Moore, D.R., & Amitay, S. (2012). A new test of attention in listening (TAIL) predicts auditory performance. *PLOS ONE, 7*(12), 1-12. doi: 10.1371/journal.pone.0053502.

Chapter 5

Contributions, implications and conclusion

The aim of the final chapter is to discuss the contributions, theoretical and clinical implications of the study. A critical evaluation of the strengths and limitations of the study is provided. The need for future research is addressed. The chapter concludes with a holistic view of the topic that was studied.

5.1 Contributions, theoretical and clinical implications of the study

Based on an initial review of literature before the commencement of the study it appeared that there was a gap between knowledge of the auditory processing difficulties of children with ASD and the clinical procedures and instruments to assess and monitor progress when these difficulties would be addressed in intervention. A number of neurophysiological studies investigating auditory processing and auditory performance of individuals especially children with ASD have been conducted (Boddaert *et al.,2003;* Haesen *et al.*, 2011; Kuhl *et al.*, 2005; Visser *et al*., 2013). Following on the findings of neurophysiological studies, researchers such as Alcántara, Weisblatt, Moore and Bolton (2004) and Paul *et al.* (2007) started investigating the behavioural aspects of auditory processing in individuals with ASD.

When considering the substantial body of research about the auditory processing difficulties of individuals with ASD (Boddaert *et al*., 2003; Carpenter *et al*., 2014; Haesen *et al*., 2011; Kuhl *et al*., 2005; Ludlow *et al*., 2014; Paul *et al*., 2007; Visser *et al*., 2013) the most important theoretical implication of the study may be that the knowledge appears not to be reflected in the different intervention approaches currently used for preschoolers with the condition. It appears that current intervention approaches address the diverse areas of difficulty experienced by children with ASD by means of different methods, but there is no direct focus on functional auditory performance (see Chapter 2). Since auditory skills are still developing in the preschool years (Wiley, Meinzen-Derr & Choo, 2008) and auditory processing difficulties are still reported in adults with ASD (Alcántara *et al*., 2004; Carpenter *et al*., 2014) it is still not clear to which extent it can be remediated in individuals with ASD.

When close attention is paid to functional auditory performance in preschool children within a clinical context, the current study highlighted that information is mostly obtained from the field of audiology. Two leading researchers in auditory processing and functional auditory performance in children also commented that limited norm referenced instruments are available to use clinically (personal communication with Cheryl DeConde Johnson and Arlene Stredler-Brown, June, 2016). The need for a clinical instrument was confirmed by the literature review (Chapter 1).

The study also showed that there is a need for an instrument to monitor the progress in auditory performance in children with ASD during intervention. According to ASHA (2006) any diagnosis of ASD, specifically of young children, should be reviewed periodically, as diagnostic categories and conclusions may change as the child develops. The importance of interdisciplinary collaboration and family involvement is highlighted when assessing and diagnosing ASD in a child (ASHA, 2006). When diagnosing ASD in a child, it is important to monitor the findings to determine whether assessment results are consistent with the diagnostic characteristics of the disorder (ASHA, 2006).

The clinical implications of the current study demand a new perspective on the management of auditory processing difficulties of young children with ASD by speech-language therapists. In order to address the functional auditory performance difficulties of five-year-old children with ASD, it is necessary to consider the ASHA (2006) guiding principles of screening, assessment and intervention for individuals with ASD and the scope of practice of speech-language therapists (ASHA, 2007). The scope of practice of a speech-language therapist (ASHA, 2007) which includes prevention, screening, assessment, consultation, intervention, counselling, collaboration, documentation and referral, applies to children with ASD as well. According to ASHA (2006) speech-language therapists play a critical role in screening, diagnosing, and enhancing the social communication development and quality of life of children, adolescents, and adults with ASD. The role of the speech-language therapist also includes the development of treatment plans, providing treatment as well as documenting progress (ASHA, 2006; ASHA, 2007). ASHA (2007) states that a typical screening procedure includes parent and teacher report, measures and competency-based tools, such as observations and interviews, and a hearing screen to exclude hearing loss. Intervention for children with (C)APD usually requires an interdisciplinary approach involving the audiologist and speech-language therapist (ASHA, 2005). Since preschool children with ASD present with a wide range of deficits in addition to auditory processing difficulties (APA, 2013) an interdisciplinary team approach, which is both family-centred and culturally responsive (ASHA, 2008) is strongly recommended. The introduction of a clinical instrument such as the FÀPI (Stredler-Brown & Johnson, 2004), to monitor the progress of a child's auditory performance can be a valuable intervention tool. The FÀPI can be completed by caregivers, teachers and therapists after training and can provide guidelines for intervention to improve functional auditory behaviour.

Using the FÀPI (Stredler-Brown & Johnson, 2004) the overall functional auditory performance of five-year-old children diagnosed with ASD in a controlled clinical setting was successfully described. Consistent with literature, the description revealed the significant functional auditory performance difficulties of the twelve participants. As a group they mostly showed auditory skills relating to awareness and meaning of sound, auditory feedback and integration, and localising the sound source. Advanced categories of auditory skills, such as discrimination, comprehension, short-term memory and linguistic auditory processing on the FÀPI were rarely shown.

The primary focus of the study was, however, to determine the test-retest reliability and the inter-rater reliability of the FÁPI for young children with ASD. The results with both the test-retest reliability and inter-rater reliability presented only two categories with a significant difference, which confirmed that the monitoring tool is a reliable instrument to use within a controlled clinical setting. The FÁPI may contribute to evidence-based autism intervention by tracking a child's progress.

The nature of functional auditory skills found in the participants as a group clearly showed deficits which may be addressed in intervention. Functional auditory performance is complex, requiring the attention of both audiologists and speech-language therapists. When a deficit in functional auditory performance is suspected in a child with ASD, the question is whether the standard practice guidelines for (C)APD assessment and intervention as described by ASHA (2007) can be followed. The use of the FÁPI can compensate for the gap between the preschool years and eight years, when (C)APD can be formally assessed and diagnosed in children (Azouz, Kozou, Khalil, Abdou & Sakr, 2014). Given the behaviour difficulties of children with ASD, it may not even be possible to conduct formal (C)APD testing successfully in most children with ASD after eight years of age.

The study identified a gap in clinical practice and presented a possible solution. With a monitoring tool it is possible to identify the child's level of functional auditory performance. As a result of the hierarchical structure of auditory skills included in the instrument, sequential intervention goals can be set to achieve increasingly advanced function.

5.2 Critical evaluation of the strengths and limitations of the study

Despite differences in scoring the subjective categories of the instrument, some heterogeneity in participant characteristics and variations in their levels of interaction, the overall finding was that the FÁPI (Stredler-Brown & Johnson, 2004) showed good intra-rater reliability as well as inter-rater reliability. The consistency of the participant reactions and scoring by the raters demonstrated that the FÁPI could be a reliable monitoring instrument to plot the functional auditory skills of five-year-old EAL learners with ASD. The use of a control group of typically developing children could have strengthened the findings of the study.

Video recordings of participants' overt responses to sound and speech stimuli, and using an instrument that relies on direct observation of those responses made it possible to describe the participants' functional auditory performance. Even though the sample group was small and most of the participants were non-verbal, responses could still be recorded. Regular recording of a child's responses during intervention may be used to monitor functional auditory skill development over time. The value of a monitoring instrument as discussed in Chapter 2 is now evident. As a result of repeated measures a monitoring instrument can accommodate the unpredictable behaviour typical of children with ASD (Towgood *et al*., 2009) When using the FÁPI as a monitoring instrument for progress in intervention, the child's variable behaviour is not compared against a norm, but against his/her own functioning over time.

The hierarchical structure of listening skill development arranged in the FÁPI allowed a holistic view of the auditory difficulties of the participants. The results clearly showed that with an increase in complexity of the auditory stimuli, in particular speech, a decrease in behavioural responses was observed. A strength point of the study was that the results were confirmed by existing research on the auditory processing difficulties of children with ASD (Kuhl *et al.,* 2005; O'Connor, 2012; Paul *et al.,* 2007).

5.3 Recommendations for further research

It is recommended that further research is conducted on the application of the FÁPI as monitoring instrument for children with ASD. The current study focused mainly on the reliability of the instrument to record the auditory performance of young children with ASD. It may be valuable to track functional auditory performance longitudinally to determine whether children with ASD develop mechanisms and strategies to improve their auditory skills further than the level of localisation of sounds. Lastly, it is recommended that research should be conducted to determine whether intervention, based on the plotting of skills on the FÁPI, improves and accelerates auditory performance developmental of children with ASD.

Conclusion: The importance of a holistic view of functional auditory performance of five-year-old-children with ASD and the breakthroughs currently made in research regarding the complexities of the disorder appears to be apparent.

Reference list

Alcantara, E., Weisblatt, B., Moore, B.C.J., & Bolton, P.F. (2004). Speech-in-noise perception in high-functioning individuals with autism or Asperger's syndrome. *Journal of Child Psychology and Psychiatry, 45*(6), 1107-1114. doi: 10.111/j.1469-7610.2004.t01-1-00303.

Alderson, P., & Morrow, V. (2011). *The ethics of research with children and young people: A practical handbook.* (2nd ed.). UK: SAGE Publications Ltd.

American Psychiatric Association. [APA]. (2000). *Diagnostic and Statistical Manual of mental disorders* (4th ed.). Arlington: American Psychiatric Publishing.

American Psychiatric Association. [APA]. (2013). *Diagnostic and Statistical Manual of mental disorders (*5th ed.). Arlington: United States of America: American Psychiatric Publishing.

American Speech-Language-Hearing Association. [ASHA] (2004). *Auditory integration training* [Position Statement]. Retrieved from www.asha.org/policy. doi:10.1044/policy.PS2004-00218

American Speech-Language-Hearing Association. [ASHA]. (2005). *(Central) auditory processing disorders – the role of the audiologist [Position statement].* Retrieved from www.asha.org/policy. doi: 10.1044/policy.PS2005-00114.

American Speech-Language-Hearing Association. [ASHA]. (2006). *Roles and responsibilities of speech-language pathologists in diagnosing, assessment, and treatment of autism spectrum across the life span [Position Statement].* Retrieved from www.asha.org/policy. doi:10.1044/policy.PS2005-00114.

American Speech-Language-Hearing Association. [ASHA]. (2007). *Scope of practice in speech-language pathology [Scope of practice].* Retrieved from www.asha.org/policy.

American Speech-Language-Hearing Association. [ASHA]. (2008). *Roles and responsibilities of speech-language pathologists in early intervention: Guidelines*. Retrieve from www. asha.org. doi: 10.1044/policy.GL2008-00293.

Autism South Africa. (n.d.). Retrieved April 2014 from www.aut2know.co.za

Azouz, H., Kozou, M., Khalil, M., Abdou, R.M., Sakr, M. (2014). The correlation between central auditory processing in autistic children and their language processing abilities. *International Journal of Pediatric Otorhinolaryngology, 78*(12), 2297-2300. doi:10.1016/j.ijporl.2014.10.039.

Bailey, P., & Snowling, M. (2002). Auditory processing and the development of language and literacy*. British Medical Bulletin,* 63,135-146.

Banach, M. (2012). Reliability. Retrieved January 2016, from: https://www.ctspedia.org/do/view/CTSpedia.

Bazyk, S., Cimino, J., Hayes, K., Goodman, G., & Farrel, P. (2010). The use of therapeutic listening with pre-schoolers with developmental disabilities: A look at the outcomes. *Journal of Occupational Therapy, Schools & Early Intervention*, *3*, 124-138. doi: 10.1080/19411243.2010.491013.

Behaviour Analyst Certification Board. (n.d). Retrieved June 29, 2016, from http://bacb.com/.

Bless, C., & Higson-Smith, C. (2004). *Fundamentals of social research methods.* (3rd ed.). Cape Town: Juta & Company Ltd.

Boddaert, N., Belin, P., Chabane, N., Poline, J., Barthélémy, C., Mouren-Simeoni, M., Brunelle, F., Samson, Y., & Zilbovicius, M. (2003). Perception of complex sounds: Abnormal pattern of cortical activation in autism*. Autism Journal of Psychiatry*, *160(11),* 2057-2060. doi: 10.1176/appi.ajp.160.11.2057.

Bruneau, N., Bonnet-Brilhault, F., Gomot, M., Adrien, J.L., & Barthélémy, C. (2003). Cortical auditory processing and communication in children with autism: Electrophysiological/behavioural relations. *International Journal of Psychophysiology, 51*(1), 17-25. doi: 10.1016/S0167.8760(03)00149-1.

Carpenter, M., Estrem, R., Crowell, R.L., & Edrisinha, C.D. (2014). (Central) auditory processing skills in young adults with autism spectrum disorder. *Journal of Communication Disorders, Deaf Studies & Hearing Aids, 2*(2), 1-8*.* doi: 10.4172/2375-4427,1000112.

Centre for Disease Control and Prevention. (2012). Prevalence of autism spectrum disorders – Autism and Developmental disabilities monitoring network, 14 sites, United States, 2008. *Morbidity and Mortality Weekly Report, 61*(3), 1-19. doi: ss610391[pii].

Ceponiene, R., Lepitsö, T., Shestakova, A., Vanhala, R., Alku, P., Näätänen, R., & Yaguchi, K. (2003). Speech-sound-selective auditory impairment in children with autism: They can perceive but do not attend. Proceedings of the *National Academy of Sciences of the United States of America, 100*(9), 5567-5572. doi:10.1073/Pnas.0835631100.

Ching, T., & Hill, M. (2007). The Parent's Evaluation of Aural/Oral Performance of Children (PEACH) scale: Normative data. *Journal of the American Academy of Audiology, 18*(3), 220-235.

Ciaramelli, E., Grady, C.L., & Moscovitch, M. (2008). Top-down and bottom up attention to memory: A hypothesis (AtoM) on the role of the posterior parietal cortex in memory retrieval. *Neuropsychologia, 46,*1828-1851. doi: 10.1016/j.neuropsychologia.2008.03.22.

Coplan, J. (2010). *Making sense of autistic spectrum disorders.* New York: Bantam Books.

Dawson, G., Rogers, S., Muson, J., Smith, M., Winter, J., Greenson, J., Donaldson, A., & Varley, J. (2010). Randomised, controlled trail of an intervention for toddlers with autism: The Early Start Denver Model. *Pediatrics*, *125*(1), 17-23. doi:10/1542/peds.2009-0958.

Delport, C.S.L., & Fouché, C.B. (2011). Formal formulations, In De Vos, A.S., Delport, C.S.L., Fouche, C.B., & Strydom, H. *Research at grass roots: A primer for the social science and human professions* (pp 425-430)*.* South Africa: Van Schaik Publishers.

Ferreira, K., Moret, A.L.M., Bevilacqua, M.C., & Jacob, R.T. (2011). Translation and adaptation of functional auditory performance indicators (FAPI). *Journal of Applied Oral Science, 19*(6), 586-598. ISSN:16787757.

Flippen, M., Reszka, S., & Watson, L. R. (2010). Effectiveness of the picture exchange communications system (PECS) on communication and speech for children with autism spectrum disorder: A meta-analyses. *American Journal of Speech-Language Pathology*, *19*(2), 178-195. doi:10.1044/1058.0360(2010/09/0022).

Fouché, C.B., & De Vos, A.S. (2011). Formal formulations, In De Vos, A.S., Delport, C.S.L., Fouche, C.B., & Strydom, H. *Research at grass roots: A primer for the social science and human professions* (pp 89-99). South Africa: Van Schaik Publishers.

Ganz, J.B., Earles-Vollrath, T.L., Heath, A.K., Parker, R.I., Risopoli, M.J., & Duran, J.B. (2012). A meta-analysis of single case research studies on aided augmentative and alternative communication systems with individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *42*, 60-74.

Ganz, J.B., Goodwyn, F.D., Boles, M.M., Hong, E.R., Rispoli, M.J., Lund, E.M., & Kite, E. (2013). Impacts of a PECS instructional coaching intervention on practitioners and children with autism. *Augmentative and Alternative Communication*, *29*(3), 210-221. doi: 10.3109/07434618.2013.818058.

Haesen, B., Boets, B., & Wagemans, J. (2011). A review of behavioural and electrophysiological studies on auditory processing and speech perception in autism spectrum disorder. *Research in Autism Spectrum Disorders, 5(2),* 701-714. doi: 10.1016/j.rasd.2010.11.006.

Howley, M. (2015). Outcomes of structured teaching for children on the autism spectrum: Does the research evidence neglect the bigger picture? *Journal of Research in Special Educational Needs*, *15*(2), 106-119. doi: 10.1111/1471-3802.12040.

Johnson, C., & Myers, S. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics,120*(5), 1183-1215. doi:10.1542/peds.2007-2361.

Johnson, C., & Seaton, J. (2012). *Educational Audiology Handbook.* San Diego: Singular Publishing group.

Kuhl, P.K., Coffey-Corina, S., Padden, D., & Dawson, G. (2005). Links between social and linguistic processing of speech in children with autism: Behavioural and electrophysiological measures. *Developmental Science, 8,* 1-12.

Lal, R. (2010). Effect of alternative and augmentative communication on language and social behaviour of children with autism. *Educational Research and Reviews, 5*(3), 119-125.

Leaf, J.B., Leaf, R., McEachin, J., Taubman, S.A., Ross, R.K., Smith, T., & Weiss, M.J. (2016). Applied Behaviour Analysis is a science and, therefore, progressive. *Journal of Autism and Developmental Disorders*, *46*, 720-731. doi: 10.1005/510803-015-2591-6.

Leedy, P., & Ormrod, J. (2005). *Practical research: Planning research: Planning and design*. (8th ed.). New Jersey: Upper Saddle River.

Ludlow, A., Mohr, B., Whitmor, A., Garagnani, M., Pulvermuller, F., & Gutierrez, R. (2014). Auditory processing and sensory behaviours in children with autism spectrum disorders as revealed by mismatch negativity. *Brain and Cognition, 86,* 55-63*.* doi: 10.1016/j.bandc.2014.01.016.

O'Connor, K. (2012). Auditory processing in autism spectrum disorder: A review. *Neuroscience & Biobehavioural Reviews, 36*(2), 836-854. doi: 10.1016/j.neubiorev.2011.11.008.

Owens, R.E. (2008). *Language development: An introduction.* (7th ed.). United States of America: Pearson.

Pan, B.A., Rowe, M.L., Singer, J.D., & Snow, C.E. (2005). Maternal correlates of growth in toddler vocabulary production in low-income families. *Child Development, 76*(4), 763-782. doi: 10.1111/j.1467-8624.2005.00876.x.

Paul, R., Chawarska, C., Fowler, C., Cicchetti, D., & Volkmar, F. (2007). "Listen my child and you shall hear": Auditory preferences in toddlers with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research, 50*(10), 1350-1364. doi: 10.1044/1092-4388(2007/094).

Pena, E., Iglesias, A., & Lidz, C.S. (2001). Reducing test bias through dynamic assessment of children's word learning ability. *American Journal of Speech-Language Pathology, 10*(5), 138-154.

Pfeiffer, B.A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). Effectiveness of sensory integration interventions in children with autism spectrum disorder: A pilot study. *The American Journal of Occupational Therapy*, *65*(1), 76-85. doi: 10.5014/ajot.2011.09205.

Pottas, L. (2011). *Auditory processing and young children with autism spectrum disorder: Early communication intervention. A shared role of audiologist and speech-language therapist*. Paper delivered at the CHRIB Annual Seminar, University of Pretoria.

Preis, J. (2006). The effect of picture communication symbols on the verbal comprehension of commands by young children with autism. *Focus on autism and other developmental disabilities,21(4)*, 194–210. Retrieved from http://0-web.b.ebscohost.com.innopac.up.ac.za/ehost/pdfviewer/pdfviewer?vid=3&sid=35d72c3b-6b86-44f8-811b-ad1f015a084c%40sessionmgr114&hid=127.

Rossetti, L.M. (2001). *Communication intervention: Birth to three* (2nd ed.). N.Y: Singular Thomson Learning.

Schopler, E. (2005). *Cross-cultural program priorities and reclassification of outcome research methods*. Hoboken, NJ, US: John Wiley & Sons, 1174-1189.

Stredler-Brown, A., & Johnson, C. (2004). Functional auditory performance indicators. Retrieved April, 2014, from http://www.tsbvi.edu/attachments/Functional Auditory Performance Indicators.pdf.

Strydom, H., & De Vos, A.S. (2011). Formal formulations, In De Vos, A.S., Delport, C.S.L., Fouche, C.B., & Strydom, H. *Research at grass roots: A primer for the social science and human professions* (pp 113-129). South Africa: Van Schaik Publishers.

Sundberg, M.L., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behaviour for children with autism. *Behaviour Modification*, *25*(5), 698-724. doi: 10.1177/0145445501255003.

Tomchek, S., & Dunn, W. (2007). Sensory processing in children with and without autism: A comparative study using the short sensory profile. *American Journal of Occupational Therapy, 61*(2), 190-200. 10.5014/ajot.61.2.190.

Towgood, K.J., Meuwese, J.D.I., Gilbert, S.J., Turner, M.S., & Burgess, P.W. (2009). Advantages of the multiple case series approach to the study of cognitive deficits in autism spectrum disorder. *Neuropsychologica, 47*(13), 2981-2988. doi:10/1016/j.neroupsychologica.2009.06.028.

Virués-Ortega, J. (2010). Applied behaviour analytic intervention for autism in early childhood: Metananalysis, meta-regression and dose-response meta-analysis of multiple outcomes. *Clinical Psychology Review, 30(4),* 387-399. doi: 10.1016/j.cpr.2010.01.008.

Virués-Ortega, J., Julio, F., & Barriuso, R. (2013). The TEACCH program for children and adults with autism: A meta-analysis of intervention studies. *Clinical Psychology Review, 33*(8), 940-953. doi: 10/1016/j.cpr.2013.07.005.

Visser, E., Zwiers, M.P., Kan, C.C., Hoekstra, L., Van Optsel, J., & Buitelaar, J. K. (2013). Atypical vertical sound localization and sound-onset sensitivity in people with autism spectrum disorders. *Journal of Psychiatry and Neuroscience, 38*(6), 398-406.

Vital Links. (n.d.). Therapeutic listening. Accessed July 3, 2016 from https://vitallinks.com/therapeutic-listening/.

Vivanti, G., Dissanayke, C., & The Victorian ASELCC Team. (2016). Outcome for children receiving the Early Start Denver Model before and after 48 months. *Journal of Autism and Developmental Disorders, 46*, 2441-2449. doi: 10.1007//S10803-016-2777-6.

Watson, H.H. (2012). Makaton. *Nursing Standard*, *27*(5), 30.

Whitely, E., & Ball, J. (2002). Statistics review 6: Nonparametric methods. *Critical Care,6*(6), 509-513. doi: 10.1186/cc1820.

Wiley, S., Meinzen-Derr, J., & Choo, D. (2008). Auditory skills development among children with developmental delays and cochlear implants. *Annals of Otology, Rhinology & Laryngology, 117*(10), 711-718.

Appendices A

Ethical clearance form included in the original copy, submitted to the Faculty of Humanities.

Appendices B

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

Information brochure

October 2014

Dear Parent or Caregiver

Invitation to participate in a research study

Title of study: The reliability of the Functional Auditory Performance Indicators as measuring instrument of functional auditory performance in five-year-old children with Autism Spectrum Disorder

I am conducting a research study as part of my Master's degree in Speech-Language Pathology. The aim is to determine the reliability of the Functional Auditory Performance Indicators (FAPI) as a tool to obtain auditory indicators of five-year- old children with Autism Spectrum Disorder (ASD). I would like to include your child as a participant in my study.

The Research Ethics Committee of the Department of Speech-Language Pathology and Audiology, and the Cluster of Social Sciences of the Faculty of Humanities at the University of Pretoria, have granted permission to conduct the study.

The following information is relevant to my study:

Purpose of the study

It is known that young children with ASD display a preference for non-speech signals and that they do not consistently respond to speech directed at them (Kuhl et al., 2005), but a comprehensive description of the different aspects of their functional auditory performance is limited. One of the reasons could be that there is not an auditory performance tool specifically designed for preschool children with ASD. The aim of the present study is to determine if the FAPI, an instrument designed for children with hearing impairment, can be used to describe functional auditory performance indicators of children with ASD. The results may contribute to better understanding of the apparent atypical listening skills of young children with ASD.

Procedure

Each participant will be video recorded during a table top activity with the researcher in the classroom. Sitting at a table, the researcher and the participant will interact naturally during shared book reading while the child's reaction to pre-recorded stimuli of environmental noise, noisemakers and speech will be recorded on video. The recording will be approximately 30 minutes in duration and will not disrupt the class programme. This procedure will be repeated three times during a 2 week period.

The researcher is trained to asses and provide therapy to children with ASD.

Risks and inconvenience

No risks are involved in this research project. Your child will not be forced to participate in any activity and will not be separated from the teacher.

Benefits of the study

You will not gain any direct benefits. Children with ASD in general might benefit as their functional auditory performance may be better described and understood.

Rights of participants

You may withdraw your child at any time during the study and participation is voluntary. If you decide to withdraw, the data already collected will be omitted from the study.

Confidentiality

Information obtained from the video recordings will be used for the single purpose of research. Only the researcher, the study leader and the raters will have access to the video recordings. The raters will sign an agreement of confidentiality. The data obtained during the study will be securely stored for 15 years at the University of Pretoria. If the data is to be used in future research, consent will be obtained again. The identity of the participants or their school will not be included in the study.

Your child's participation will be much appreciated. Should you require any further information, please contact me at 082 563 2688.

To enable me to include your child in the study you are kindly requested to sign the attached informed consent form.

Yours sincerely

____

Carlien Muller

Master's Degree student

______________________ ______________________

Professor AM Kritzinger Dr L Pottas

Supervisor **Co-Supervisor**

____

Professor B Vinck

HEAD: Department of Speech-Language Pathology and Audiology

<u>Informed consent</u>

Title of study: The reliability of the Functional Auditory Performance Indicators as measuring instrument of functional auditory performance in five-year-old children with Autism Spectrum Disorder

I understand my rights and I voluntarily give consent that my child can participate in this study. I understand the purpose of this study and the procedures involved.

Parent or caregiver's signature　　　　　　Date

_________________________　　　　　　___________________________

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

March 2015

XXXXXXXXX

XXXXXXXXX

XXXXXXXXX

Pretoria

Permission to recruit learners from XXXXXX for a research study

Title of study: The reliability of the Functional Auditory Performance Indicators as measuring instrument of functional auditory performance in five-year-old children with Autism Spectrum Disorder.

I am conducting a research study as part of my Master's degree in Speech-Language Pathology. The aim is to determine the reliability of the Functional Auditory Performance Indicators (FAPI) as a tool to obtain auditory indicators of five-year-old children with Autism Spectrum Disorder (ASD). I would like to include as many five-year-old learners as possible from your school, diagnosed with ASD as participants' in my study. I request your permission to release contact details of parents of the 5 year old children with ASD in your school and to make use of a space in a classroom for data collection.

The Research Ethics Committee of the Department of Speech-Language Pathology and Audiology, and the Cluster of Social Sciences of the Faculty of Humanities at the University of Pretoria, have granted permission to conduct the study.

The following information is relevant to my study:

Purpose of the study

It is known that young children with ASD display a preference for non-speech signals and that they do not consistently respond to speech directed at them (Kuhl et al., 2005), but a comprehensive description of the different aspects of their functional auditory performance is limited. One of the reasons could be that there is not an auditory performance tool specifically designed for preschool children with ASD. The aim of the present study is to determine if the FAPI, an instrument designed for children with hearing impairment, can be used to describe functional auditory performance indicators of children with ASD. The results may contribute to better understanding of the apparent atypical listening skills of young children with ASD.

Procedure

Each participant will be recorded during a table top activity with the researcher in the classroom. Sitting at a table, the researcher and the participant will interact naturally during shared book reading while the child's reaction to pre-recorded stimuli of environmental noise, noisemakers and speech will be recorded. The recording will be approximately 30 minutes in duration and will not disrupt the class programme. This procedure will be repeated three times during a 5 week period.

The researcher is trained to asses and provide therapy to children with ASD.

Risks and inconvenience

No risks are involved in this research project. Your child will not be forced to participate in any activity and will not be separated from the teacher.

Benefits of the study

You will not gain any direct benefits. The population of children with ASD might benefit as their functional auditory performance may be better described and understood.

Rights of participants

You may withdraw your child at any time during the study and participation is voluntary. If you decide to withdraw, the data already collected will be omitted from the study.

Confidentiality

Information obtained from the observations and video recordings will be used for the single purpose of research. Only the researcher, the study leader and the third party raters will have access to the video recordings. The data obtained during the study will be securely stored for 15 years at the University of Pretoria. If the data is to be used in future research, consent will be obtained again. The identity of the participants or their school will not be included in the study.

The children from XXXXXX participation will be much appreciated. Should you require any further information, please contact me at 082 563 2688.

To enable me to include learners from your school in the study you are kindly requested to sign the attached informed consent form.

Yours sincerely

____

Carlien Muller

Master's Degree student

_____________________	______________________
Professor AM Kritzinger	Dr L Pottas
Supervisor	**Co-Supervisor**

____

Professor B Vinck

HEAD: Department of Speech-Language Pathology and Audiology

<u>Informed consent</u>

The reliability of the Functional Auditory Performance Indicators as measuring instrument of functional auditory performance in five-year-old children with Autism Spectrum Disorder

I understand my rights and I voluntarily give consent that recruitment of learners at Chrysalis Preschool may occur. I understand the purpose of this study and the procedures involved.

Principal's signature Date

__________________________ ____________________________

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

June 2014

I ______________________________ agree to keep all information on video recordings of the study: *The reliability of the Functional Auditory Performance Indicator as a reliable measuring instrument in five-year-old children with Autism Spectrum Disorder,* confidential.

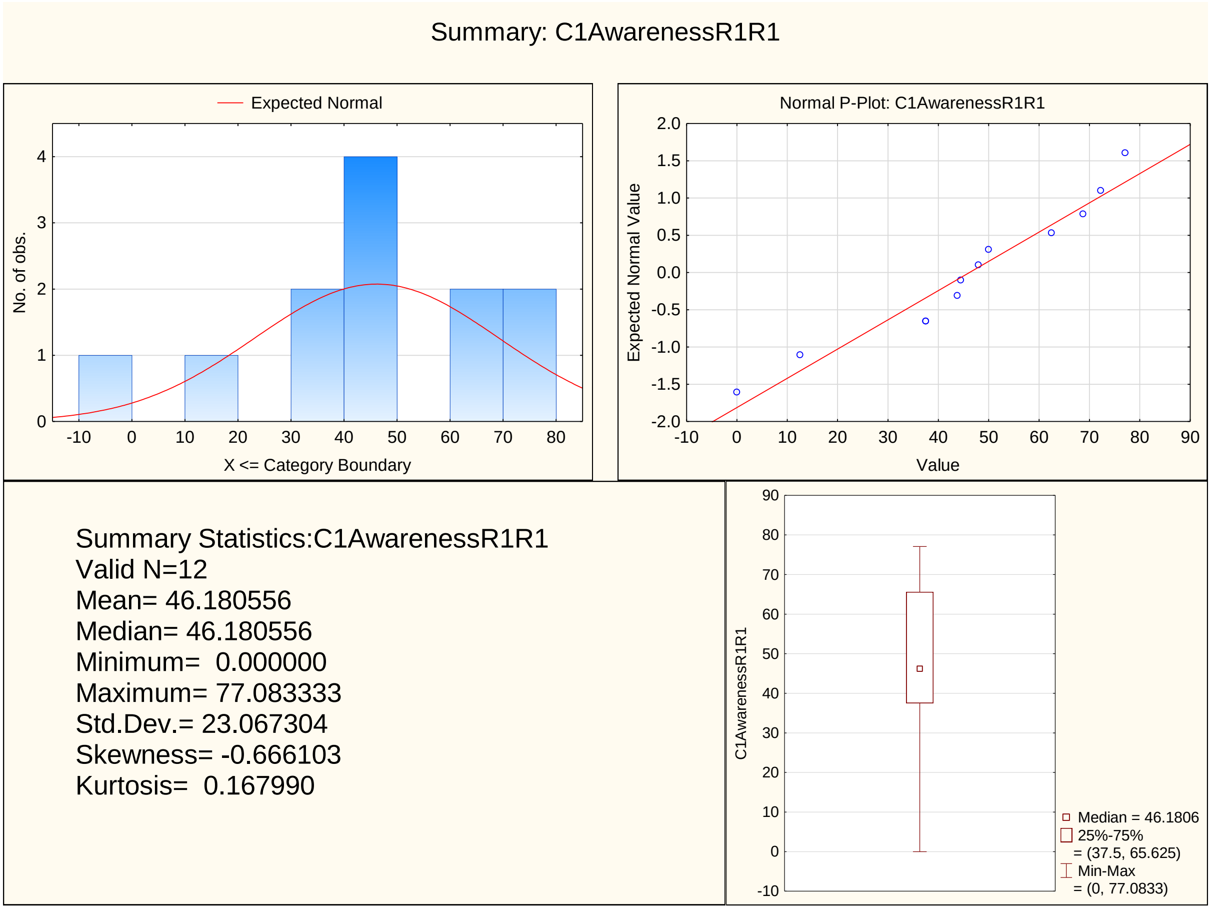
Signed ___________________________________ on ____________________________________ at

____

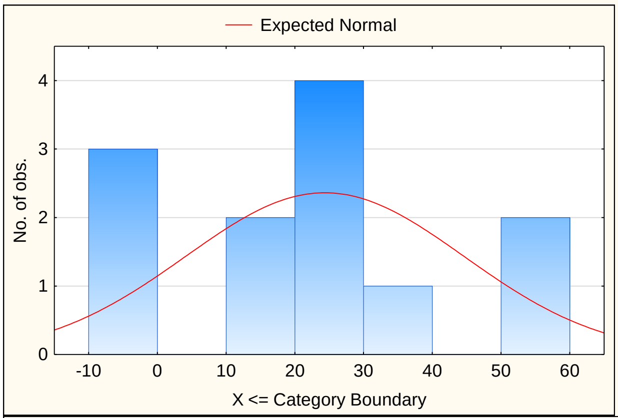
Appendices C

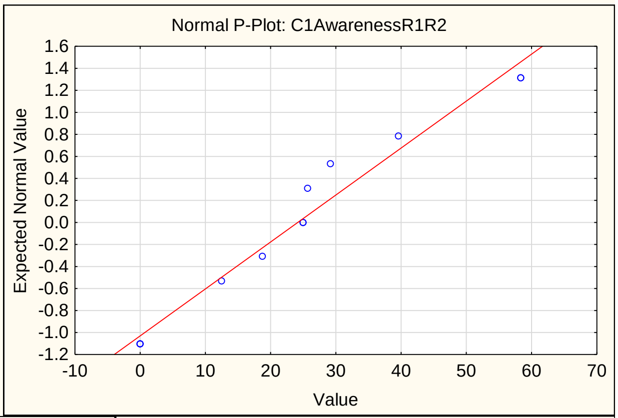
FÁPI included in the original copy, submitted to the Faculty of Humanities.

Appendices D

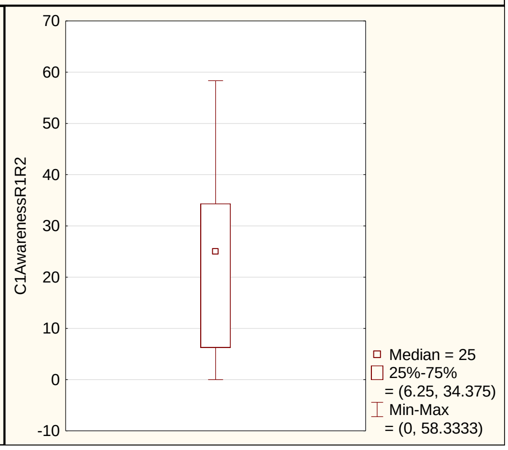

Summary: C1AwarenessR1R1
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C1AwarenessR1R1
Expected Normal Value
Value
Summary Statistics:C1AwarenessR1R1
Valid N=12
Mean= 46.180556
Median= 46.180556
Minimum= 0.000000
Maximum= 77.083333
Std.Dev.= 23.067304
Skewness= -0.666103
Kurtosis= 0.167990
C1AwarenessR1R1
Median = 46.1806
25%-75%
= (37.5, 65.625)
Min-Max
= (0, 77.0833)

Summary: C1AwarenessR1R2

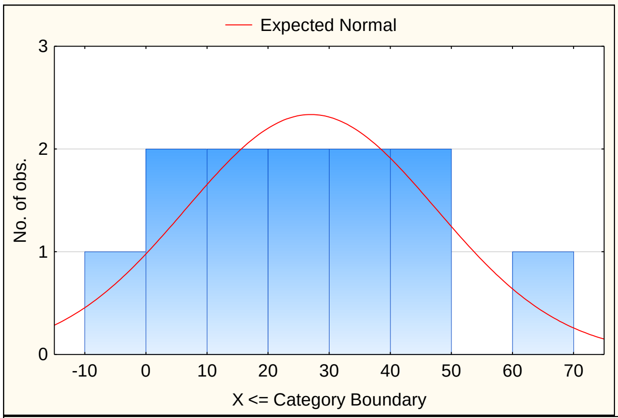


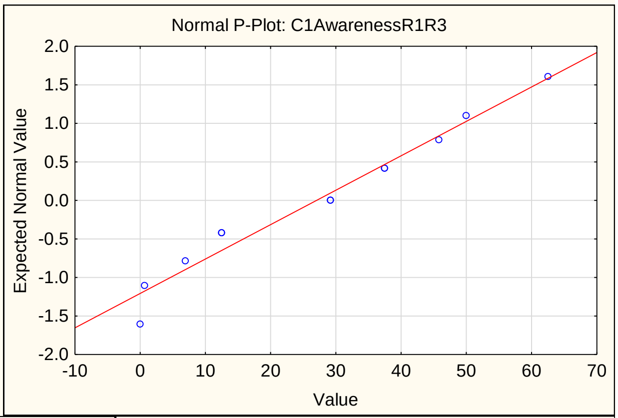


Summary Statistics:C1AwarenessR1R2
Valid N=12
Mean= 24.363426
Median= 25.000000
Minimum= 0.000000
Maximum= 58.333333
Std.Dev.= 20.266831
Skewness= 0.482356
Kurtosis= -0.488607

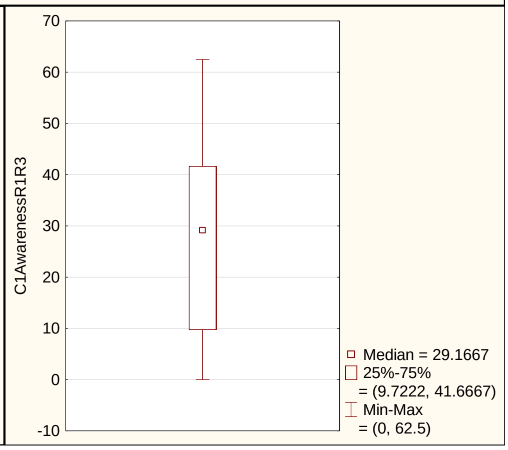


Summary: C1AwarenessR1R3

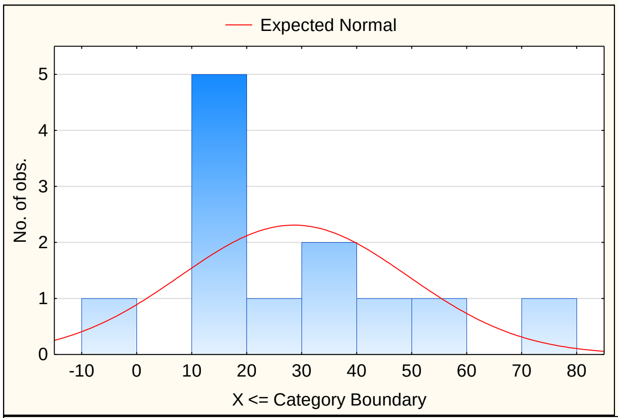


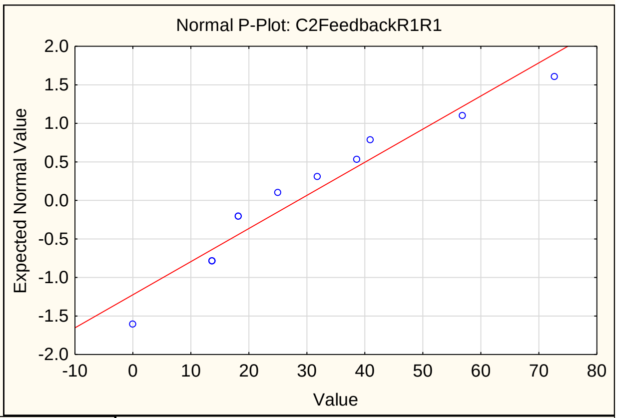


Summary Statistics:C1AwarenessR1R3
Valid N=12
Mean= 27.025463
Median= 29.166667
Minimum= 0.000000
Maximum= 62.500000
Std.Dev.= 20.488429
Skewness= 0.171474
Kurtosis= -1.102623

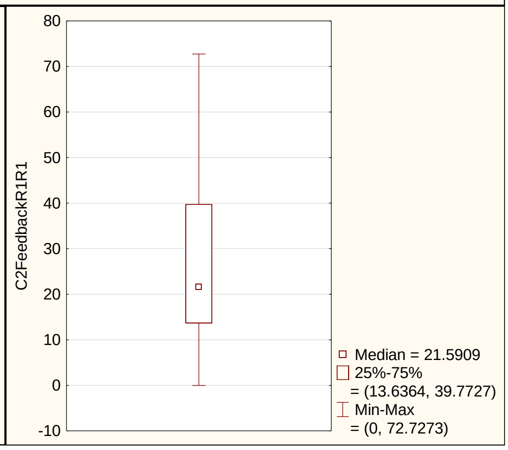


Summary: C2FeedbackR1R1

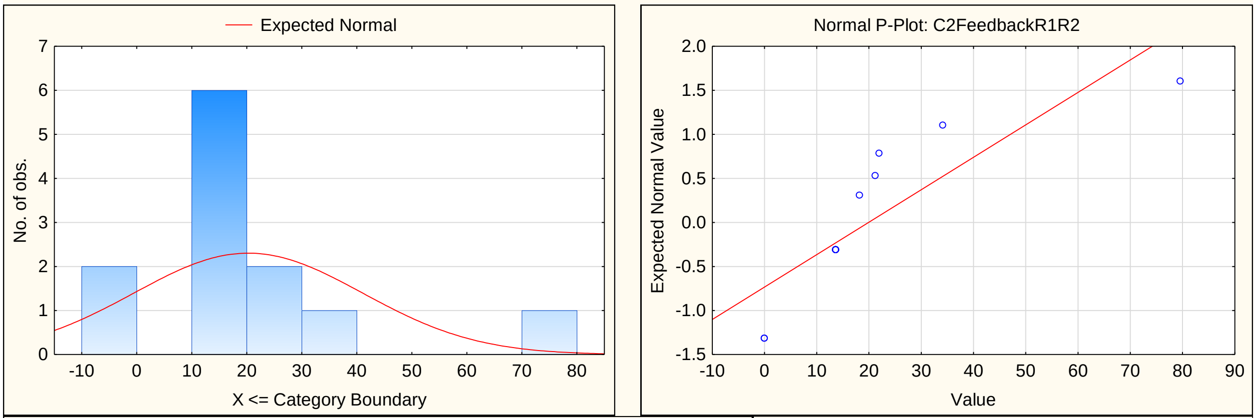




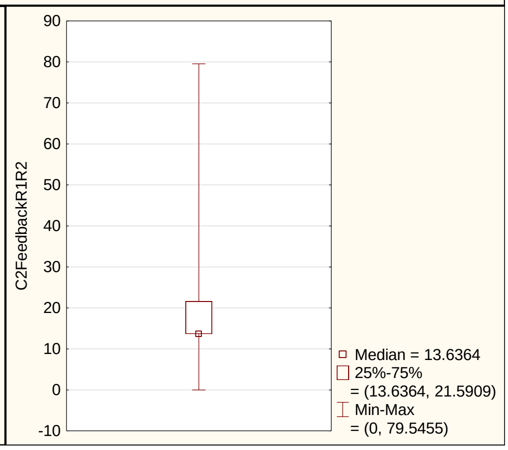
Summary Statistics:C2FeedbackR1R1
Valid N=12
Mean= 28.598485
Median= 21.590909
Minimum= 0.000000
Maximum= 72.727273
Std.Dev.= 20.727253
Skewness= 0.925813
Kurtosis= 0.493635

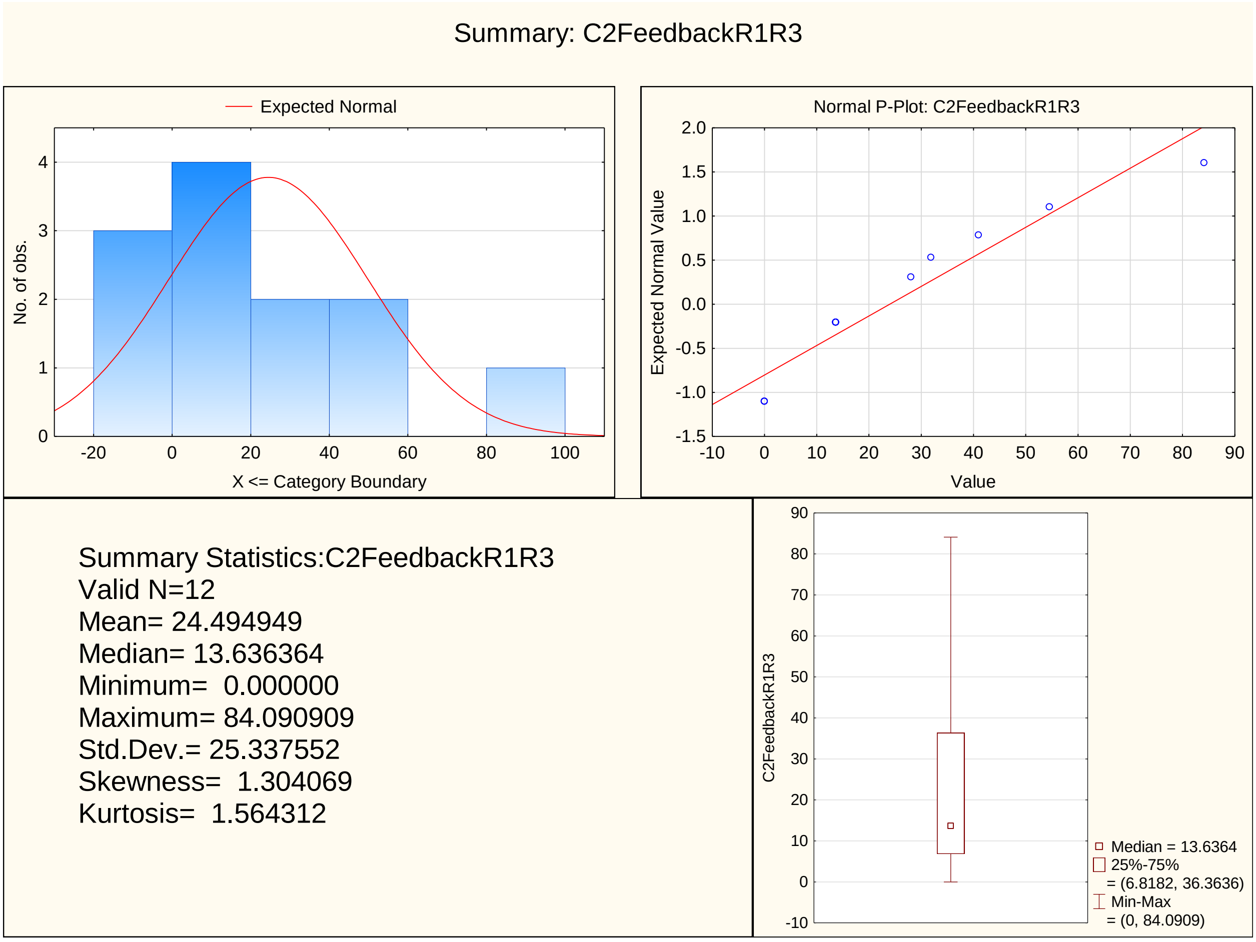


Summary: C2FeedbackR1R2

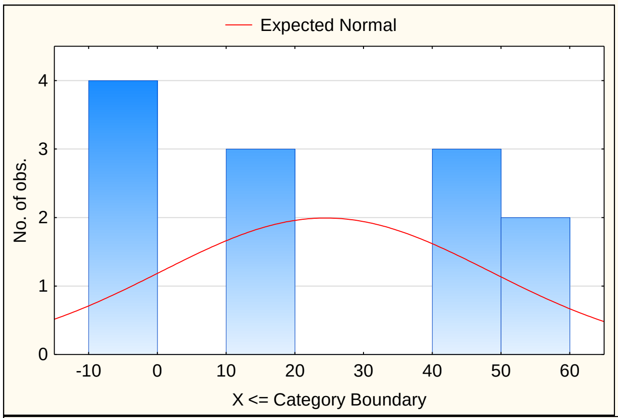


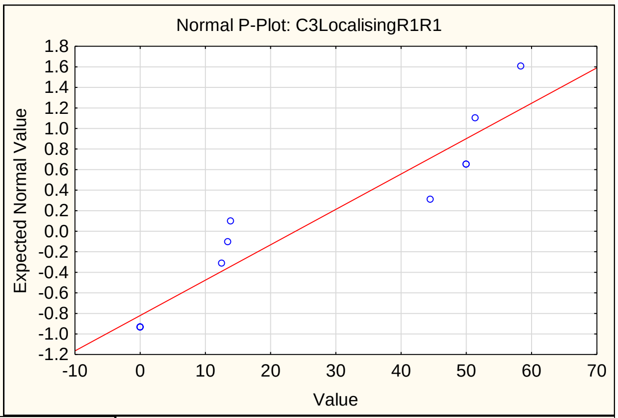
Summary Statistics:C2FeedbackR1R2
Valid N=12
Mean= 20.265152
Median= 13.636364
Minimum= 0.000000
Maximum= 79.545455
Std.Dev.= 20.790088
Skewness= 2.341307
Kurtosis= 6.706275



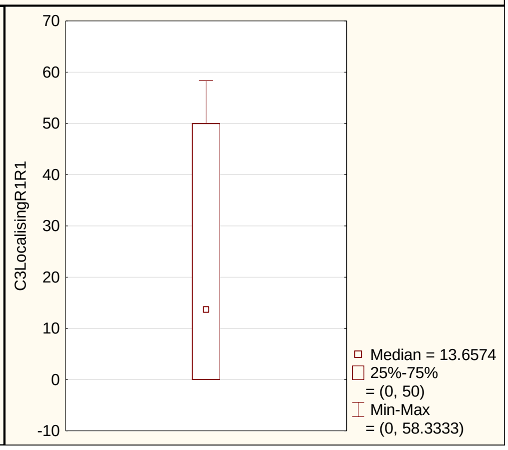

Summary: C2FeedbackR1R3
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C2FeedbackR1R3
Expected Normal Value
Value
Summary Statistics:C2FeedbackR1R3
Valid N=12
Mean= 24.494949
Median= 13.636364
Minimum= 0.000000
Maximum= 84.090909
Std.Dev.= 25.337552
Skewness= 1.304069
Kurtosis= 1.564312
C2FeedbackR1R3
Median = 13.6364
25%-75%
= (6.8182, 36.3636)
Min-Max
= (0, 84.0909)

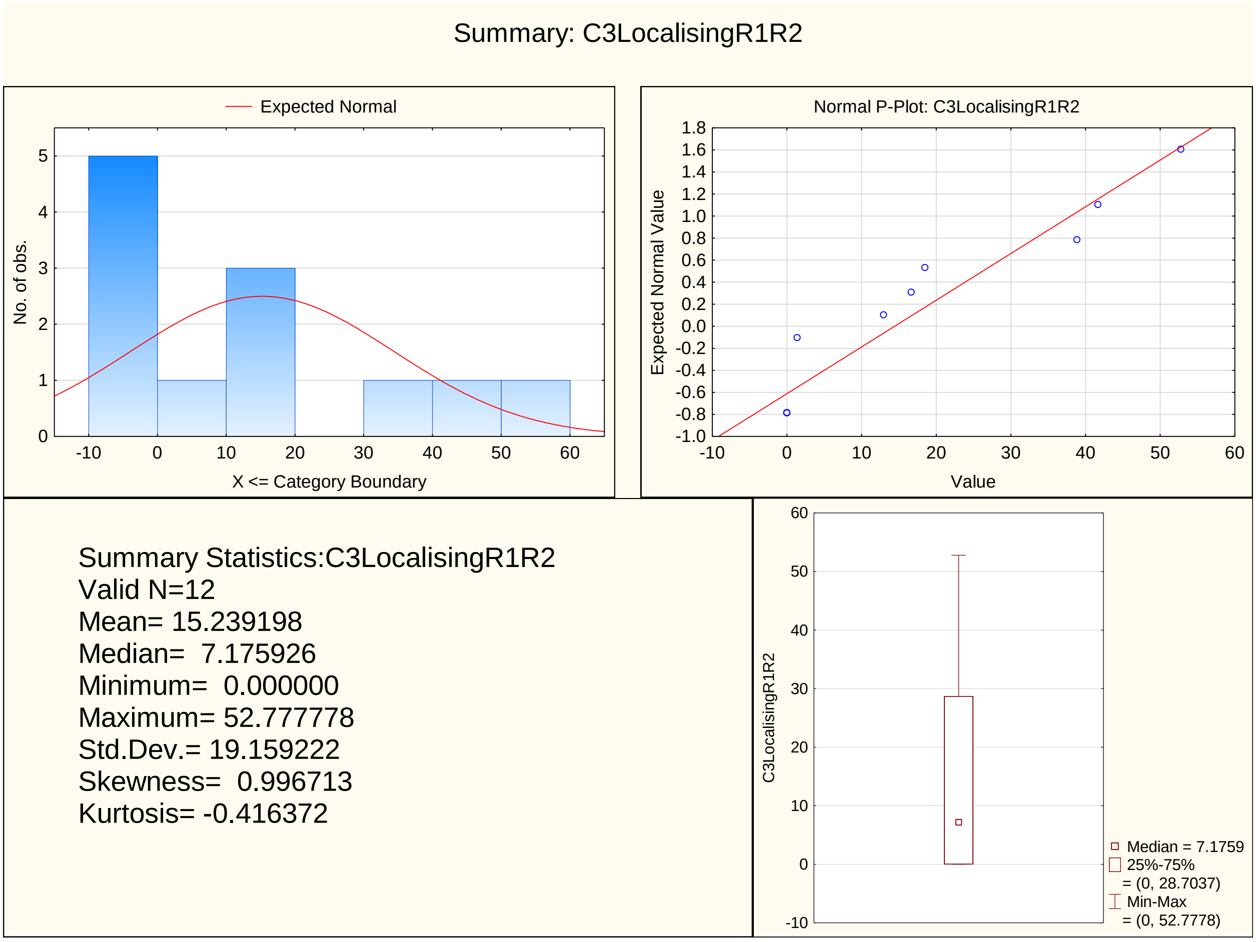
Summary: C3LocalisingR1R1



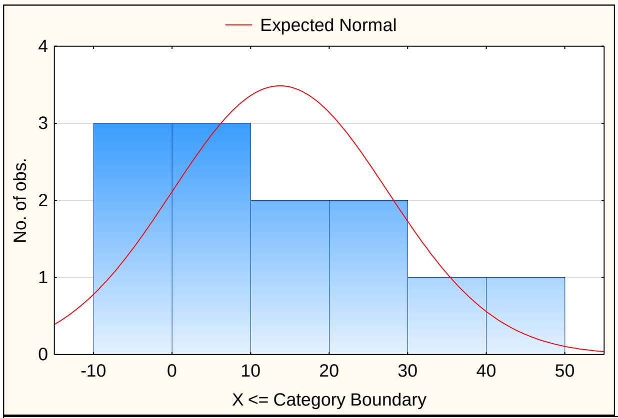


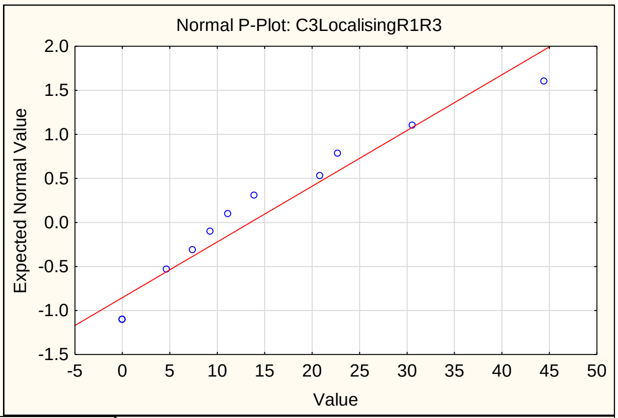
Summary Statistics:C3LocalisingR1R1
Valid N=12
Mean= 24.498457
Median= 13.657407
Minimum= 0.000000
Maximum= 58.333333
Std.Dev.= 24.019345
Skewness= 0.284902
Kurtosis= -1.984935



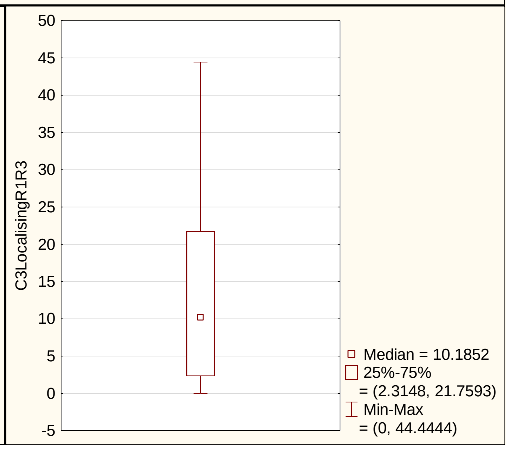

Summary: C3LocalisingR1R2
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C3LocalisingR1R2
Expected Normal Value
Value
Summary Statistics:C3LocalisingR1R2
Valid N=12
Mean= 15.239198
Median= 7.175926
Minimum= 0.000000
Maximum= 52.777778
Std.Dev.= 19.159222
Skewness= 0.996713
Kurtosis= -0.416372
C3LocalisingR1R2
Median = 7.1759
25%-75%
= (0, 28.7037)
Min-Max
= (0, 52.7778)

Summary: C3LocalisingR1R3

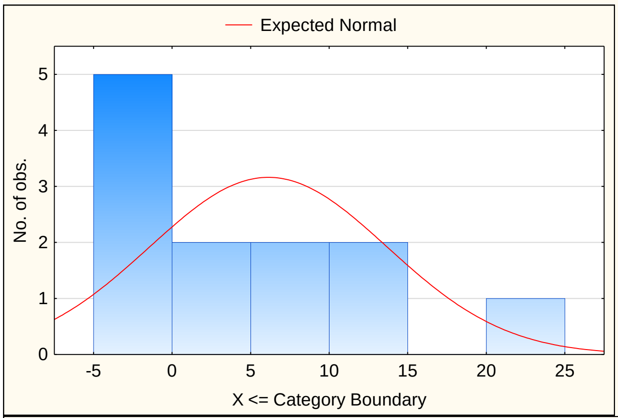


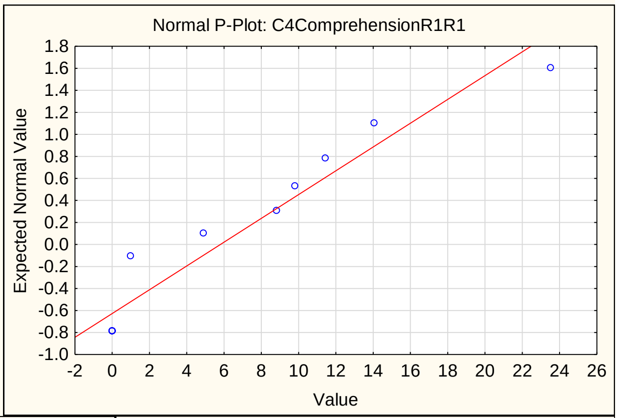


Summary Statistics:C3LocalisingR1R3
Valid N=12
Mean= 13.734568
Median= 10.185185
Minimum= 0.000000
Maximum= 44.444444
Std.Dev.= 13.725659
Skewness= 1.093016
Kurtosis= 0.824281

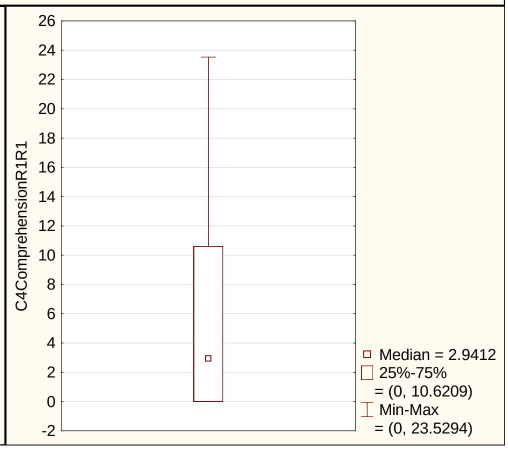


Summary: C4ComprehensionR1R1

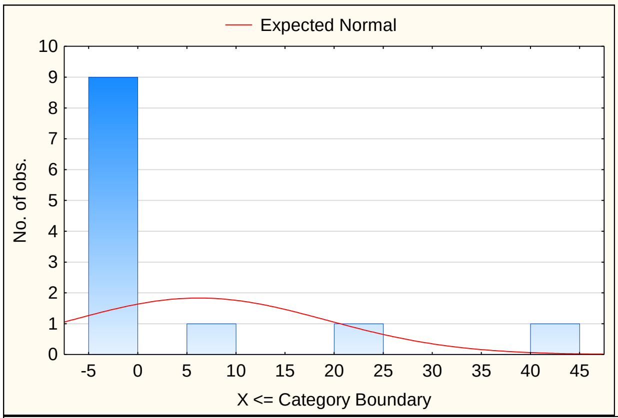


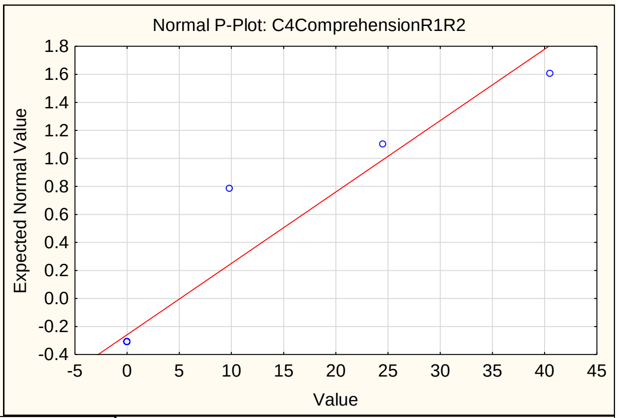


Summary Statistics:C4ComprehensionR1R1
Valid N=12
Mean= 6.127451
Median= 2.941176
Minimum= 0.000000
Maximum= 23.529412
Std.Dev.= 7.569915
Skewness= 1.181502
Kurtosis= 0.978087

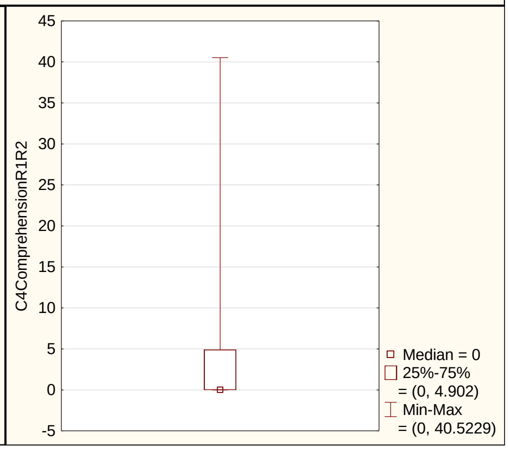


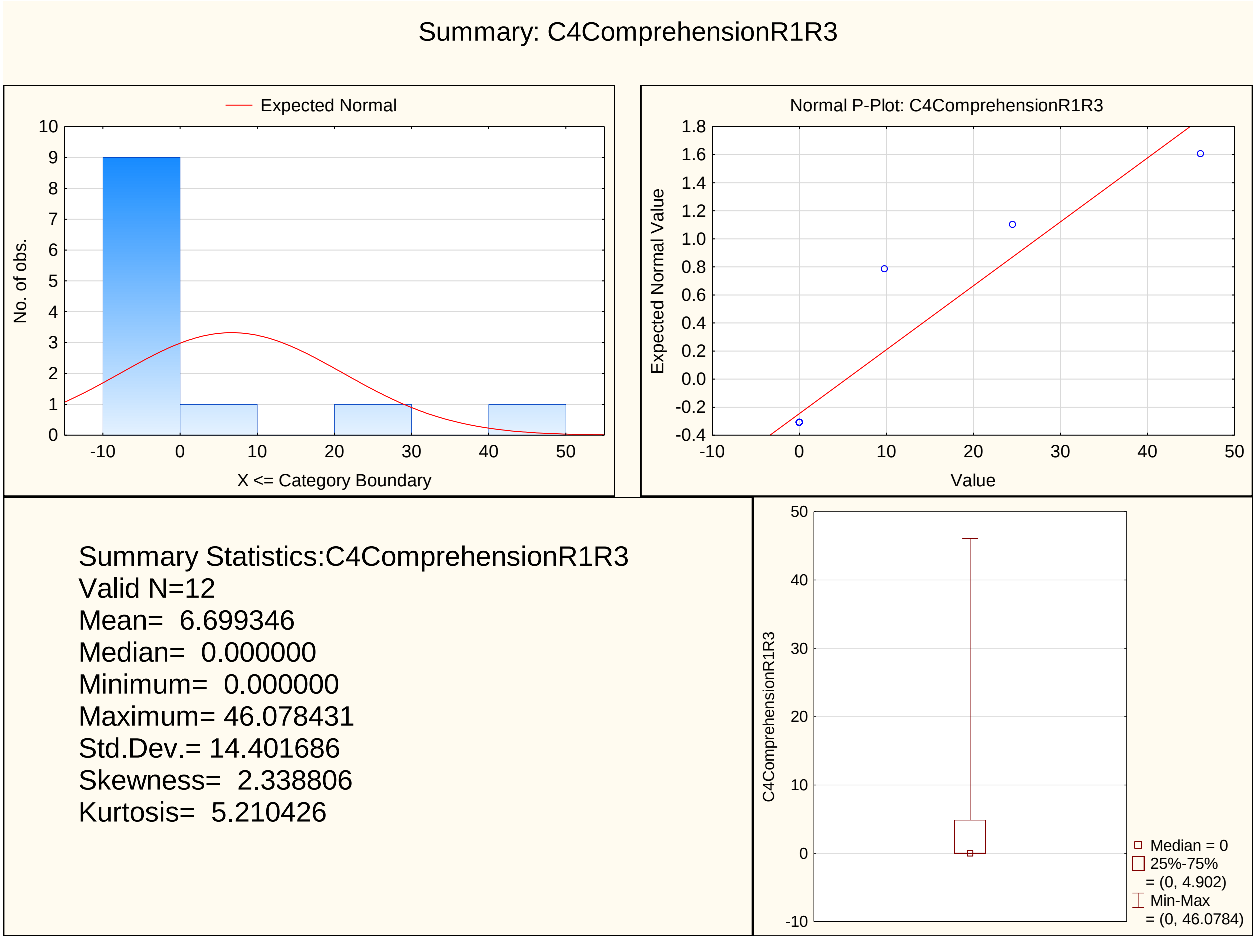
Summary: C4ComprehensionR1R2

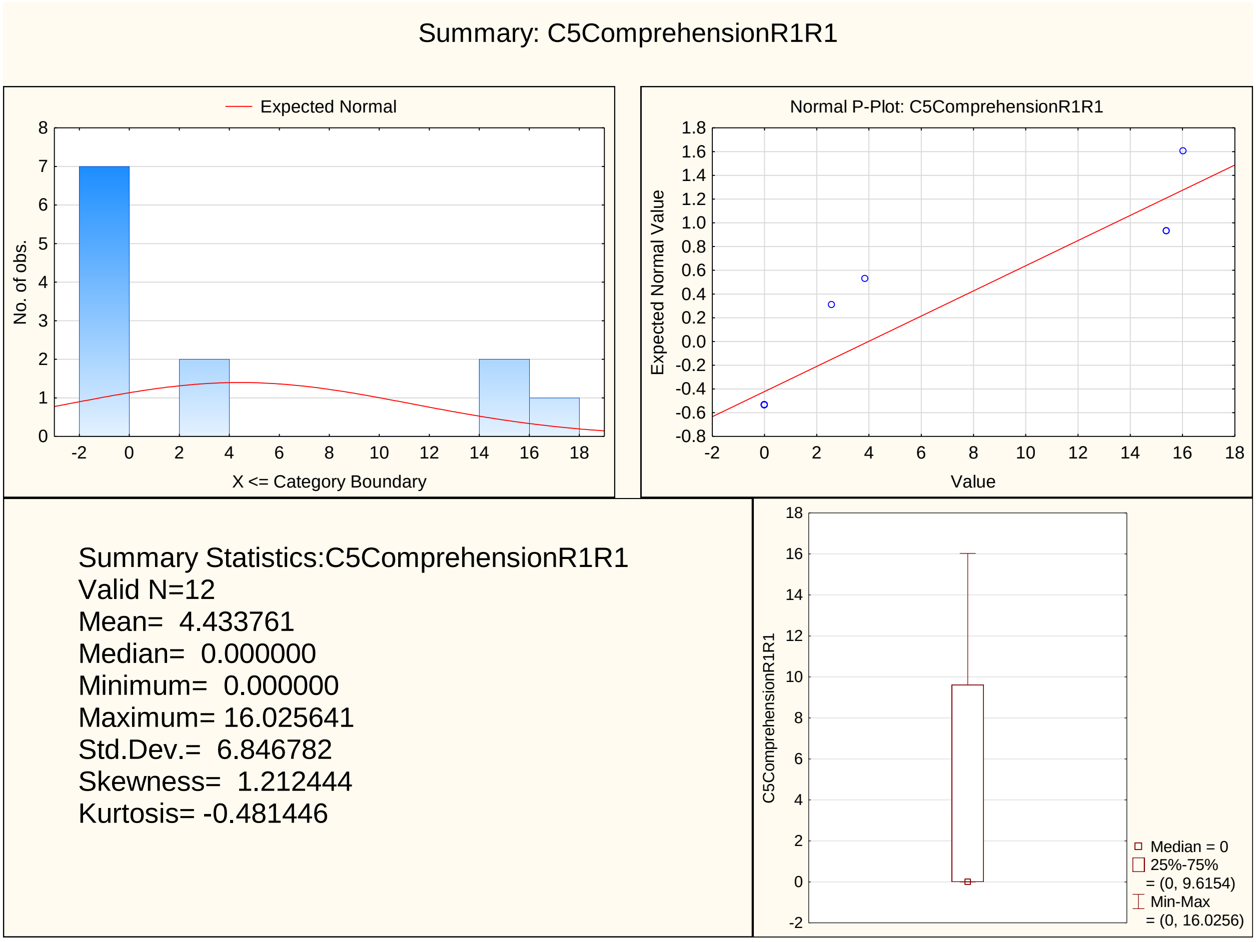




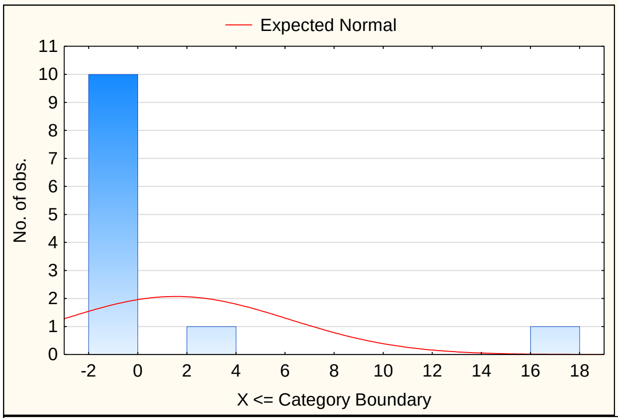
Summary Statistics:C4ComprehensionR1R2
Valid N=12
Mean= 6.236383
Median= 0.000000
Minimum= 0.000000
Maximum= 40.522876
Std.Dev.= 13.046215
Skewness= 2.174938
Kurtosis= 4.165079

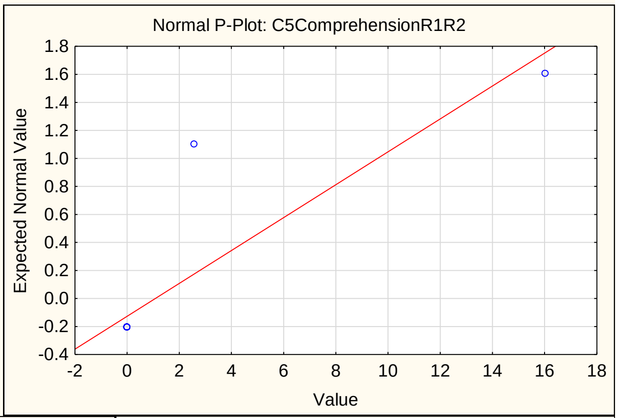



Summary: C4ComprehensionR1R3
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C4ComprehensionR1R3
Expected Normal Value
Value
Summary Statistics:C4ComprehensionR1R3
Valid N=12
Mean= 6.699346
Median= 0.000000
Minimum= 0.000000
Maximum= 46.078431
Std.Dev.= 14.401686
Skewness= 2.338806
Kurtosis= 5.210426
C4ComprehensionR1R3
Median = 0
25%-75% = (0, 4.902)
Min-Max = (0, 46.0784)

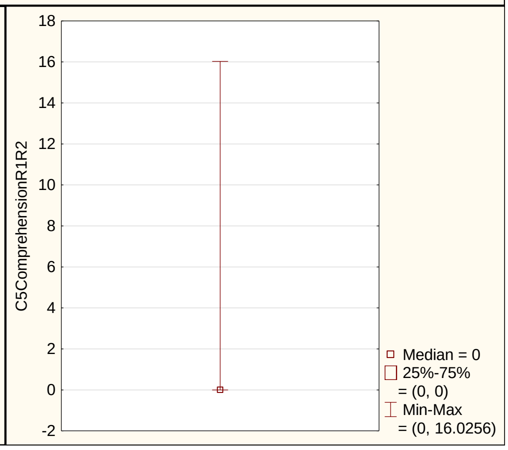

Summary: C5ComprehensionR1R1
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C5ComprehensionR1R1
Expected Normal Value
Value
Summary Statistics:C5ComprehensionR1R1
Valid N=12
Mean= 4.433761
Median= 0.000000
Minimum= 0.000000
Maximum= 16.025641
Std.Dev.= 6.846782
Skewness= 1.212444
Kurtosis= -0.481446
C5ComprehensionR1R1
Median = 0
25%-75%
= (0, 9.6154)
Min-Max
= (0, 16.0256)

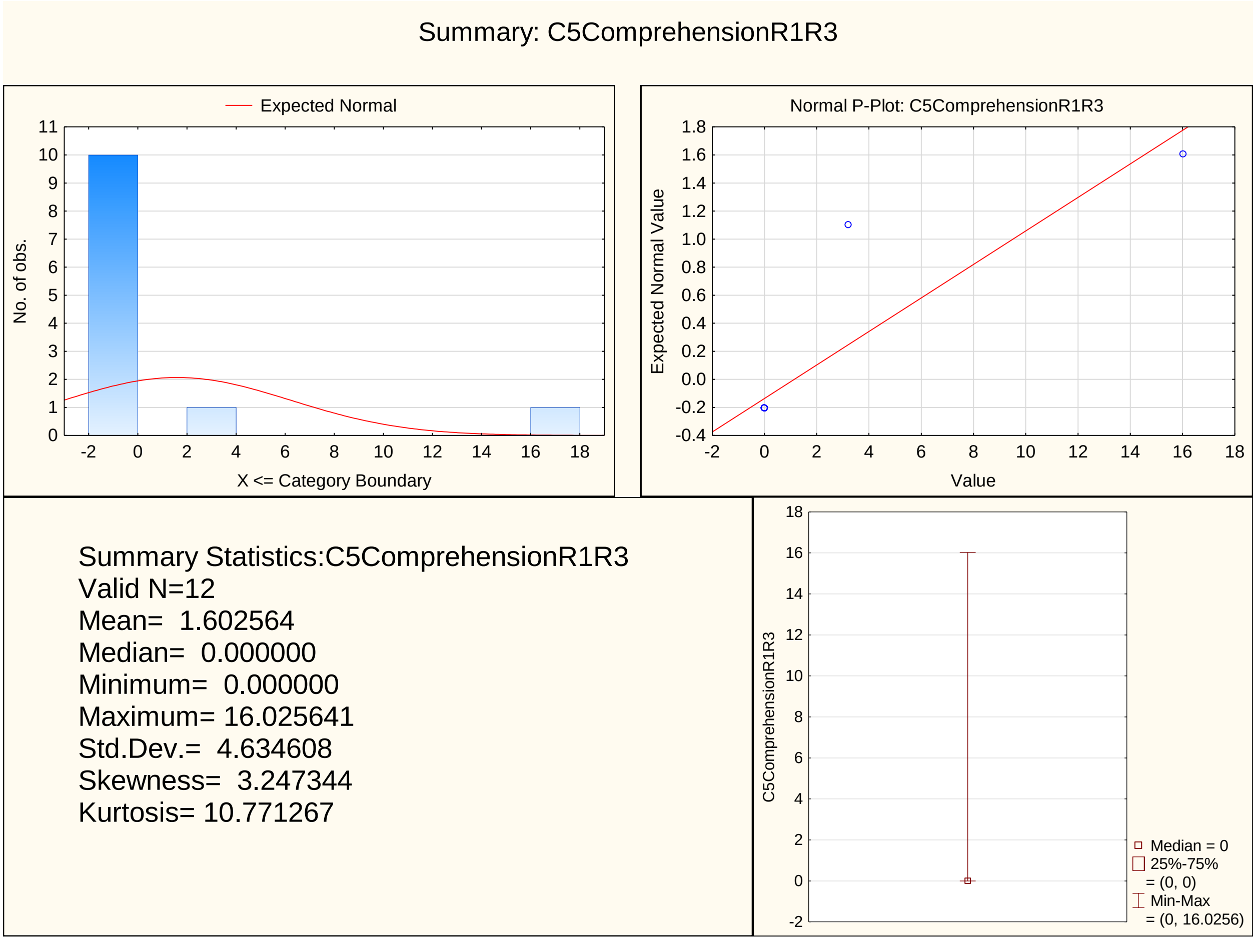
Summary: C5ComprehensionR1R2



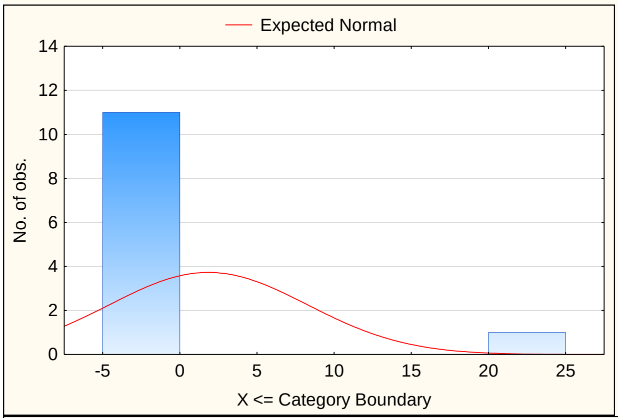


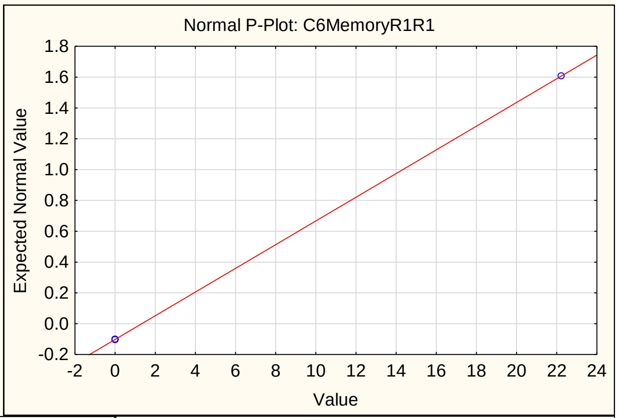
Summary Statistics:C5ComprehensionR1R2
Valid N=12
Mean= 1.549145
Median= 0.000000
Minimum= 0.000000
Maximum= 16.025641
Std.Dev.= 4.618122
Skewness= 3.320315
Kurtosis= 11.202321



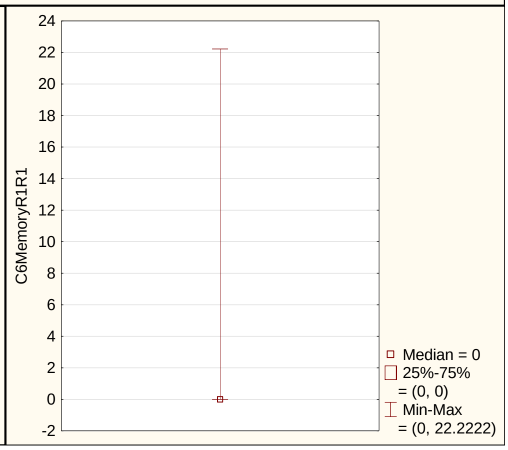

Summary: C5ComprehensionR1R3
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C5ComprehensionR1R3
Expected Normal Value
Value
Summary Statistics:C5ComprehensionR1R3
Valid N=12
Mean= 1.602564
Median= 0.000000
Minimum= 0.000000
Maximum= 16.025641
Std.Dev.= 4.634608
Skewness= 3.247344
Kurtosis= 10.771267
C5ComprehensionR1R3
Median = 0
25%-75%
= (0, 0)
Min-Max
= (0, 16.0256)

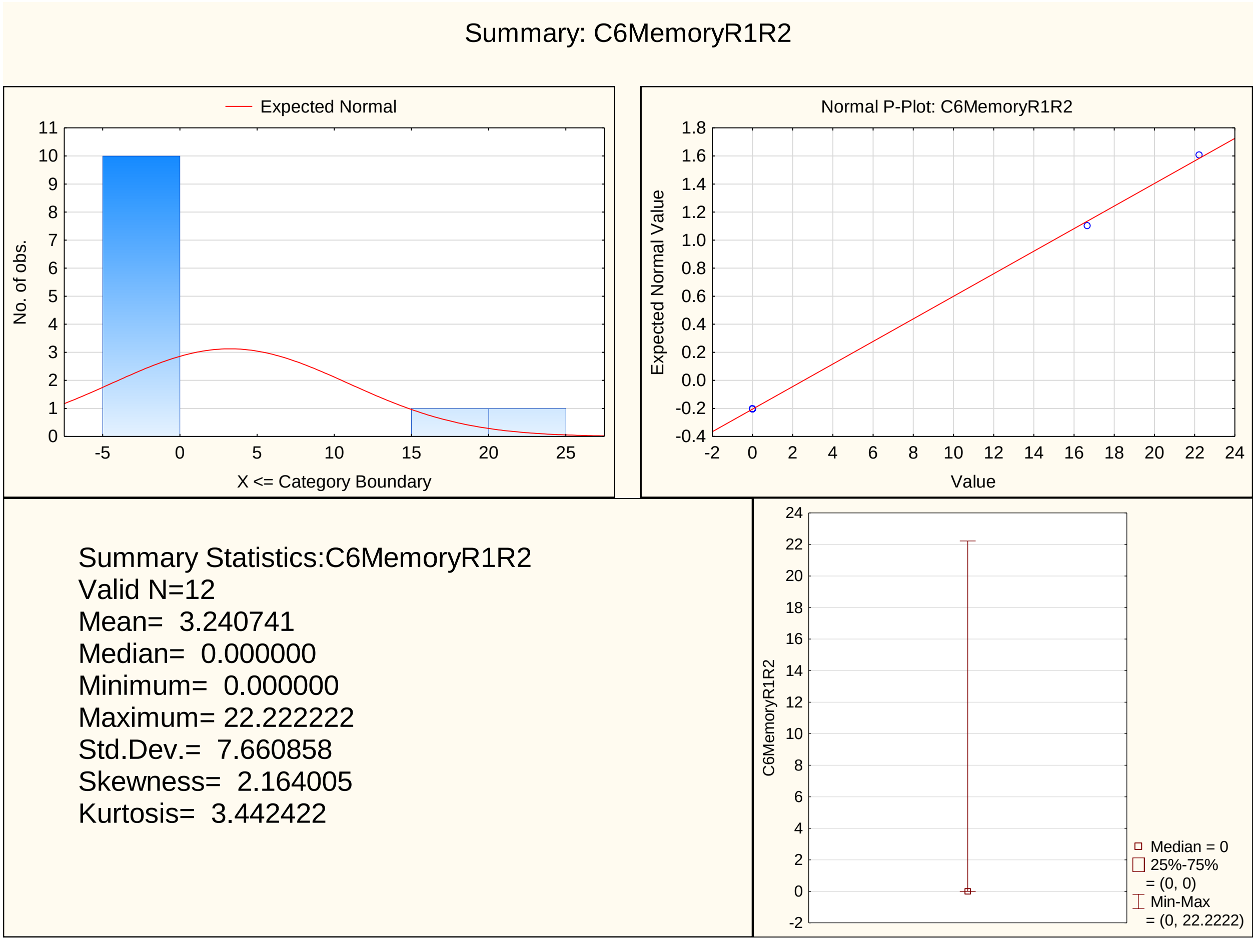
Summary: C6MemoryR1R1



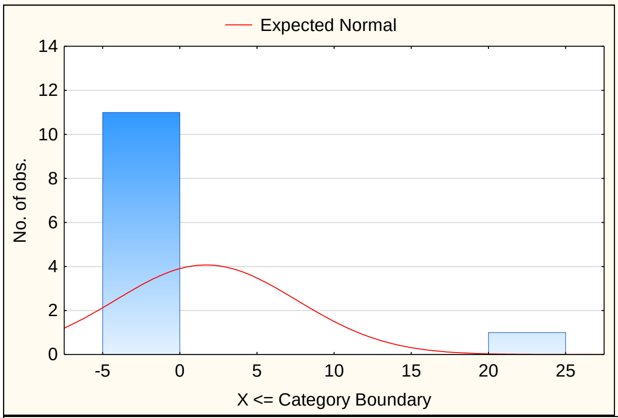


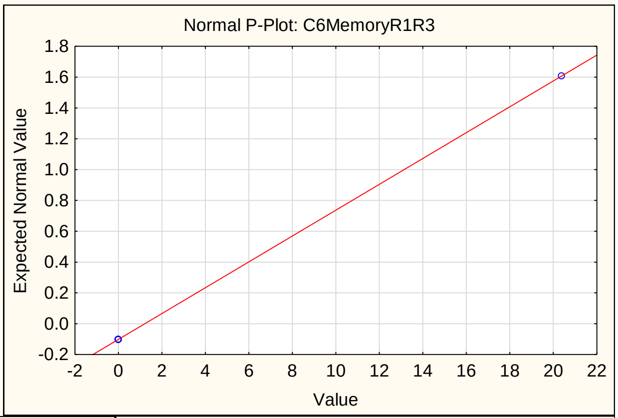
Summary Statistics:C6MemoryR1R1
Valid N=12
Mean= 1.851852
Median= 0.000000
Minimum= 0.000000
Maximum= 22.222222
Std.Dev.= 6.415003
Skewness= 3.464102
Kurtosis= 12.000000



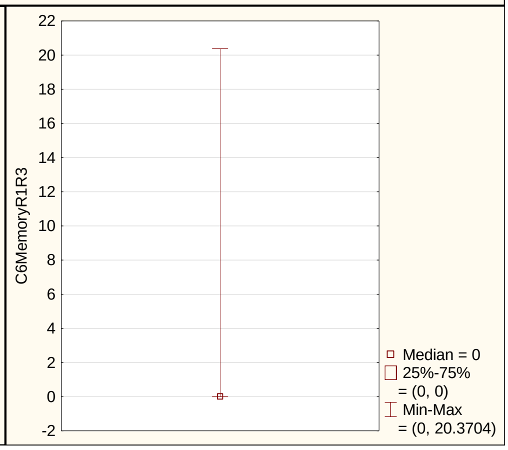

Summary: C6MemoryR1R2
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C6MemoryR1R2
Expected Normal Value
Value
Summary Statistics:C6MemoryR1R2
Valid N=12
Mean= 3.240741
Median= 0.000000
Minimum= 0.000000
Maximum= 22.222222
Std.Dev.= 7.660858
Skewness= 2.164005
Kurtosis= 3.442422
C6MemoryR1R2
Median = 0
25%-75% = (0, 0)
Min-Max = (0, 22.2222)

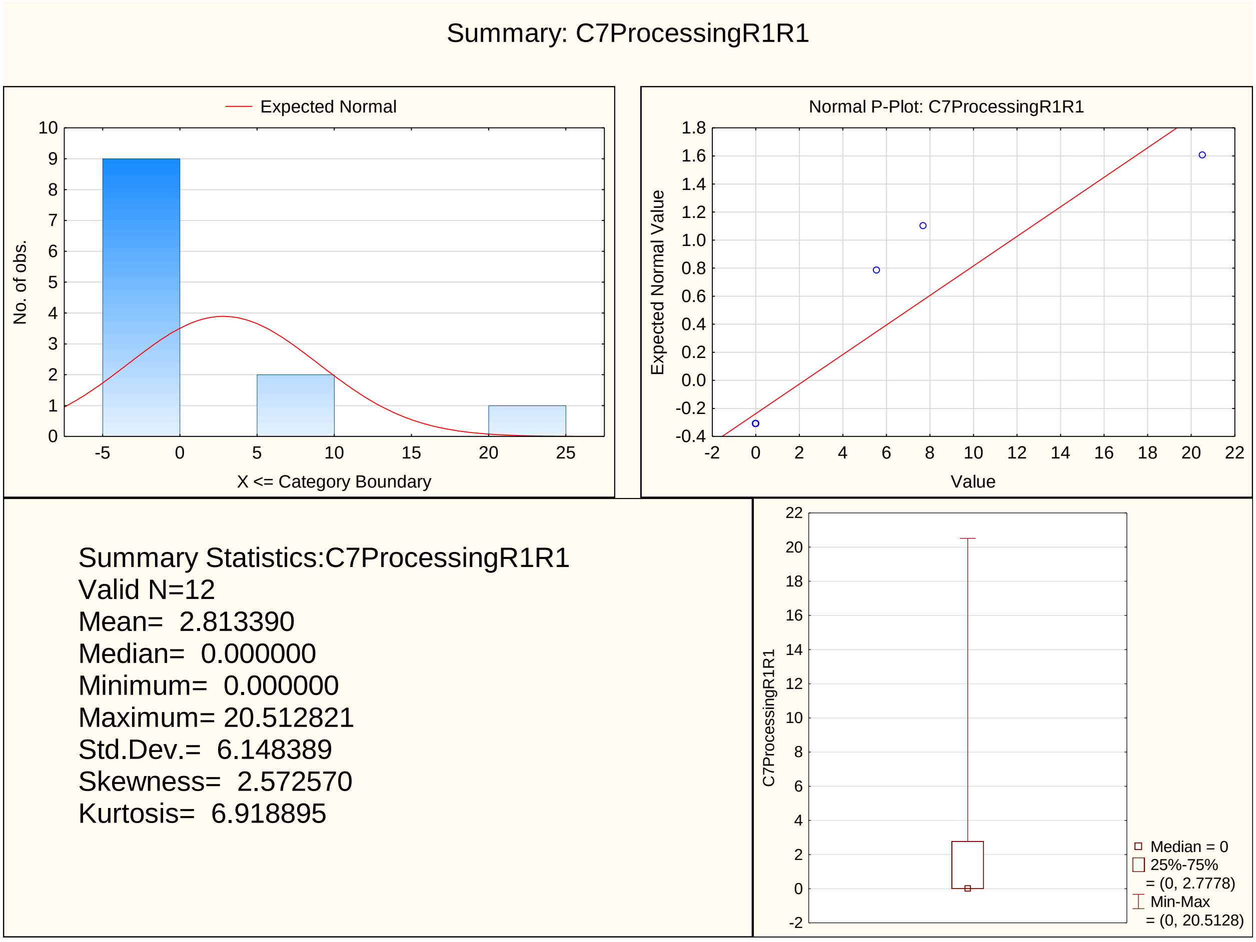
Summary: C6MemoryR1R3



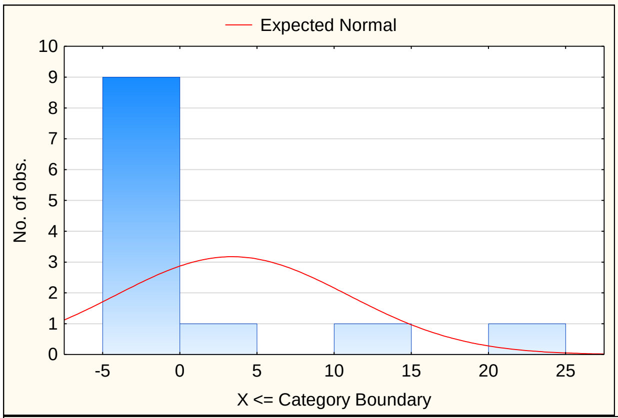


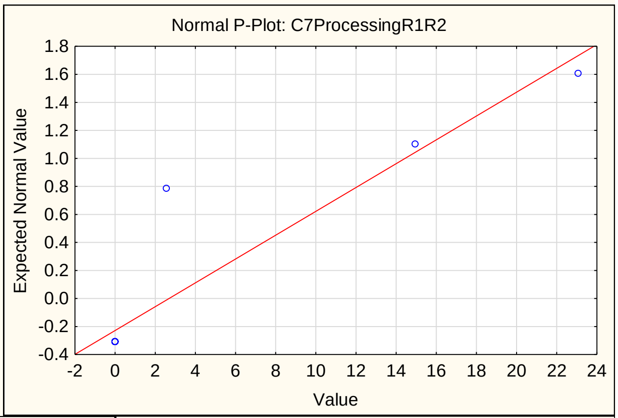
Summary Statistics:C6MemoryR1R3
Valid N=12
Mean= 1.697531
Median= 0.000000
Minimum= 0.000000
Maximum= 20.370370
Std.Dev.= 5.880419
Skewness= 3.464102
Kurtosis= 12.000000



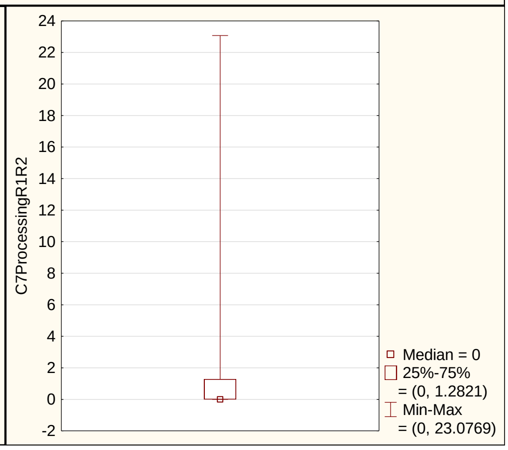

Summary: C7ProcessingR1R1
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C7ProcessingR1R1
Expected Normal Value
Value
Summary Statistics:C7ProcessingR1R1
Valid N=12
Mean= 2.813390
Median= 0.000000
Minimum= 0.000000
Maximum= 20.512821
Std.Dev.= 6.148389
Skewness= 2.572570
Kurtosis= 6.918895
C7ProcessingR1R1
Median = 0
25%-75%
= (0, 2.7778)
Min-Max
= (0, 20.5128)

Summary: C7ProcessingR1R2

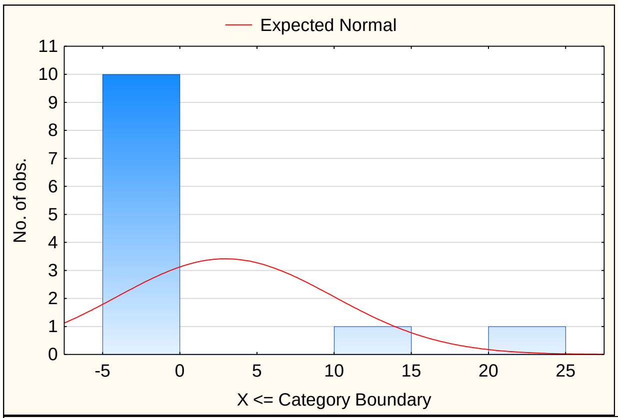


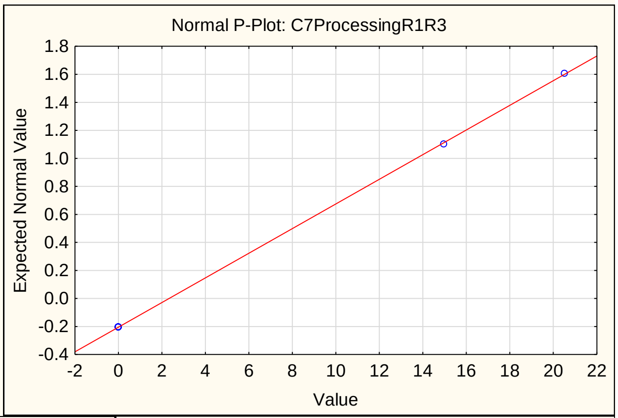


Summary Statistics:C7ProcessingR1R2
Valid N=12
Mean= 3.383191
Median= 0.000000
Minimum= 0.000000
Maximum= 23.076923
Std.Dev.= 7.540720
Skewness= 2.248931
Kurtosis= 4.229480

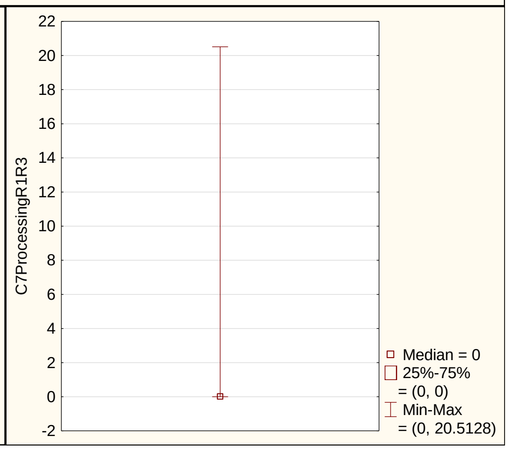


Summary: C7ProcessingR1R3

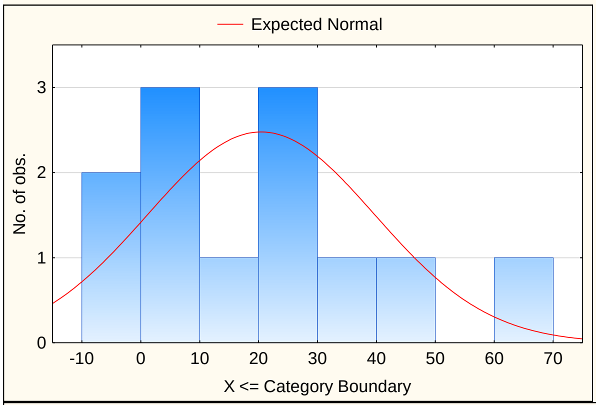


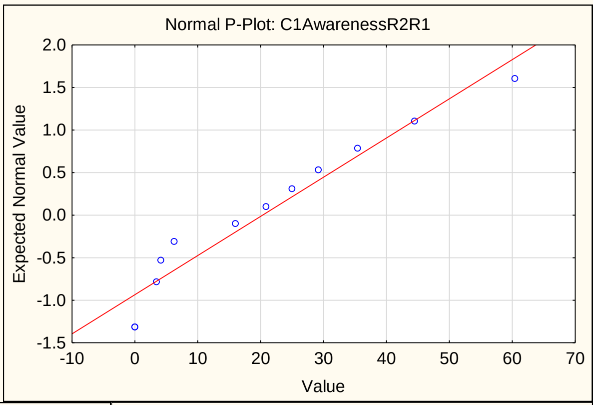


Summary Statistics:C7ProcessingR1R3
Valid N=12
Mean= 2.955840
Median= 0.000000
Minimum= 0.000000
Maximum= 20.512821
Std.Dev.= 7.004230
Skewness= 2.184934
Kurtosis= 3.595702

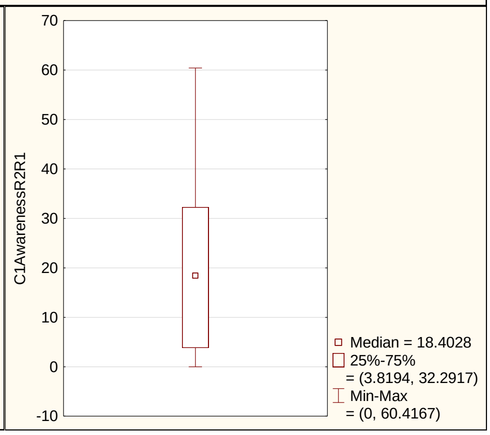


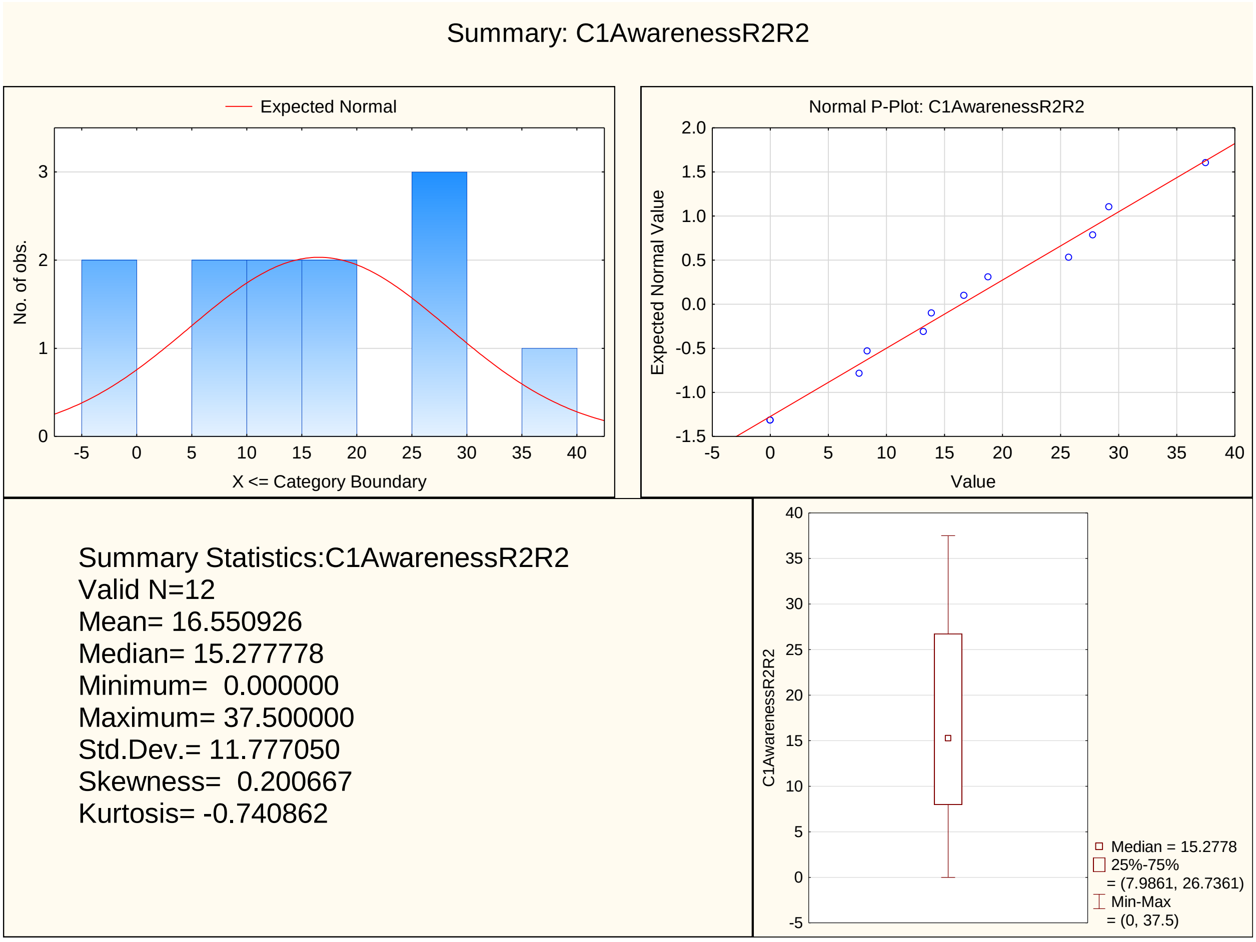
Summary: C1AwarenessR2R1



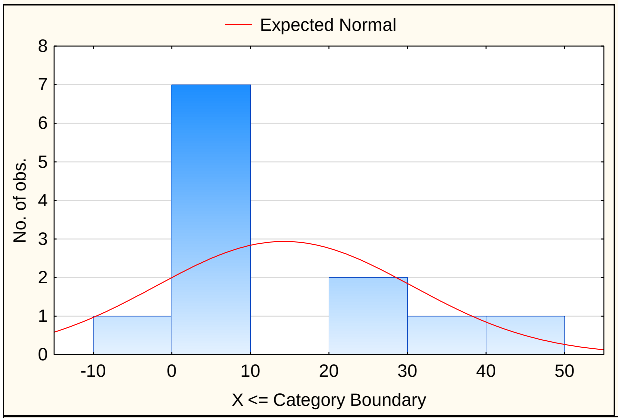


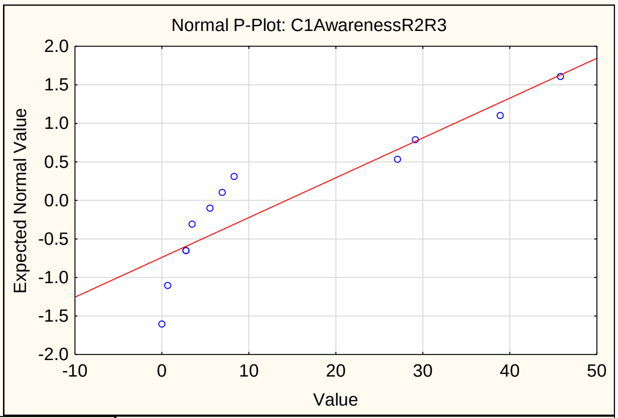
Summary Statistics:C1AwarenessR2R1
Valid N=12
Mean= 20.428241
Median= 18.402778
Minimum= 0.000000
Maximum= 60.416667
Std.Dev.= 19.318809
Skewness= 0.798317
Kurtosis= -0.087289



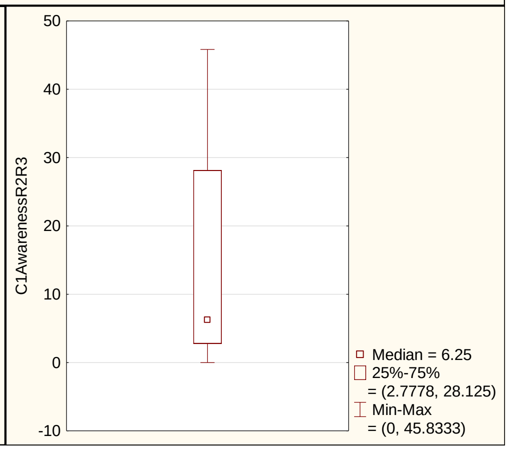

Summary: C1AwarenessR2R2
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C1AwarenessR2R2
Expected Normal Value
Value
Summary Statistics:C1AwarenessR2R2
Valid N=12
Mean= 16.550926
Median= 15.277778
Minimum= 0.000000
Maximum= 37.500000
Std.Dev.= 11.777050
Skewness= 0.200667
Kurtosis= -0.740862
C1AwarenessR2R2
Median = 15.2778
25%-75%
= (7.9861, 26.7361)
Min-Max
= (0, 37.5)

Summary: C1AwarenessR2R3

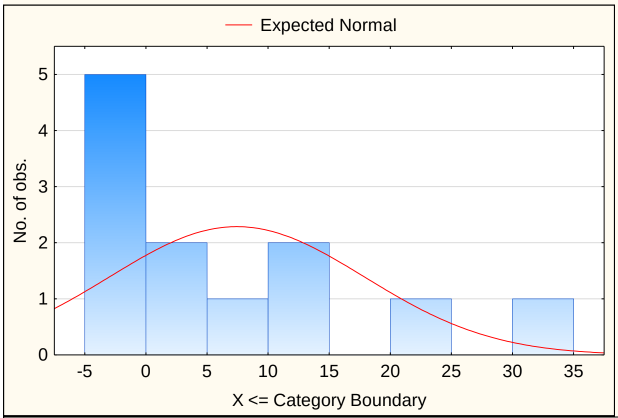


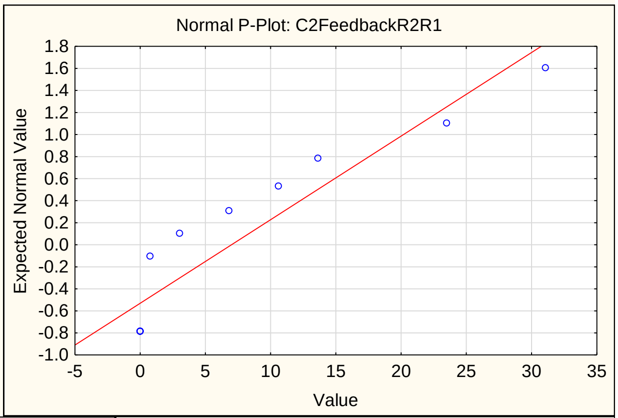


Summary Statistics:C1AwarenessR2R3
Valid N=12
Mean= 14.293981
Median= 6.250000
Minimum= 0.000000
Maximum= 45.833333
Std.Dev.= 16.298163
Skewness= 1.023025
Kurtosis= -0.536214

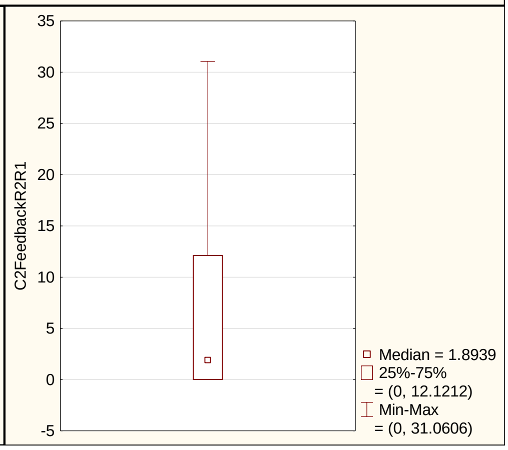


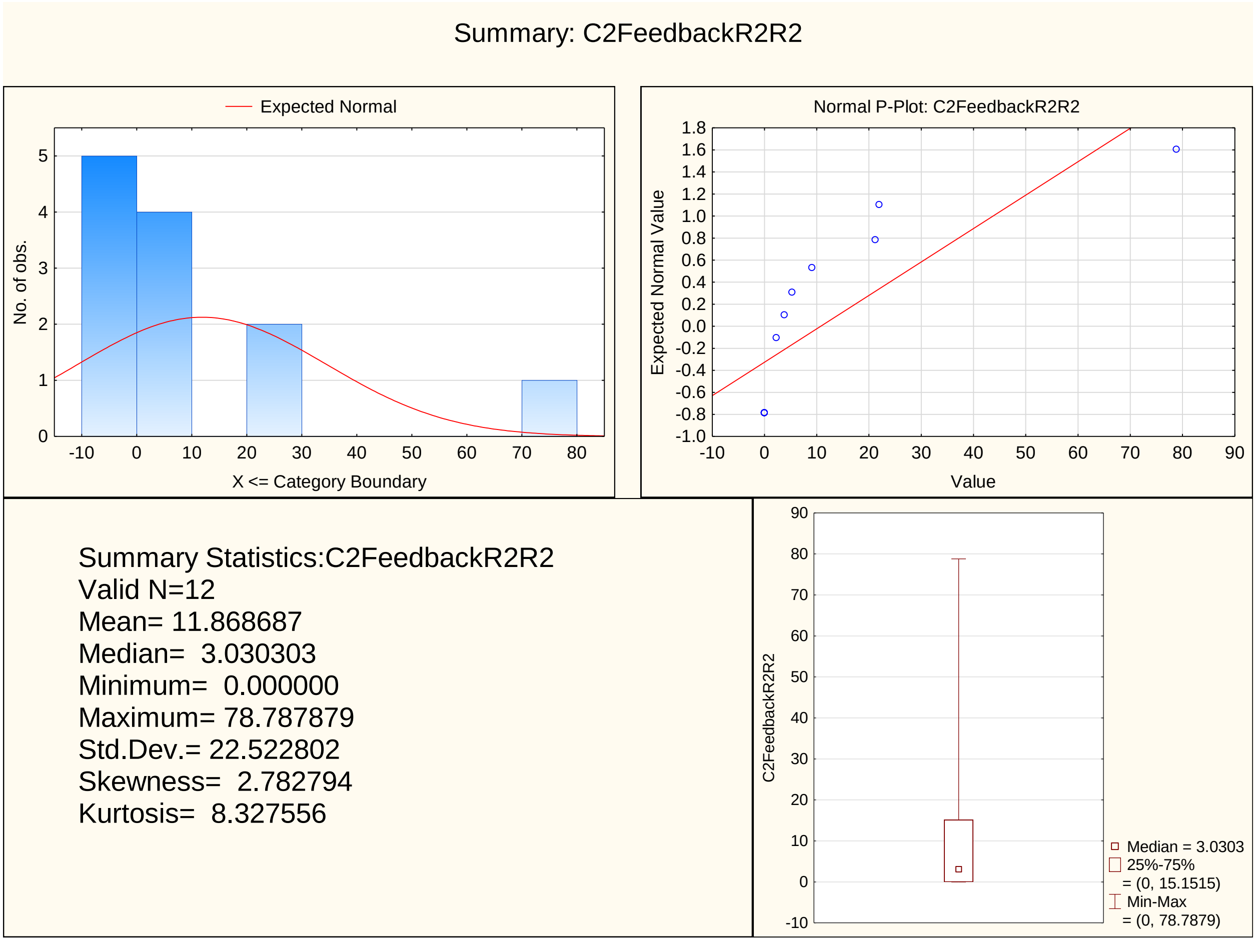
Summary: C2FeedbackR2R1



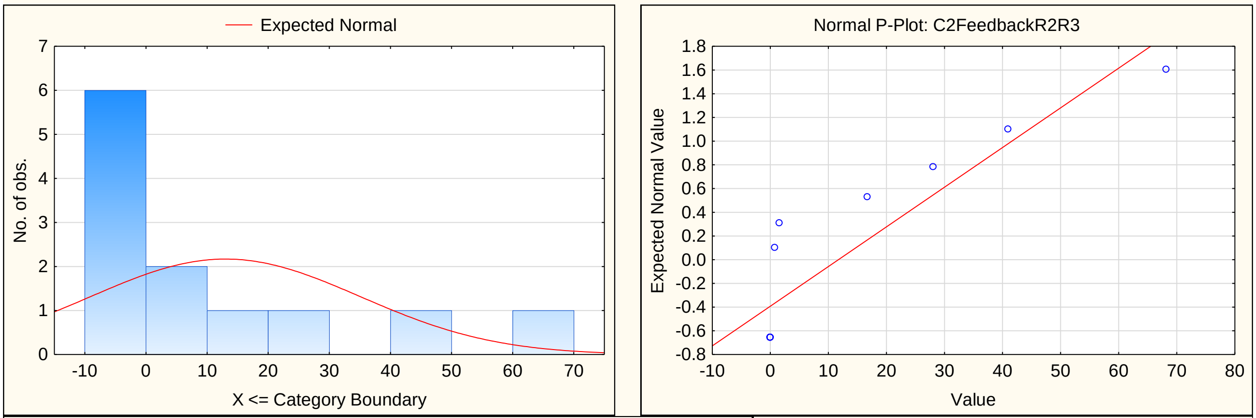


Summary Statistics:C2FeedbackR2R1
Valid N=12
Mean= 7.449495
Median= 1.893939
Minimum= 0.000000
Maximum= 31.060606
Std.Dev.= 10.466583
Skewness= 1.436748
Kurtosis= 1.169569

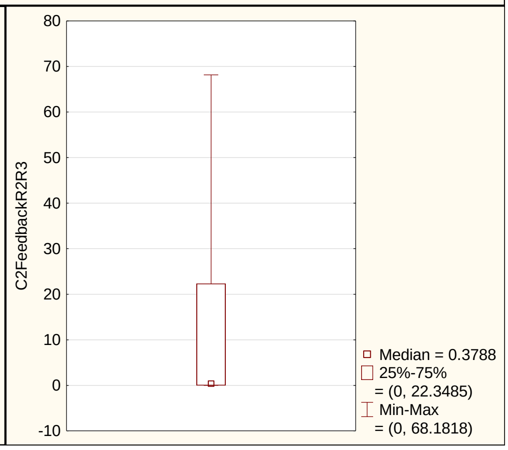



Summary: C2FeedbackR2R2
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C2FeedbackR2R2
Expected Normal Value
Value
Summary Statistics:C2FeedbackR2R2
Valid N=12
Mean= 11.868687
Median= 3.030303
Minimum= 0.000000
Maximum= 78.787879
Std.Dev.= 22.522802
Skewness= 2.782794
Kurtosis= 8.327556
C2FeedbackR2R2
Median = 3.0303
25%-75%
= (0, 15.1515)
Min-Max
= (0, 78.7879)

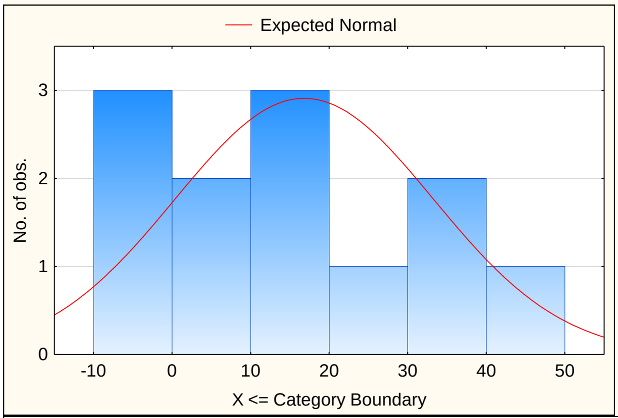
Summary: C2FeedbackR2R3

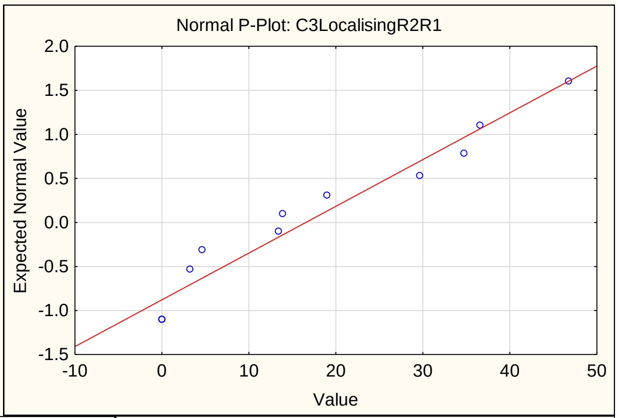


Summary Statistics:C2FeedbackR2R3
Valid N=12
Mean= 13.005051
Median= 0.378788
Minimum= 0.000000
Maximum= 68.181818
Std.Dev.= 22.072367
Skewness= 1.791577
Kurtosis= 2.697023

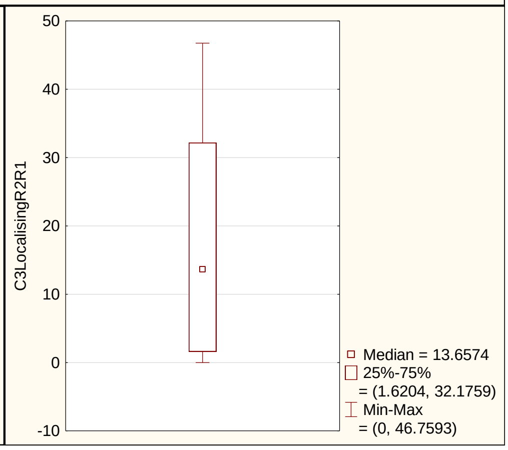


Summary: C3LocalisingR2R1

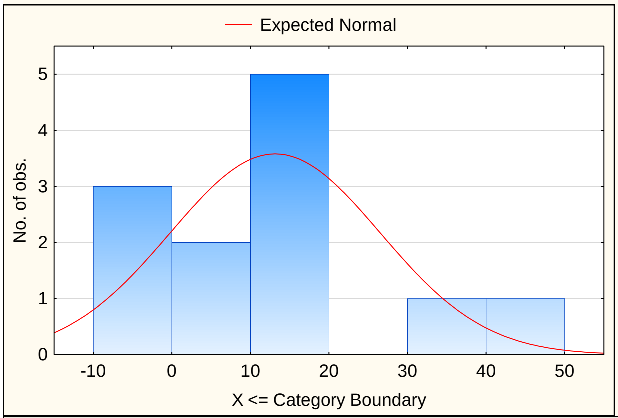


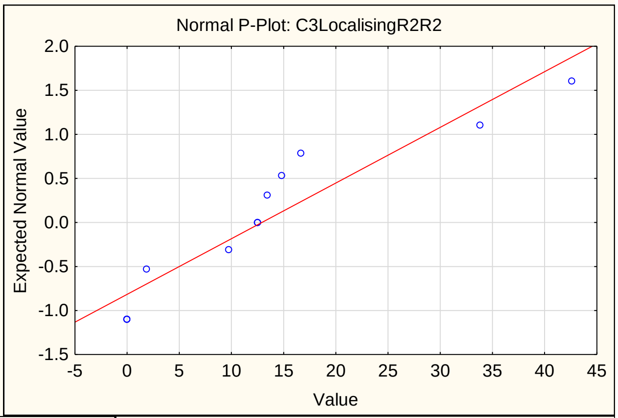


Summary Statistics:C3LocalisingR2R1
Valid N=12
Mean= 16.820988
Median= 13.657407
Minimum= 0.000000
Maximum= 46.759259
Std.Dev.= 16.452910
Skewness= 0.581242
Kurtosis= -1.062108

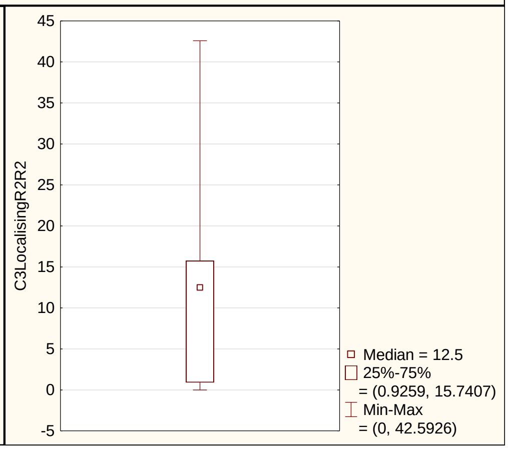


Summary: C3LocalisingR2R2

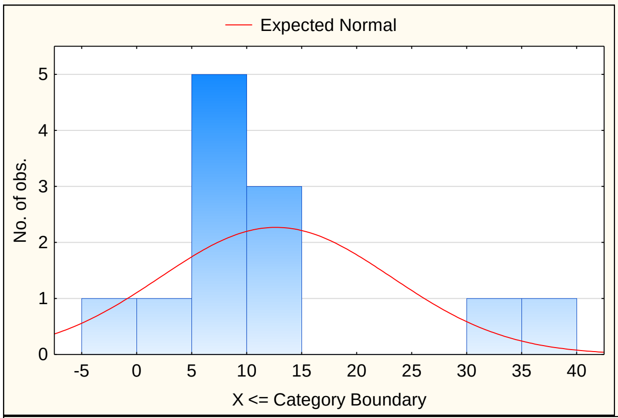


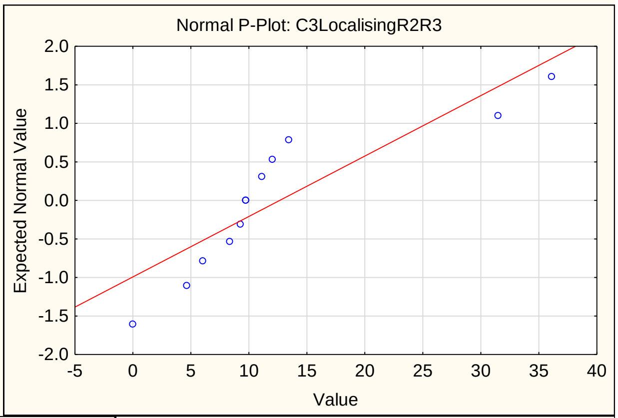


Summary Statistics:C3LocalisingR2R2
Valid N=12
Mean= 13.155864
Median= 12.500000
Minimum= 0.000000
Maximum= 42.592593
Std.Dev.= 13.373517
Skewness= 1.187314
Kurtosis= 1.084196

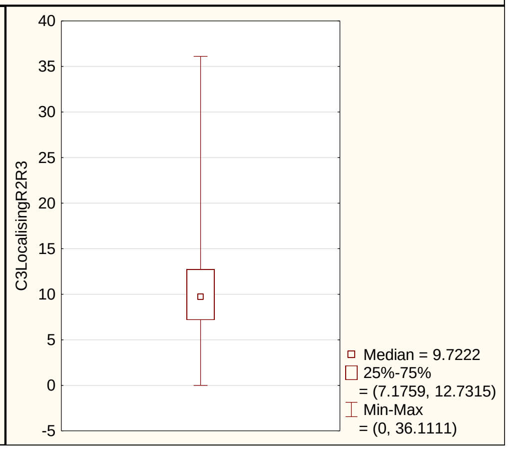


Summary: C3LocalisingR2R3

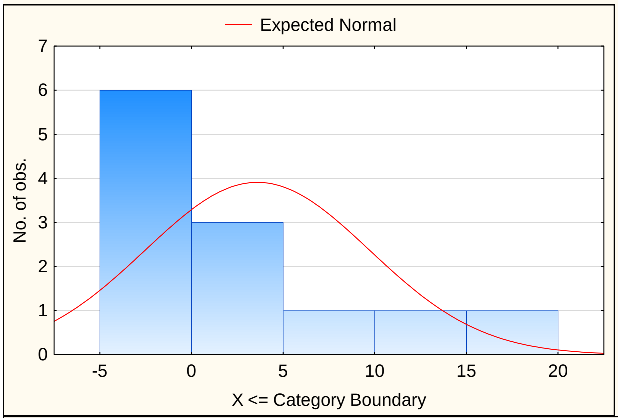


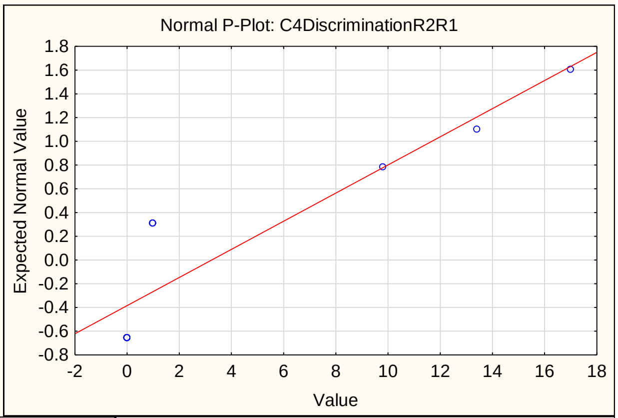


Summary Statistics:C3LocalisingR2R3
Valid N=12
Mean= 12.654321
Median= 9.722222
Minimum= 0.000000
Maximum= 36.111111
Std.Dev.= 10.548563
Skewness= 1.540124
Kurtosis= 1.830497

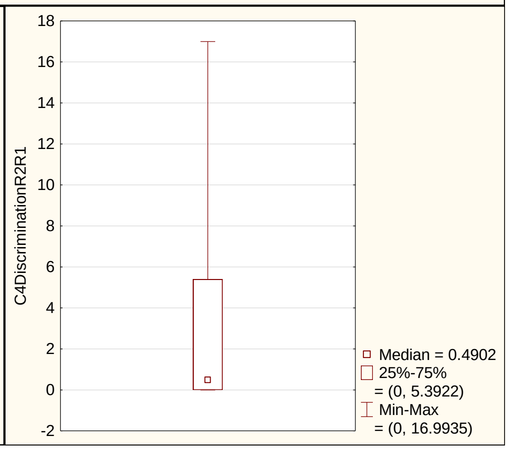


Summary: C4DiscriminationR2R1

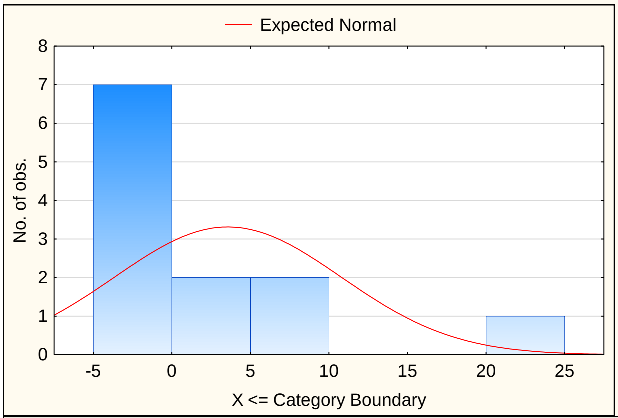


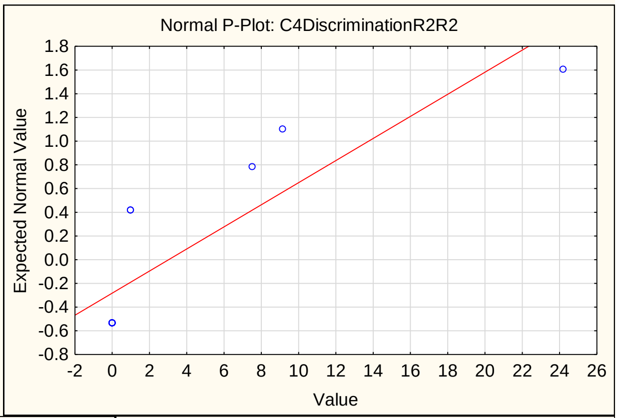


Summary Statistics:C4DiscriminationR2R1
Valid N=12
Mean= 3.594771
Median= 0.490196
Minimum= 0.000000
Maximum= 16.993464
Std.Dev.= 6.121754
Skewness= 1.547686
Kurtosis= 0.914172

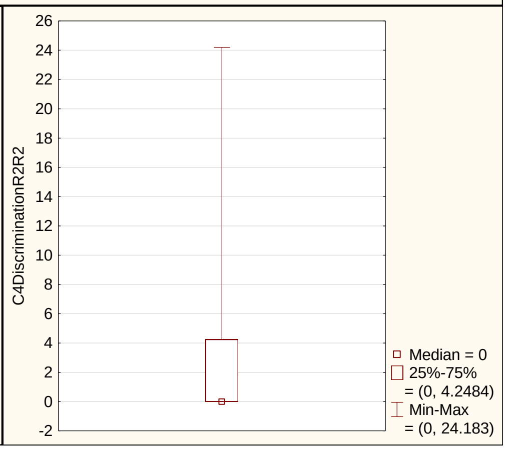


Summary: C4DiscriminationR2R2

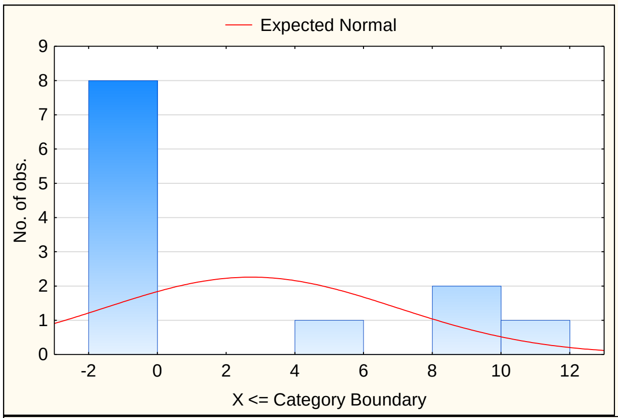


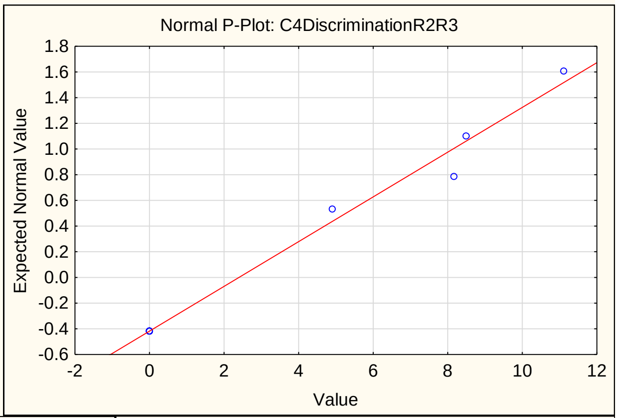


Summary Statistics:C4DiscriminationR2R2
Valid N=12
Mean= 3.567538
Median= 0.000000
Minimum= 0.000000
Maximum= 24.183007
Std.Dev.= 7.225184
Skewness= 2.500278
Kurtosis= 6.551636

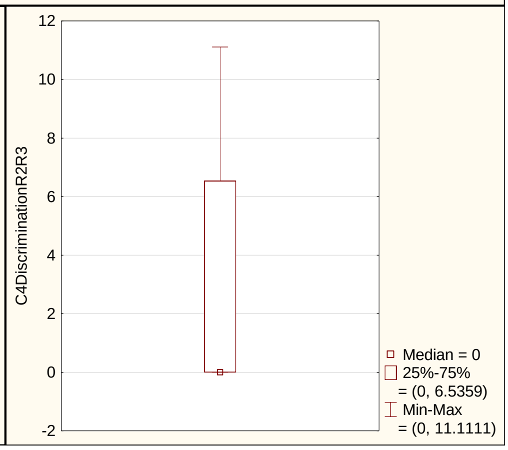


Summary: C4DiscriminationR2R3

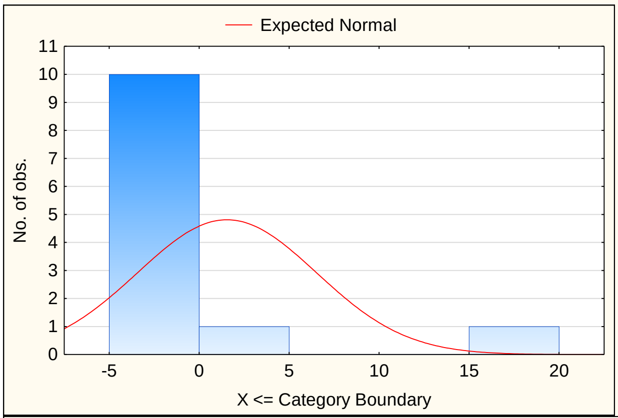


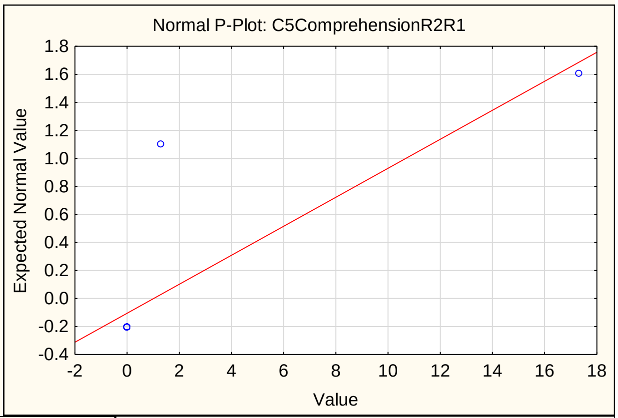


Summary Statistics:C4DiscriminationR2R3
Valid N=12
Mean= 2.723312
Median= 0.000000
Minimum= 0.000000
Maximum= 11.111111
Std.Dev.= 4.236542
Skewness= 1.137566
Kurtosis= -0.411897

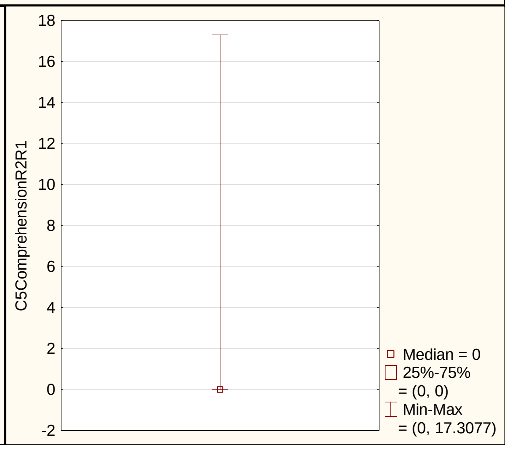


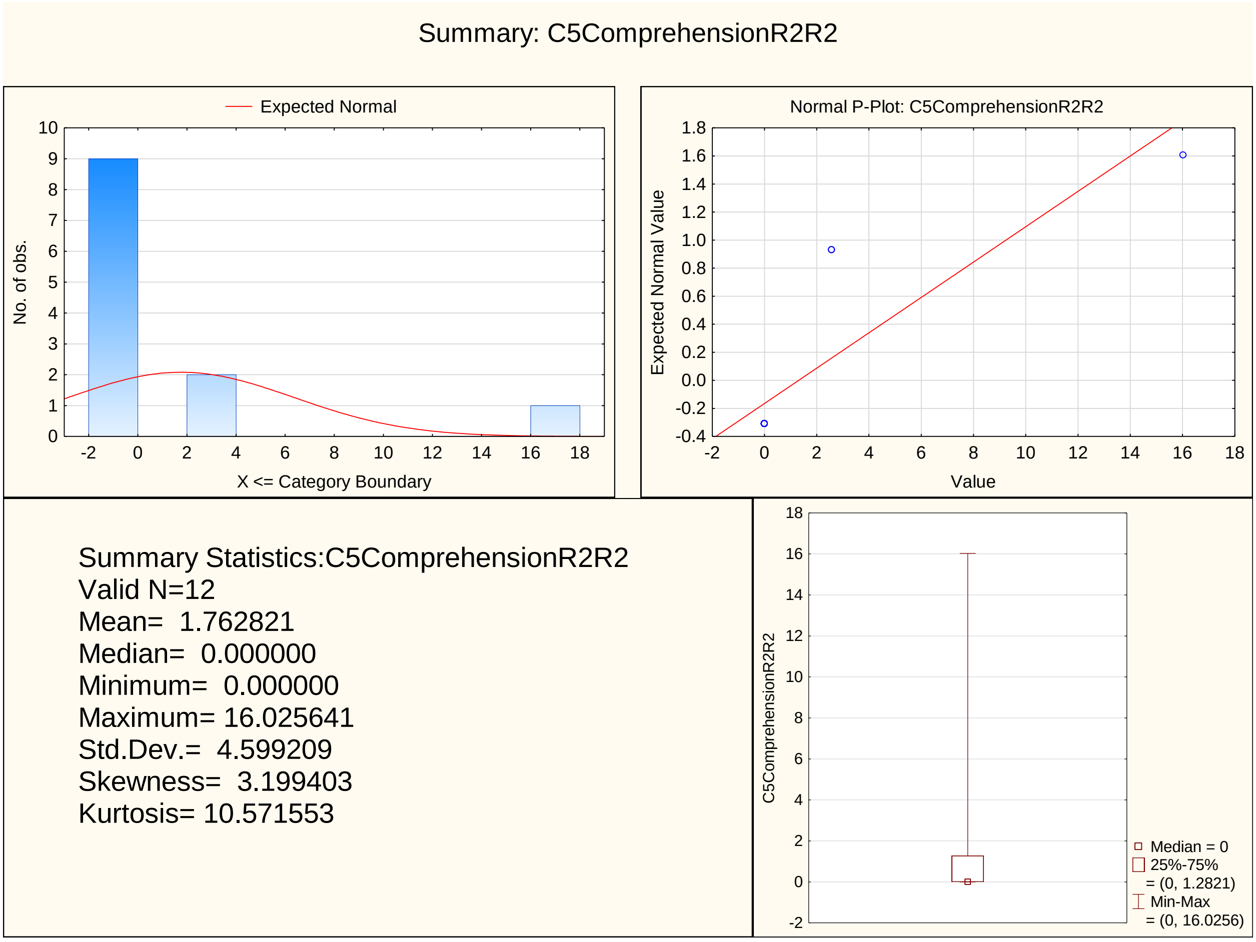
Summary: C5ComprehensionR2R1



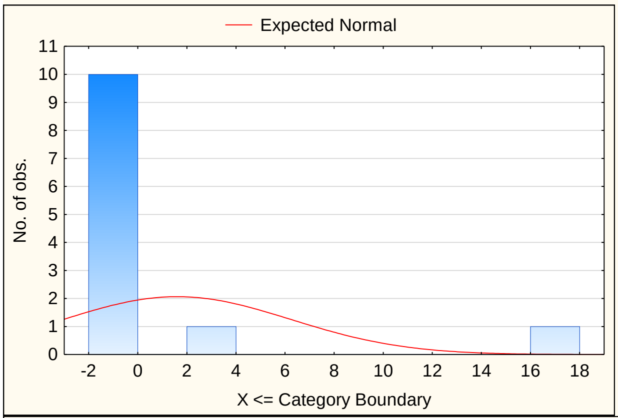


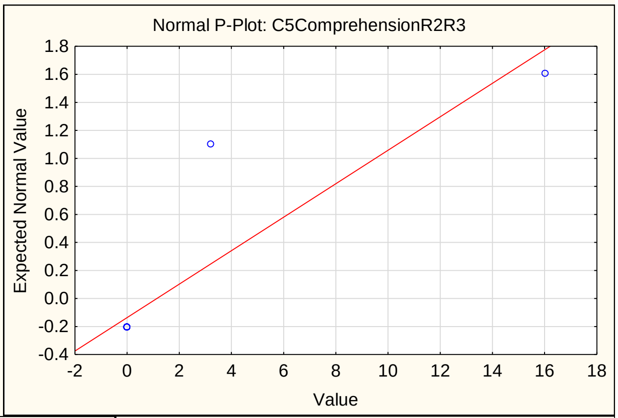
Summary Statistics:C5ComprehensionR2R1
Valid N=12
Mean= 1.549145
Median= 0.000000
Minimum= 0.000000
Maximum= 17.307692
Std.Dev.= 4.976323
Skewness= 3.431340
Kurtosis= 11.827479



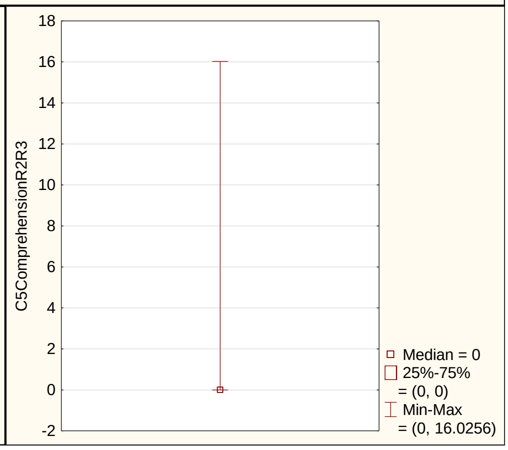

Summary: C5ComprehensionR2R2
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C5ComprehensionR2R2
Expected Normal Value
Value
Summary Statistics:C5ComprehensionR2R2
Valid N=12
Mean= 1.762821
Median= 0.000000
Minimum= 0.000000
Maximum= 16.025641
Std.Dev.= 4.599209
Skewness= 3.199403
Kurtosis= 10.571553
C5ComprehensionR2R2
Median = 0
25%-75%
= (0, 1.2821)
Min-Max
= (0, 16.0256)

Summary: C5ComprehensionR2R3

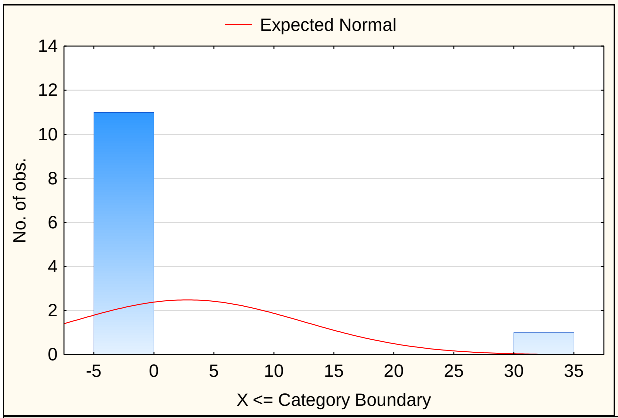


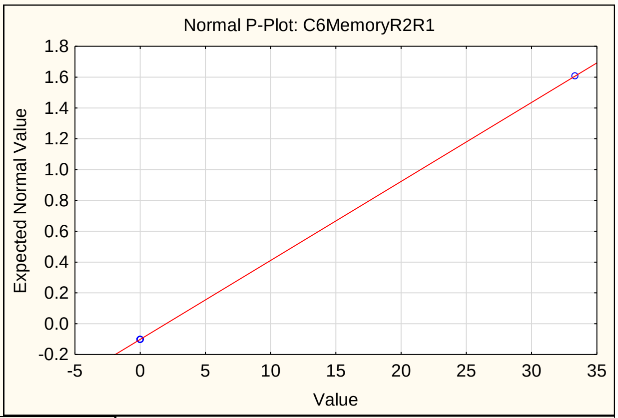


Summary Statistics:C5ComprehensionR2R3
Valid N=12
Mean= 1.602564
Median= 0.000000
Minimum= 0.000000
Maximum= 16.025641
Std.Dev.= 4.634608
Skewness= 3.247344
Kurtosis= 10.771267

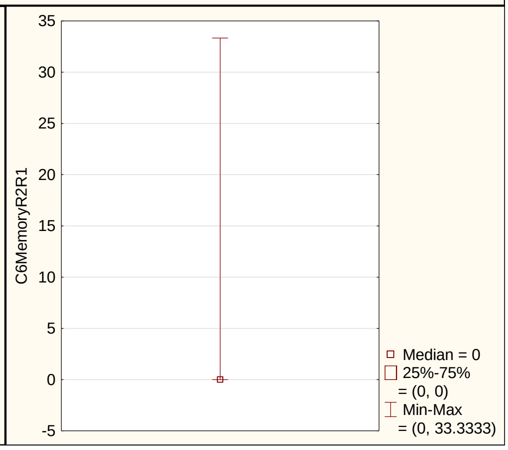


Summary: C6MemoryR2R1

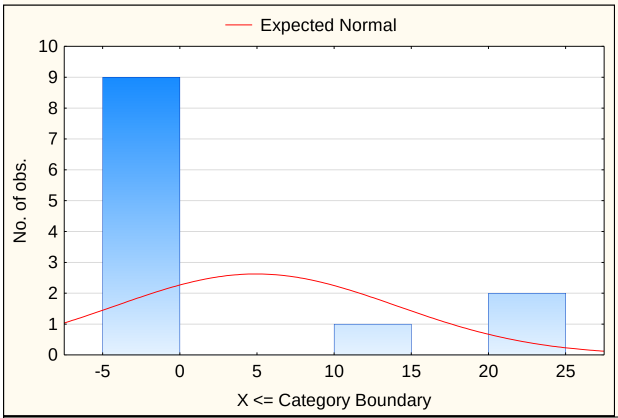


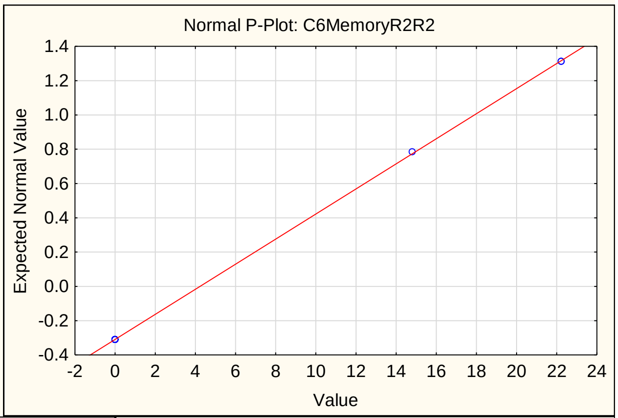


Summary Statistics:C6MemoryR2R1
Valid N=12
Mean= 2.777778
Median= 0.000000
Minimum= 0.000000
Maximum= 33.333333
Std.Dev.= 9.622504
Skewness= 3.464102
Kurtosis= 12.000000

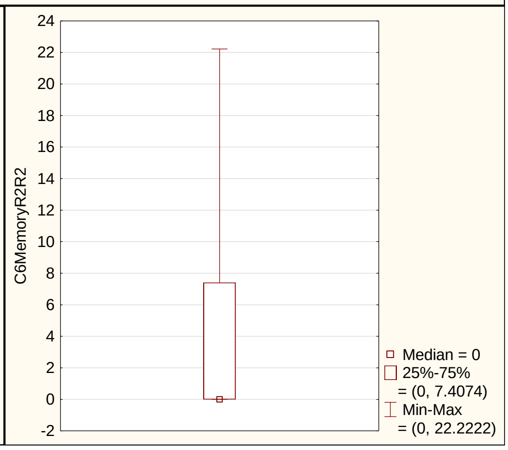


Summary: C6MemoryR2R2

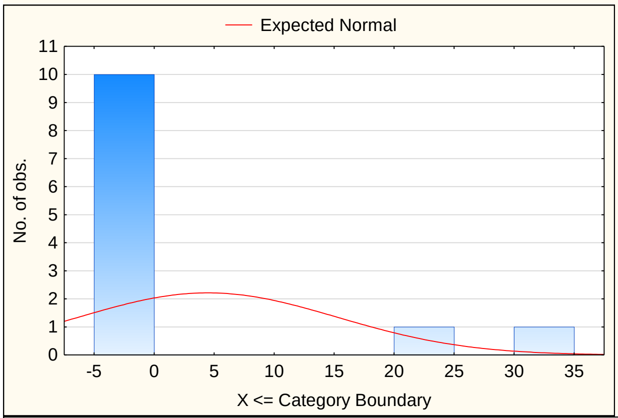


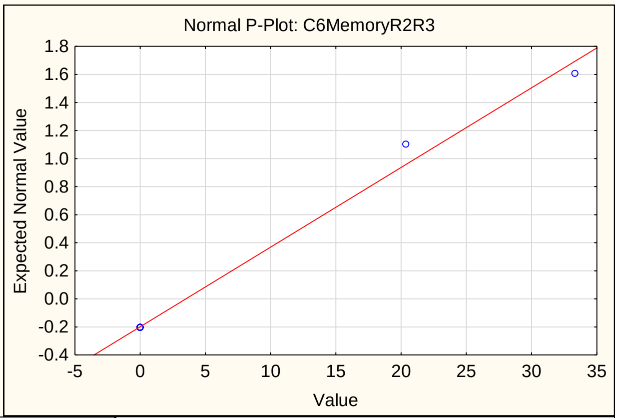


Summary Statistics:C6MemoryR2R2
Valid N=12
Mean= 4.938272
Median= 0.000000
Minimum= 0.000000
Maximum= 22.222222
Std.Dev.= 9.117888
Skewness= 1.468826
Kurtosis= 0.374880

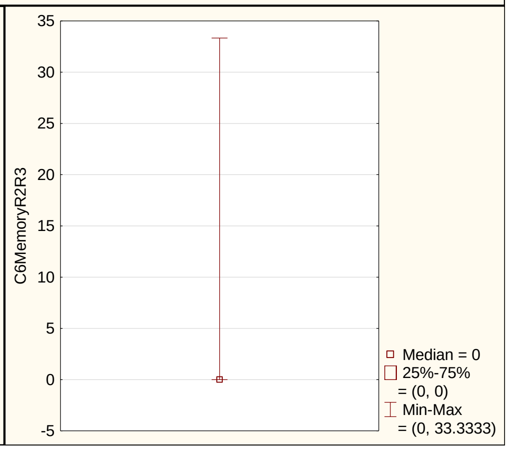


Summary: C6MemoryR2R3

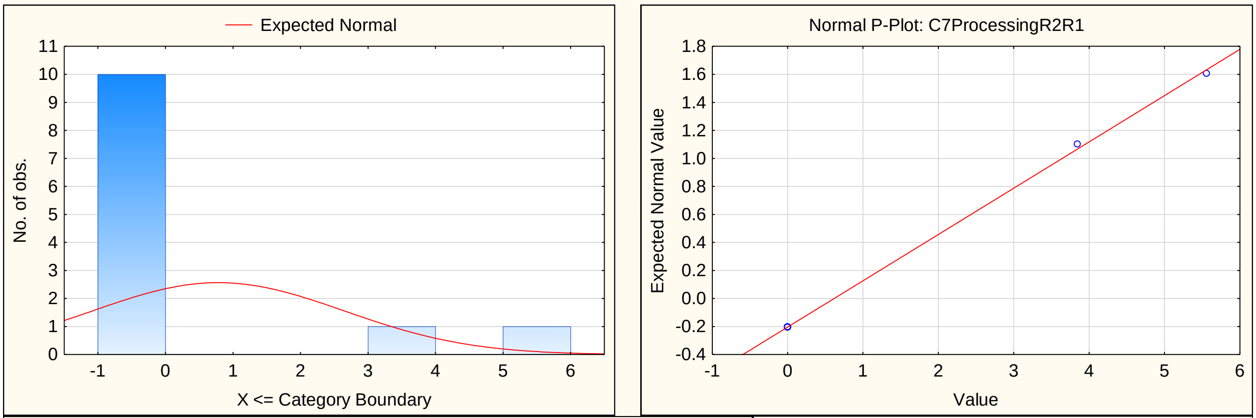




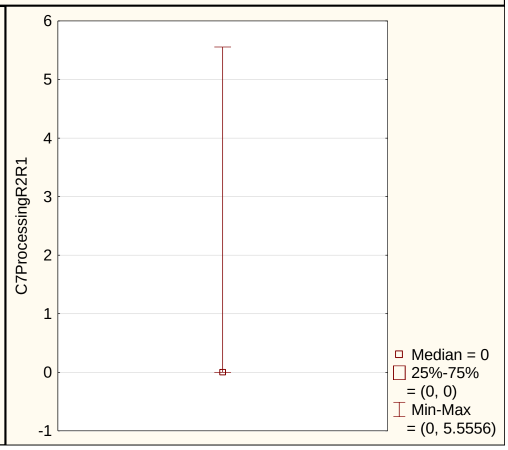
Summary Statistics:C6MemoryR2R3
Valid N=12
Mean= 4.475309
Median= 0.000000
Minimum= 0.000000
Maximum= 33.333333
Std.Dev.= 10.811284
Skewness= 2.344018
Kurtosis= 4.748393



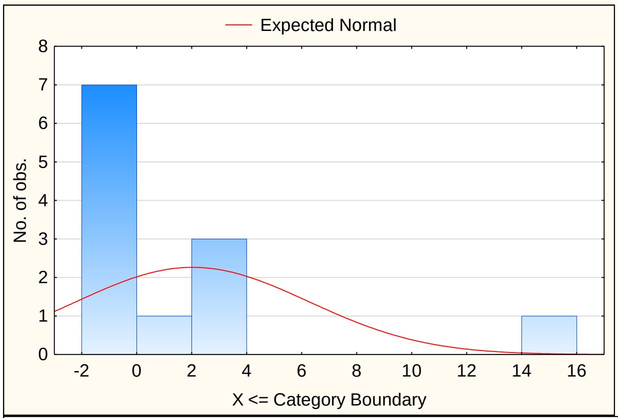
Summary: C7ProcessingR2R1

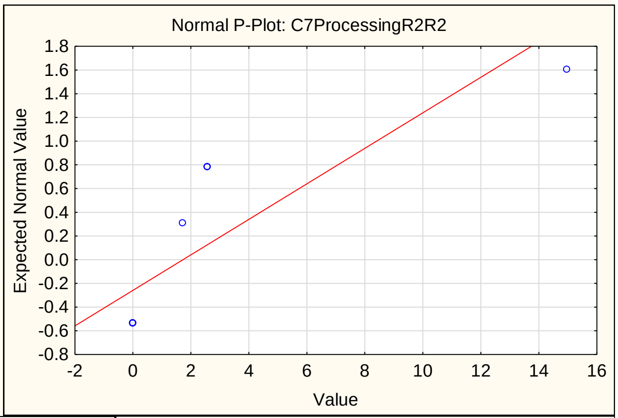


Summary Statistics:C7ProcessingR2R1
Valid N=12
Mean= 0.783476
Median= 0.000000
Minimum= 0.000000
Maximum= 5.555556
Std.Dev.= 1.865746
Skewness= 2.227145
Kurtosis= 3.903706

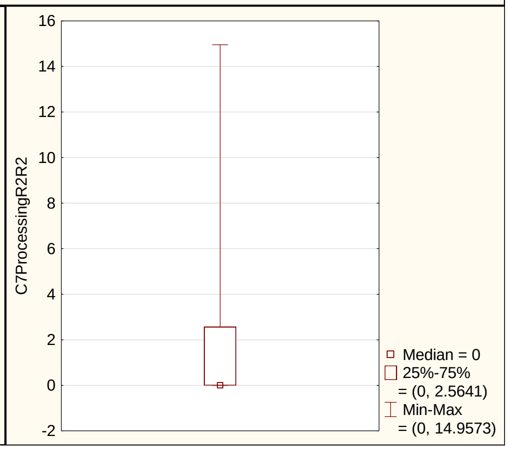


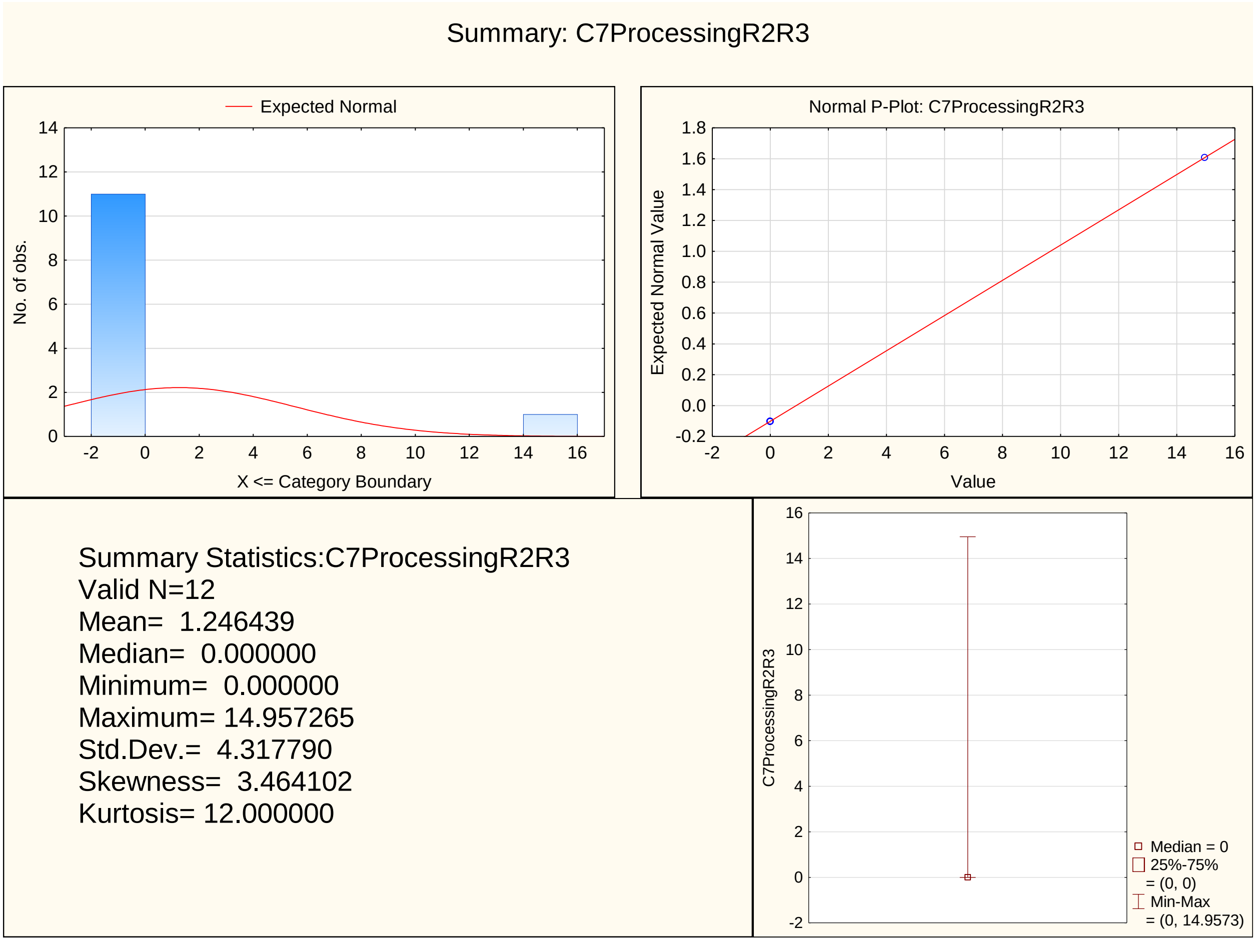
Summary: C7ProcessingR2R2





Summary Statistics:C7ProcessingR2R2
Valid N=12
Mean= 2.029915
Median= 0.000000
Minimum= 0.000000
Maximum= 14.957265
Std.Dev.= 4.231044
Skewness= 3.027816
Kurtosis= 9.757344




Summary: C7ProcessingR2R3
Expected Normal
No. of obs.
X <= Category Boundary
Normal P-Plot: C7ProcessingR2R3
Expected Normal Value
Value
Summary Statistics:C7ProcessingR2R3
Valid N=12
Mean= 1.246439
Median= 0.000000
Minimum= 0.000000
Maximum= 14.957265
Std.Dev.= 4.317790
Skewness= 3.464102
Kurtosis= 12.000000
C7ProcessingR2R3
Median = 0
25%-75% = (0, 0)
Min-Max = (0, 14.9573)