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AUDIOLOGOPEDICS

APD

- Identification and Intervention

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Dansk Resume

Baggrund

Auditory Processing Disorders (APD) er et område som vi i Danmark først har fået øjnene op for for nylig, da en interessegruppe i sommeren 2004 satte fokus på fænomenet.

APD er defineret[1] som vanskeligheder på et eller flere af følgende 6 områder: lokalisering og lateralisering af lyd, auditiv diskrimination, auditiv mønstergenkendelse, temporale aspekter af auditiv processering, auditiv præsentationsaftagen ved tilstedeværelse af konkurrerende akustiske signaler, auditiv præsentationsaftagen ved forringede akustiske signaler (ASHA, 2006). Det er desuden et kendetegn, at ingen af vanskelighederne er forårsaget af perifert høretab. Et af de primære symptomer er vanskeligheder med at forstå tale i baggrundsstøj.

Formål og metode

Jeg har inddelt specialet i tre hovedafsnit. Det første afsnit er et rent teoretisk afsnit, hvor jeg præsenterer APD, kommer med et forslag til en screenings procedure og beskriver testmuligheder med primært fokus på det audiologiske perspektiv. I samarbejde med Teknisk Audiologisk Laboratorium (TAL) kommer jeg med et forslag til et psykoakustisk testbatteri til APD screening. Da det er vigtigt at få børn med APD i behandling tidligst muligt, ser jeg et stort problem i, at børn under 7 år ikke kan medvirke i de nuværende tests. Dette bringer mig til den anden del af mit speciale, som er en empirisk del. Her redegør jeg for min pilotundersøgelse af nogle nyoversatte spørgeskemaer til screening af børnehavebørn, der er under mistanke for APD.

Den tredje og sidste del af mit speciale, er et teoretisk afsnit, hvor jeg beskriver hvilke interventionsmuligheder, der findes for børn med APD. Fokus flyttes altså fra identificering af børnene til selve interventionen og afslutningsvist diskuterer jeg, hvad der skal gøres for at få APD-behandlingen implementeret i det danske sundhedssystem.

Resultater

Mens jeg søgte information om APD, gik det op for mig, at der mangler utrolig meget forskning på dette område. Der findes mange rapporter, der indikerer, hvilken retning udviklingen bevæger sig i, men meget mangler stadig at blive videnskabeligt bevist.

I min målsætning om at komme med et forslag til en screeningsprocedure og til et psykoakustisk testbatteri til APD screening løb jeg ind i problemer, da der ikke eksisterer konsensus på området. Alligevel nåede jeg frem til et forslag både til screeningsprocedure og testbatteri, sidstnævnte i samarbejde med TAL.

Jeg har brugt resultaterne af min pilotundersøgelse til at udarbejde et nyt sæt spørgeskemaer, som findes i specialets appendiks og er klar til at blive implementeret.

Ved at fokusere på intervention og beskrive de eksisterende behandlingsmuligheder kan jeg konkludere, at interventionsstrategier kan opdeles som følger:

1. Optimering af det akustiske miljø ved manipulation af miljøet, signalforstærkning eller tilpasning foretaget af læreren/taleren.
2. Auditiv træning som formel eller uformel træning. Sidstnævnte bør indeholde aktiviteter der træner evnen til auditiv closure, temporal mønstergenkendelse og prosodisk træning, auditiv diskriminationstræning og dikotisk lyttetræning.
3. Kompensatoriske strategier

I min diskussion af, hvad der skal gøres for at få APD-behandlingen implementeret i det danske sundhedssystem, fremlægger jeg et konkret eksempel og en tjekliste til brug i de danske audiologiske afdelinger.

Konklusioner

Der mangler stadig meget forskning på området, og der er utrolig meget vi ikke ved om APD. Men vi ved nok til allerede at kunne hjælpe mange børn med APD, og det haster derfor med at videreformidle denne viden, så vi kan få implementeret et effektivt behandlingssystem i det danske sundhedsvæsen.

[1] Dette er en fri oversættelse af ASHA's definition, som APD-gruppen pt. anbefaler midlertidigt.

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1 Introduction and objective

Human communication requires perception of multisensory information from the external environment and meaningful interpretation by means of complex mental processes involving attention and memory. Hearing is one of the cornerstones of human communication, and it is dependent on complex sound analysis and transmission within the outer-, middle- and inner ear and auditory nerve as well as further processing of the signal in the brain. The inner hair cells transduce sound into an electrical stimulus, which maintains the sound signal's temporal characteristics. This electrical signal is then transmitted to the brain for further processing, which includes pattern recognition and labelling, and subsequent meaningful interpretation is generated in the language domain (Bamiou et al., 2006). This process is, however, not always carried out successfully as many things can go wrong. Here is an example of a child for whom the above mentioned process does not work as smoothly as in the theoretical description:

Lisa, who is seven years old, quickly sits down on her seat in the classroom. She waits for the teacher's instructions. She stares at the teacher and is ready to listen. He says: "Before we start on chapter 5 in the history book, you have to take your math homework out of your blue folder and put it in front of you. I will come around to pick it up in a minute." Lisa takes out her history book and looks at it nervously. She looks around at her classmates to get a hint about what she is supposed to do. The same evening she cries at home and tells her parents that she is stupid and unable to keep up in school. Lisa's mother then calls the school and accuses them of destroying her daughter's self-confidence.

For most children the teacher's message was easy to follow, but for a child like Lisa it was enough to give her a feeling of defeat. Everyday in school, children are asked to listen, be alert and receive messages and instructions. For some children this is a difficult task. In spite of their normal hearing, they still have difficulties processing and understanding the spoken language, especially when lots of information must be received at the same time, in a noisy environment. These children will often be considered "a bit stupid" or " inattentive", but the real explanation might be that they suffer from an auditory processing disorder, in short APD.

1.1 APD – a field in development

Children with APD have always been noticed. Their behaviour makes us suspect that they have a problem, but here in Denmark we have until now been unable to depict the cause of their behaviour and the parents have not been offered any help with their children's difficulties.

Last year when I began writing this thesis, I found it striking that most people I met did not know anything about APD in spite of the fact that they work within a field where this knowledge would be relevant[2]. For many years APD has been more acknowledged abroad than in Denmark - especially in the United States and in Australia, where most of the literature about APD comes from. The consequence of the lack of knowledge in Denmark is that children like Lisa might not have received the proper treatment because the cause of their difficulties could not be identified. Denmark is, however, not the only country with this problem. In the United Kingdom, Hind (2006) found that only a very limited number of the professionals who offered the service of diagnosing APD considered themselves "very well informed about the condition". This underlines the immediate risk of receiving a diagnosis of poor quality or even a wrong diagnosis in the United Kingdom.

During the past year the general knowledge about APD has been increasing, and several conferences have been held in the United Kingdom and in the USA. In Denmark the national interest group, "APD-gruppen", has managed to bring APD into focus. Today, when I tell colleagues what I am writing about they have often heard about APD, are going to attend a course or have already been on a course in APD and would like to know more about my project. The knowledge about the disorder seems to be spreading and the latest development is that APD finally received an official diagnosis from the Danish national Board of Health called DH933B.

1.2 Prevalence

There has been no reported attempt to ascertain the prevalence of APD and so publications refer only to prevalence estimates (Hind, 2006). The exact prevalence would be difficult to determine due to several reasons (Chermak and Musiek, 1997):

1. The first problem is that we still do not have a standard definition of APD and that makes the diagnostic process difficult.
2. The second problem is that children with mild types of APD might stay undiscovered, because they have learned to compensate for the disorder in many situations.
3. The third problem is that since there is not yet agreement on diagnostic markers, it is the tester's interpretation of the test results that decides if it is a case of APD or not.

[2] Generally speaking all areas where the personnel are in contact with children, especially when problems occur, are fields where knowledge about APD is relevant. This will be discussed further later in this thesis.

Auditory Processing Disorder is estimated to affect 2-3% of all children (Chermak and Musiek, 1997). This estimate builds upon the scientist's knowledge of comorbid disorders such as ADHD, learning disabilities and language disabilities, and on their own clinical experience.

Santucci evaluates the prevalence amongst children to be approximately 3-5 % (Bellis 2004), while Bamiou, Musiek and Luxon (2001) report a frequency of 7% and Schminky (2000) adds that APD is seen twice as often in boys as in girls.

Throughout most of the literature the scientists seem to agree with Chermak and Musiek (1997) on a prevalence of 2-3 % and therefore I assume that this is the best estimate.

1.3 The objective of this thesis

With this thesis I wish to inspire other professionals who are working in the field to be more aware of APD. I aim to assist those who need to take the next step in the process in order to make APD screening a reality in the Danish health system. I hope to accomplish this by carrying out the following objective:

1. Present APD and testing possibilities with primary focus on the audiological perspective. I will suggest a screening procedure and in co-operation with Teknisk Audiologisk Laboratorium (TAL), I will present a suggestion for a psychoacoustic test battery for investigation of APD.
2. Submit questionnaires for investigating APD in kindergartens to a pilot study and use the results to propose a set of improved questionnaires ready for implementation.

Then I will move on to examine what happens when children with APD are identified:

3. Describe the intervention possibilities for children with APD.
4. Finally, discuss what kinds of measures need to be taken to get APD screenings implement in the Danish health system.

1.4 Delimitations

APD can be present in both children and adults. This thesis will focus on children, even though much of the information is also true for adults. I have chosen to focus on the children, because I recognise the danger of disregarding, misdiagnosing or mistreating children, because they will not receive the optimal benefit of their schooling and will suffer unnecessary personal defeats, which can affect their self-esteem.

When children with APD are identified they can learn how to compensate for their problems, and their environment can be optimised in order to help them. Early identification furthermore increases the possibilities of using the plasticity of the brain.

This thesis will emphasise the audiological perspective rather than the logopedic- and the psychological perspective. I will take all perspectives into account, but will dedicate more space to the audiological area. I have chosen to do so because it is this area that needs most attention for the APD screening to be implemented in the Danish health system.

1.5 Method

This thesis consists of an introduction, three main parts, followed by a discussion and conclusion. The three main parts include a theoretical part in which I present APD, an empirical part where I make a pilot investigation of two questionnaires, and finally another theoretical part where I move from the issue of identifying children with APD to the issue of intervention once they are found. In the latter part I present the intervention possibilities for APD. This is not a typical disposition because I have chosen *not* to compress all theory into one part, but rather to distribute it according to the logic progression of the topic.

Part 1 is purely theoretical and builds on scientific literature by e.g. Bellis, Jerger and Musiek and apart from this primary literature, I have also been inspired by Andersen (2006), whose pedagogic angle I have found useful.

As I move through the theoretical literature about APD I realise that most theorists- if not all - focus on children in the early years of school, because this is when their difficulties begin to be obvious. I want to look into the possibilities of identifying the children before they enter school in order to prevent them from falling behind like Lisa in the introductory example. In my pursuit of finding means to identify the children with APD as early as possible, I decided to make a pilot study of two carefully chosen questionnaires. This is described in the empirical part 2 of this thesis.

In the third part of this thesis I review the different possibilities of intervention. Similar to the first part this section is purely theoretical and based on scientific literature. In this part I find inspiration in authors such as Bamiou, Campbell, Jerger and Bellis.

In conclusion I would like to direct attention to the fact that I have included a ***glossary*** in the appendix in order to ease the reading.

1.6 Target Readers

My target readers are speech and hearing therapists, but other professionals can benefit from reading this thesis, especially the staff in audiological departments in hospitals. Knowledge of APD is also relevant to school teachers, school nurses, speech therapists, psychologists and

especially kindergarten teachers, who are the first to be confronted with the child's symptoms (except for the parents, of course).

I have made the rather untraditional choice of writing this thesis in English. My main motivation for making this choice is one of personal nature, as I wish to use this thesis when working abroad. The thesis is made from a Danish viewpoint, but even so recommendations and findings in this thesis can be useful abroad as well as in Denmark. One might argue that my choice creates a constraint for the Danish population, as it is only useful to the Danes that are capable of reading and understanding English. This is true to a certain extent, but I find that most of the readers that I target in this thesis will be able to read and understand English. A permission to write my thesis in English can be found in the appendix.

1.7 Terminology – the "C" in APD

Reviewing the literature of APD I have encountered the following abbreviations, which are all synonymous to the same disorder: CAPD, (C)APD and APD.

Some scientists view APD as hearing difficulties that cannot be explained by peripheral hearing loss. This is their reason to keep the C (for "central") in the name (Neijenhuis et al., 2002), but others disagree. On a consensus conference with the American Academy of Audiology (Jerger & Musiek, 2000) an auditory processing disorder was broadly defined as "a deficit in the processing of information that is specific to the auditory modality". The term was hereafter changed from CAPD to APD. The scientists at the conference argued that this would prevent the naming of loci and they find that the interaction between the peripheral and central hearing would be pointed out (Jerger & Musiek, 2000).

ASHA (2006) use the term (C)APD and their wide-ranging description goes like this, "(Central) Auditory Processing Disorder refers to the efficiency and effectiveness by which the central nervous system (CNS) utilises auditory information".

I suggest that we use the term APD in Denmark. I have several reasons for this: One is due to simplicity, another is the fact that the Danish national APD group has already chosen this term, and confusion of terms is certainly of no benefit to the field. Lastly I agree with the outcome of the consensus conference - it does make sense to leave out naming of location.

1.8 Structure

This thesis is divided into three main parts. The first main part begins with chapter 2, where I open with a short statement about auditory processing. Chapter 3 presents how scientists have not yet reached consensus on neither definitions nor diagnostic markers, and consequently not on

what is to be considered APD and what is a comorbid condition. Chapter 4 describes what is presently considered to be causes, risk factors and indicators of APD, and chapter 5 touches on the problematic field of dividing APD into profiles. Chapter 6 initiates the wide area of describing the investigative and diagnostic process, and it should be noted that the audiological part of the screening process is at all times my primary focus. This chapter concludes the first theoretical part of the thesis.

Chapter 7 constitute the second main part of the thesis, and here I submit two pilot study questionnaires for screening kindergarteners who are thought to suffer from APD. I aim to make empirically founded criticism and suggestions for two new and better questionnaires, which I will present to the Danish interest group, “APD-gruppen”, when this thesis has been finalised. In this chapter I draw conclusions upon the problematic field of identifying and diagnosing the children.

In the third part of this thesis, chapter 8, I expand on the issue by describing the intervention possibilities for children with APD. In the discussion in chapter 9 I address the issue of how to take the necessary action for APD-screenings to be implemented in the Danish health system. In chapter 10 I conclude upon all of my findings.

2 Auditory Processing

To understand APD it is necessary to understand normal hearing processes. I presume that my readers are familiar with the peripheral hearing processes that occur in the outer-, middle- and inner ear. My starting point is therefore a review of some central processing abilities, and this will be followed by a review of the Central Auditory Nervous System (CANS).

The human auditory system provides us with vast amounts of information about the world around us. Central auditory processing is the CANS's ability to process and use incoming auditory signals. Physical characteristics as frequency, intensity and temporal features are analysed, and we perceive these characteristics as the pitch, volume and duration of the sound. Based upon these signals the brain creates an image of the sound. This image will be compared to already stored sound images, and if the newly created sound image matches one of the existing ones we understand what is being said – that is, we recognise the meaning of the sound (Schminky, 2000).

To perform the function of locating a sound, the brain uses a phenomenon called auditory coherence, which means that the brain combines temporal features (or more specifically delay or phase) and amplitude information (intensity) from the sound with information from our other senses (Rubel, 1989). Auditory coherence becomes possible when the auditory pathways cross over to the opposite side. Then the auditory system can compare spatial, intensity related and temporal stimulus features from both ears. This plays a significant role in our ability to listen under adverse conditions (Katz, 2002).

Internal redundancy is an over-capacity in the auditory pathways of the brain. External redundancy in spoken language builds upon the assumption that spoken language is perceived on the basis of both the acoustic signal (bottom-up-processing) and on the listeners predictions based on the context and knowledge (top-down-processing). Because of the internal- and the external redundancy the normal hearing listener is usually capable of making an assumption and performing auditory discrimination, even though there might be missing parts of the auditory signal (Katz, 2002). If, however, an individual suffers from APD this ability is compromised (Bellis, 1996), the person will experience problems especially in situations where speech is mixed with noise.

The following sections explain the physical background and how the brain processes the relatively simple pieces of information it receives from the cochlea and transforms them into conscious and unconscious perceptions of the world around us.

2.1 The Auditory Nerve (CN VIII)

Function

The auditory nerve is also called Nervus Vestibulocochlearis. The nerve uses the synapses to transmit information about the frequency, intensity, and phase of a sound (Rubel, 1989). Synapses are the main structure behind the brain's ability to process information (Chermak and Musiek, 1997). The most basic functional part of the brain is the neurone. A neurone consists of a cell body, a dendrite that transports nervous impulses towards the cell body, and an axon that transports the nervous impulses away from the cell body. The purpose of the neurone is to transport nervous impulses from one part of the nervous system to another. This happens when the neural impulse moves as an electrical tension along the axon over a synaptic cleft to another neurone's dendrite. The synapses are the linking element between two neurones. The axon and the dendrite lead the neurotransmitters into the synaptic cleft, which makes the transmission of the impulse more likely to take place. Other types of neurotransmitters inhibit impulse transmissions (Freed, 2000). Axons or dendrites are joined in bundles and are commonly referred to as nervous pathways within the auditory nerve (Wie, 2005).

Anatomy

The auditory nerve is the cochlear branch of the 8th cranial nerve (Zemlin, 1998). The nerve enters at the bottom of the brainstem at the ponto-medullary junction, which is located in the lower part of the brainstem. The nerve synapses on the ipsilateral cochlear nucleus[3] (Haines, 1991). The auditory nerve consists of approximately 30,000 nerve fibres with afferent (sensory) portions projecting from cell bodies in the spiral ganglion and efferent axons from cells in the olivary complex[4] (Ehret, 1997).

Functional Properties

Frequency discrimination, amplitude discrimination and temporal information are all relayed by the auditory nerve through interpretation of the rate with which the neurones are fired from the two cochlear (Rubel, 1989).

2.2 The brainstem

The brainstem connects the cerebrum and the cerebellum with the spinal cord. The brainstem consists of medulla oblongata, pons, mesencephalon and diencephalon. The myelination in the brainstem is not fully developed until the age of 13 (Zemlin, 1998) and before this age the

[3] Will be described later in this thesis.
[4] Will be described below.

synapses are less efficient in children. The maturation of the central auditory nervous system occurs from the periphery and up. This can be seen on ABR-, MLR- and LLR- tests[5], where the transmission speed in the measurements are in direct connection with the degree of myelination (Bellis, 1996). Therefore these measurements are difficult to apply to young children.

The nuclei within the brainstem are joints of neurones where nerve fibres synapse. Nuclei act as relaying stations for neural information (Stach, 1998). The following review will begin from the bottom of the brainstem where the auditory nerve meets the cochlea nucleus. During the reading of the following paragraphs it is important to remember that this system must function correctly for the normal hearing process to work smoothly.

2.2.1 Cochlear Nucleus

Function

The cochlear nucleus is a switchboard, distributing auditory information to several different areas in the auditory pathway. It also carries out substantial amount of processing of both time and frequency information (Ehret, 1997).

Anatomy

The auditory pathway diverges into multiple parallel tracts as it leaves the cochlear nucleus. While the auditory nerve connects almost exclusively to the ipsilateral cochlear nucleus, the cochlear nucleus divides its output into several different ascending tracts (Rubel, 1989).

The cochlear nuclei are typically divided into three regions based on the morphology of the cells they contain and the structures with which they connect. These divisions are the anterior ventral cochlear nucleus (AVCN), the posterior ventral cochlear nucleus (PVCN) and the dorsal cochlear nucleus (DCN) (Rubel, 1989).

Functional Properties

The cochlear nucleus is the only nucleus in the brainstem where the synapses happen ipsilaterally. The three above-mentioned divisions are each associated with a specific pathway. The entry to the "binaural pathway" is the anterior ventral cochlear nucleus (AVCN). Through the binaural pathway, the AVCN provides direct and indirect input (via the medial nucleus of the trapezoid body) to the superior olivary complex. This pathway is likely to be involved in spatial localisation and other tasks requiring convergence of information from both ears. The posterior ventral cochlear nucleus (PVCN) is the starting point of the "intermediate brainstem pathway". The functionality of this pathway is not yet fully understood. However, it is known to ascend to

[5] A description of these tests can be found later in this thesis.

the lateral lemniscus where it connects to nuclei of the lateral lemnicus and inferior colliculus. "The monaural contralateral pathway" begins at the dorsal cochlear nucleus (DCN). As its name suggests, this pathway carries information from only the contralateral ear (right ear for a neuron left of the midline). This pathway is unique in the sense that it carries a substantial amount of descending input (Rubel, 1989).

2.2.2 Superior Olivary Complex

Function

The superior olivary complex processes information about interaural delays and amplitudes. It also acts as a crossover site for spatially oriented auditory information (Rubel, 1989).

Anatomy

The superior olivary complex is the first place in the hearing pathways that receive both ipsilataral and contralateral input. This input provides the auditory system with the anatomic basis for the unique functions in bilateral listening ability, as for example localisation of sound (Bellis, 1996).

Functional Properties

Studies in which the superior olivary complex is selectively damaged demonstrates that it is essential in the localisation of the source of a sound. Furthermore, studies indicate that lesions above the superior olivary complex result in a loss of the ability to localise sound in the contralateral hemifield (Rubel, 1989). Along with the characteristics of the responses in the superior olivary complex such studies support the assumption that the superior olivary complex performs processing that is essential to determining the location of a sound. In addition, it seems that projections from the superior olivary complex to the inferior colliculus provide a crossover point for information involved in source localisation (Rubel, 1989). This allows the segregation of information according to hemifield rather than ear source. Other types of information gathered from the ear, however, appear to cross over at different points or not to cross over at all (Zemlin, 1998).

2.2.3 Lateral Lemniscus and Nuclei of the Lateral Lemniscus

Function

The lateral lemnicus is primarily a tract of axons ascending in the brainstem. The nuclei of the lateral lemnicus are, however, sensitive to changes in both the timing and the amplitude of sound (Rubel, 1989).

Anatomy

The lateral lemnicus is a tract of axons travelling from just above the superior olivary complex and all the way to the inferior colliculus. The nucleus of cell bodies is referred to as the nuclei of the lateral lemnicus. Only some of the axons travelling in the lateral lemniscus synapse here. Most continue directly to their destination in the inferior colliculus, medial geniculate body or other regions of the brain (Zemlin, 1998).

Functional Properties

The nuclei of the lateral lemnicus have good temporal resolution compared to other cells, and therefore it seems logical that they are involved in the acoustic reflex. The nuclei of the lateral lemnicus are located at a crossover point near the cochlear nuclei (Rubel, 1989).

2.2.4 Inferior Colliculus

Function

The two main functions of the inferior colliculus are:

1. To act as a switchboard to higher auditory and multi-modal sensory areas.
2. To take part in spatial localisation (Rubel, 1989).

Anatomy

The inferior colliculus is located in the diencephalon. Some of the nerve fibres that arrives contralaterale and ipsilaterale from the lower nuclei synapse in the inferior colliculus and some of these continue without synapses through the inferior colliculus to the medial geniculate body in thalamus (Zemlin, 1998).

Functional Properties

The inferior colliculus appears to be an integrative station as well as a switchboard. It is responsive to interaural delay and amplitude differences and may provide a spatio-topic map of the auditory environment (Rubel, 1989). Changes in the spectrum of sounds such as amplitude and frequency modulation appear to have a modulo-topic representation in the inferior colliculus. This sensitivity to spectral changes conceivably provides the building blocks for neurons responsive to specific phonemes and intonations which are necessary to recognise speech (Rubel, 1989). Finally, the inferior colliculus is involved in integration and routing of multi-modal sensory perception. It is involved in the acoustic reflex and sends projections that are involved in ocular reflexes. It also modifies activity in regions of the brain responsible for attention and learning (Rubel, 1989).

2.2.5 Thalamus and the Geniculate Body

Function

The function of the Thalamus and the Geniculate Body is amongst others to relay to cortex, make relative intensity comparison and relative duration comparison (Rubel, 1989).

Anatomy

The thalamus is the last relay site on the way to the cortex for almost all sensory information, including auditory, visual, and somatosensory.

The medial geniculate body is located on the lower side of the thalamus. Most of the nerve fibres from the lemnicus lateralis synapse with fibres that continue out to gyrus transversus in the temporal lobe in cortex here (Zemlin, 1998).

2.3 Auditory Cortex in the Sylvian Fissure of the Temporal Lobe

There does appear to be a tonotopic organisation in auditory cortex with higher frequencies located more medially. It is likely that there are several tonotopic maps represented in the cortex, each with specific functions in demodulation of speech and other sounds (Rubel, 1989). There also appears to be a spatiotopic map with sounds from the contralateral hemifield being more excitatory in a given hemisphere. Regions with specific temporally sensitive responses have also been found which may play a role in several phenomena of perception such as virtual pitch perception, timbre[6] discrimination, spatial localisation, or even noise filtering.

The primary auditory cortex also called gyrus transversus or Heschls gyrus is located in the upper part of the surface of lobus temporalis. Around the primary auditory cortex are associated areas that also contain non-auditory-sensory fibres. Planum temporale is one of these areas and it is in direct contact with Wernickes area. Planum temporale seems to correlate with the perception of language (Katz, 2002). Gyrus supramarginalis is another area not far from Wernickes area, which also corresponds to auditory stimuli. This area is a part of a complex association area that seems to integrate auditory-, visual- and motor information (Katz, 2002). The inferior part of lobus parietalis, the inferior part of lobus frontalis and insula also correspond with auditory stimuli (Katz, 2002). The primary auditory cortex has both intra-hemispheric and inter-hemispheric connections. The inter-hemispheric connections mainly run through corpus callosum (Chermak and Musiek, 1997).

[6] The psychoacoustic perception of tone.

In this paragraph I have reviewed the part of the normal hearing process that I find relevant for my purpose. With APD we still do not know where within this system the problems occur and we even have no scientific proof that the problem lies within this system at all.

3 APD: consensus or confusion

In this chapter I will give an overview of the field by outlining the scientific consensus or lack of it, and by discussing the comorbidity that exists with other disorders and the problems that this entails.

On a conference in 1977 APD in children becomes a prominent term and since then ASHA and many others have tried to define APD, but this is not an easy task (Chermak and Musiek, 1997). To illustrate this, I will now mention a few of the descriptions and definitions that have been suggested during the last decade:

- The Danish interest group writes, "When the brain doesn't understand what the ears are hearing" (APD-gruppen, 2006).

- Bellis (2002) writes, "When the Brain can't hear" and explains that APD is when the ears hear normally, but the processing of the auditory input in the central auditory nervous system does not work properly. The child with APD does not have peripheral hearing loss, and will therefore manage the pure tone audiometry normally, but the problems will appear with complex signals, as speech often is. This means that APD is a form of hearing loss, which is not located in the ear, but in the auditory pathways or in the brain (Bellis, 2002).

- In 2003 the British Society of Audiology's special interest group on APD tried to define APD as: "APD is a hearing disorder resulting from impaired brain function and characterised by poor recognition, discrimination, separation, grouping, localisation or ordering of non-speech sounds" (Hind, 2006; Bamiou et al., 2006).

- To the above mentioned definition the American Speech and Hearing Association adds: "…diagnosis of APD requires demonstrating of a deficit in neural processing of auditory stimuli that is not due to higher order language, cognitive or related factors". (Bamiou et al., 2006)

- In 2006 ASHA's taskforce on APD consensus development defined APD like this: "APD refers to difficulties in the perceptual processing of auditory information in the

Central Nervous System as demonstrated by poor performance in one or more of the following skills:

1. Sound location and lateralisation.
2. Auditory discrimination.
3. Auditory patterns recognition.
4. Temporal aspects of audition, including temporal integration, temporal discrimination, temporal ordering, and temporal masking.
5. Auditory performance in competing acoustic signals.
6. Auditory performance with degraded acoustic signals.

There is very limited epidemiological information on APD. This is largely due to the fact that there is presently no general agreement or consensus, either nationally nor internationally, on diagnostic markers or definition of APD. This is underlined by the potential overlap between the symptomatology of APD and other developmental conditions that impact on differential diagnosis (Hind, 2006).

3.1 Comorbidity

APD is a deficit in the neural processing of auditory stimuli, which is *not* caused by superior language-, cognitive or corresponding factors (ASHA, 2006) nor by peripheral hearing loss (Bamiou et al., 2006). However APD and these disorders do not rule out each other. They can be comorbide, which means that APD can co-occur with one of the other disorders, but is not caused by them (ASHA, 2006).

Scientists within the field frequently discuss if one of the disorders is superior to the other and is causing it. Some scientists argue that the frequent comorbidity suggests that APD is not an independent disorder but is merely the characteristic symptom of a superior and more global disorder. This is because deficits in the central auditory processing are also often seen in both ADHD (Attention Deficit Hyperactivity Disorder), learning disabilities and language disorders (Chermak and Musiek, 1997), but central auditory deficits in children with ADHD are amongst several scientists viewed as the existence of APD rather than a symptom within ADHD itself. The reasoning behind this is amongst others the results on the Staggered Spondiac Word Test (SSW)[7], where the results from APD do not correlate with the characteristic behaviour of ADHD, which are inattentive behaviour, hyperactivity and impulsive behaviour (Chermak and Musiek, 1997). In APD the attention disorder specifically targets the auditory modality. This supports the studies of

[7] This test will be described in detail later in this thesis.

dichotic speech tests and tests with competing signals, where the child with APD does poorly because of the disorder in the brainstem and not because of a superior attention deficit (Chermak and Musiek, 1997).

The state-of-the-art conclusion is that APD can coexist with superior disorders and peripheral hearing loss, but is not caused by these. A key element in this discussion is if it is the auditory processing difficulties that cause lack of attention or if it is the lack of attention that causes auditory processing difficulties. Even the most basic auditory processing depends on processes like attention and language representation (Bellis, 2002).

Most scientists support the idea that the auditory processing difficulties in APD cause the attention difficulties, which then supports the assumption that APD is an independent disorder (Chermak and Musiek, 1997, Mathiesen, 2006).

4 Causes, Risk factors and Indicators of APD

4.1 Causes of APD

A system like the brain can be compromised in several ways, which will result in different disorders. The system can be compromised physically for example by a tumour, metabolically for example by a neurotransmitter disorder or it can be compromised developmentally for example by deprivation (Chermak and Musiek, 1997). In this chapter I will review the current knowledge of causes and risk factors for APD.

Cameron, Dillon and Newall (2006) write that the biological basis of APD has not yet been established, but they suggest the following two possibilities:

- Immaturity or deficiency of the central auditory nervous system, which is central conditions.
- Deficiencies due to peripheral conditions like deprivation because of middle ear infection.

The processes of the brain work in a complicated and dynamic network. If a process in the brain is being compromised even on a relatively low level, for example perceptually, it can result in a cascade of errors and the symptoms can appear behaviourally on a higher cognitive level (Chermak and Musiek, 1997).

The aetiology of APD varies throughout the research literature. Starch (1998) suggests that most cases of APD in children are not caused by a documented separate neuropathological weakening, but that the hearing disorder is an idiopathic dysfunction in CANS. Matson and Parathasarathy (2005) believe that even though some children can be genetically predisposed for APD, it is more likely a developmental disorder, which is a result of inconsistent auditory input during the auditory perceptual development.

4.2 Risk factors for APD

An American group of otologists, paediatricians and audiologists, JCIH (Joint Committee on Infant Hearing) has worked on finding factors, which can cause hearing loss in children. Bellis (2002) argued that the factors that increase the risk of a child getting ear related auditory problems also could increase the risk of problems anywhere else in the auditory system.

This immediate comparison of the risk factors of hearing loss in children and the risk factors for APD seems a bit hasty. One would think that it must be necessary to distinguish between peripheral hearing loss, central hearing disorders, infections and other possible conditions. Nevertheless Bellis' suggestion of transferring these risk factors to APD, seems to be the only attempt scientists have made to identify risk factors for APD and I am therefore forced to assume that this is the best guess, even though I find this assumption problematic.

JCIH mention the following risk factors[8]:

- Any type of disease or condition that result in the child spending 48 hours or more in neonatal intensive care.
- Physical sign of any syndrome associated with hearing loss, for example Down syndrome or Treacher-Collins syndrome.
- Family history with permanent hearing loss in the early years of childhood.
- Any apparent malformation in the face or head including even small deformation of the ears.
- Maternal infections during pregnancy, for example herpes, rubella infection, toxoplasmosis or cytomegalovirus (CMV).
- Infections in the child after birth, which can be related to hearing loss for example bacterial meningitis.
- Conditions after birth, for example severe jaundice that require blood transfusion, or breathing difficulties that require ventilation or oxygen supply.
- The occurrence of any syndrome that is related to progressive hearing loss.
- The occurrence of any neurological disorder, which in time will result in weakening of the motor- or sensory function.
- Head trauma.
- Several chronicle ear infections with effusion and duration of minimum 3 months.
- Any concern that the parents or others might have concerning the child's hearing, speech, language and/ or developmental delay.

Furthermore it is a risk factor if the parents had difficulties in school, because APD can occur in more members of a family.

Another risk factor that is evident, is the one in connection to maturation of the brain and middle ear infections. There is a clear connection between several middle ear infections in the

[8] Some of which to me seems more like things that are associated with hearing loss rather than risk factors.

early years of childhood and APD. The risk is imbedded in the deprivation of acoustic stimulation that results from the fluid in the middle ear. This type of deprivations can result in delayed development of the brainstem and the resulting APD-symptoms (Bellis, 1996).

Even though the structure of the brain is complete at the time of birth, it has to interact with the surroundings to complete the system and adjust to the environment. The first seven years are crucial. During this time the brain is very plastic and can change and functionally reorganise if anything goes wrong (Bellis, 1996). It is during this time that auditory deprivation in connection with middle ear infections can compromise the development of important auditory functions within the brain.

The plasticity of the brain in the early childhood years is one reason why it is important to identify the children with auditory dysfunctions as early as possible. Then the training and intervention can help the brain to develop normally through focused auditory stimulation. Just as deprivations of stimulation can result in structural and functional neurophysical changes in CANS, increased stimulation can result in structural changes and functional improvements (Bellis, 1996).

4.3 Indicators of APD

Some of the symptoms in children with APD may become apparent in the early school years or at a later academic stage of the child's life due to changes in the acoustic environment or to increased academic demands (Cameron et al., 2006). But we might be able to identify the problems earlier if we are aware of the indicators. Young (2006) wrote about indicators present in children with APD, but the topic is still filled with uncertainties and I have only been able to find one article concerning the subject. It is my opinion that more research is needed before we accept these indicators, and for this reason I choose to only make a brief review of Young's findings in the table on the following page. I have chosen to leave Young's last category out "Indicators in older schoolchildren", because the content here is covered in chapter 6 concerning symptoms.

Indicators in infants	Abnormal reaction to sound, which was not caused by peripheral hearing loss. Only little reaction to voices and sounds, or Very alert to sounds and might have seemed hypersensitive to sound. These hypersensitive children will typically get difficulties with auditory sensitivity and understanding speech in background noise. The parents might experience that their 1-year-old child speaks less than other children of same age do and they might seek help to get the ears checked. The audiometry will typically show normal hearing (Young, 2006).
Indicators in pre-school children	Difficulties with rhymes, reel offs and song Might show difficulties sitting still when being read aloud to. The child might need oral messages repeated and might benefit from tactile or visual support. The child can be perceived as a daydreamer or someone with a selective hearing, and Pronunciation problems might be present. The parents will notice that the child rather wants to lay a puzzle than to watch TV (Young, 2006). Some of the hypersensitive children are easy to recognise, because they may hold their ears when they experience noise. This behaviour might be misinterpreted as an immature behaviour of a child who wants to get attention and make a scene. Others can be so over focused on for example TV that they are difficult to get through to (Young, 2006).
Indicators in young school children	In the first year of school the child's language related demands will get bigger when the child will start to learn the letters. Some places the children are trained in phonological awareness, which particularly creates problems for children with APD, because of their incorrect auditory sound processing in the central auditory nervous system (Young, 2006). In spite of these difficulties, the child might get through the first years of school unnoticed, and might even be perceived as a good listener, because of the extra energy that the child puts in the listening activity. The extra visual awareness might make it seem as if the child is participating in the class (Young, 2006).

It is important to remember that this is not a complete list of indicators of APD. There is no unique pattern that indicates if a child has APD, but it is important that teachers, speech therapists, psychologists, doctors and other relevant personal are aware of APD and know the possible symptoms, so that the children in question can be referred to investigation of their hearing problems and the right action can be taken.

5 APD symptoms and profiles

James Jerger (2006) reviewed the literature and found that there may be more theories of what symptoms make up an auditory processing disorder (APD) in children than there are children with the disorder. Here are just some of the explanations that have been proffered over the past few decades. Problems with:

- Auditory discrimination
- Auditory pattern recognition
- Competing signals
- Degraded signals
- Auditory memory
- Closure
- Sound localisation
- Language
- Phonemic structure
- Phonological awareness
- Listening or comprehending auditory information
- Learning through hearing
- Dichotic listening
- Rapid temporal processing

With Jerger's list in mind it seems that dividing APD into profiles[9] might provide a better understanding of the difficulties the child is experiencing. It might be helpful to use APD profiles in the interpretation of tests and in the planing of the treatment (ASHA, 2006), but even though several scientists have worked with models for subdividing APD, none of them have been universally accepted (Bellis, 2002). For this reason it is my opinion, that the profiles should not be seen as definite, but rather as a reminder of the different difficulties that can be present in a child with APD. This way of planning the treatment will consider these differences.

There are two primary models of dividing APD into profiles. First the Buffalo-model by Katz et al. (Bellis, 2002), for which the dichotic listening test called Staggered Spondaic Word Test

[9] There exists terminological confusion in this topic. Some scientists talk about "profiles", some about "types" and others talk about "subtypes". These are all the same, but the confusion becomes greater when further division is needed, then they call them "subtypes" or "secondary subtypes". I have chosen to talk about "profiles" and when division is needed I call these "secondary subtypes".

(SSW-test) was developed[10]. The buffalo-model itself no longer seems to be used much, but the SSW-test is still in use and has been translated into Danish by Merete Wolff under the name of SSO-testen. The second model is the Bellis/Ferre-model by Bellis and Ferre. It is developed from the Buffalo-model, but diverse literature considers the two models as separate. I will describe the Bellis/Ferre-model below. However, it should be stressed that there is presently a paucity of evidence to support either of the two models.

5.1 The Bellis/Ferre-model

This model is based on the underlying neuropsychology and the relationship between different APD-profiles and their difficulties with language, learning and cognition (Bellis, 2002). This model divides APD into 3 profiles and 2 secondary subtypes. The first profile is by far the most accepted and applied one, the two secondary subtypes have been severely criticised, wherefore I have chosen to leave them out of this review. The profiles may occur in isolation or in combination.

5.1.1 Auditory Decoding Deficit profile

This profile is characterised by poor discrimination of fine acoustic differences in speech, with a clinical presentation similar to that of a child with peripheral hearing loss. Most other literature talks about this type of APD, when symptoms are mentioned or if suggestions to treatments are made. This type is primarily a disorder in the primary auditory cortex in the left hemisphere, where also the decoding of speech sounds occurs (Bamiou et al., 2006).

Symptoms

The auditory symptoms look like a hearing loss and include amongst other things misunderstandings of words and content, and problems with hearing in background noise and also with fast or unclear speech (Bamiou et al., 2006). The language related symptoms usually scope widely within the syntax, semantics, vocabulary and pronunciation. The expressive language is often better than the impressive language (Bamiou et al., 2006).

Possible cognitive results can be that these children exhibit better non-verbal IQ than verbal IQ, they exhibit relatively poor abilities in sequencing and analysing, but relatively good skills in synthesis[11], visual processing and visual-spatial assignments (Bellis, 2002).

[10] This test will be described later in this thesis.
[11] Definition from Oxford Advanced Learner's Dictionary: "The act of combining separate ideas", in this case different acoustic information.

Academic symptoms

The academic symptoms can be difficulties in reading and writing and the resulting poor reading comprehension caused by the slow reading speed, poor phonological abilities, poor abilities in phonemic writing, more profound difficulties in language related courses than in natural science related courses and difficulties understanding foreign languages (Bellis, 2002).

Speech sounds and the meaning of them meet in the auditory association cortex, and consequently the better general language ability the child has, the more the child will be able to compensate for this type of APD (Bellis, 2002).

5.1.2 Prosodic Deficit profile

This second profile is characterised by deficiency in using prosodic features in speech, poor facial mimic and the child exhibiting poor performance in auditory pattern and temporal ordering tasks, which will be explained in detail later in this thesis (Bamiou, 2006). This profile has its basis in a disorder in the right hemisphere. The child with Prosodic Deficit profile is good at the things that the child with Auditory Decoding Deficit profile is bad at and opposite. The symptoms in Prosodic Deficit profile are more emotional and should perhaps be considered more as a part of a global right sided dysfunction (Bellis, 2002).

Symptoms

Symptoms include difficulties in perceiving stress, rhythm and intonation patterns of speech leading to poor comprehension of communicative intent and frequent misunderstandings, as well as poor rhythm perception, music or singing skills (Bamiou, 2006). The child with this profile will have fairly good abilities in speech sound discrimination and auditory closure (Bellis, 2002).

Possible language related symptoms are pragmatic difficulties, which include inappropriate social behaviour and misuse- or no use of humour. The child can have a monotone voice and no mimic, but good syntax, semantics, articulation and vocabulary (Bellis, 2002).

Possible cognitive results can be better verbal IQ than non-verbal, relatively poor ability in synthesis and visual-spatial assignments, low abstraction level, but good understanding of concrete concepts and relatively good analysing ability.

On tests of learning and cognition the results can be close to normal and it will seem as if academic intervention is not necessary, but the child can still suffer from non-verbal learning disabilities (Bellis, 2002).

There can be associated symptoms like psychological disorders, for example depression, attention disorders that originates in the right hemisphere’s poor ability to direct attention towards the relevant. Some children even belong to the autistic spectrum (Bellis, 2002).

Academic symptoms

The child uses phonological decoding when reading known words that should be recognised and read as whole word reading. Often the child possesses good phonological abilities and good spelling in the first years of school, but bad reading comprehension because of the slow reading speed caused by the poor whole word reading (Matson and Parthasarathy, 2005).

A poor ability to perceive keywords can result in difficulties in classes that involve language and listening. Visual support might not help (Bellis, 2002).

5.1.3 Integration Deficit Profile

This profile is characterised by deficiency in the ability to perform tasks that require intersensory/multisensory communication (Bamiou, 2006). In this profile of APD the problem lies in the way the two hemispheres are interacting and communicating through corpus callosum (Bamiou et al, 2006).

Symptoms

Associated symptoms may include difficulty with any task requiring interhemispheric integration, such as integrating the prosodic and segmental elements of a sentence to comprehend its meaning (Bamiou, 2006). The auditory symptoms can create difficulties in understanding the relationship between what is said and the intentions behind it. Also, the poor interaction between the ears can result in a bad perception of speech in background noise. However, the children with this type of APD often have good speech sound discrimination (Bellis, 2002).

Syntax, semantics, pragmatics and vocabulary are good, when tested separately, and both the impressive and expressive language is usually within the normal range (Bellis, 2002).

Associated symptoms could be poor co-ordination between hands and between feet, and attention related difficulties because of the problems with regulation of the resources between the hemispheres (Bellis, 2002).

It is important to note that in this particular profile, the verbal and non-verbal IQ can be equally good on assignments that do not require interaction between the two hemispheres (Bellis, 2002).

Academic symptoms

The academic symptoms can be difficulties with the sound-symbol- relationship when reading or spelling, which results in bad reading comprehension. There might be more profound difficulties in language related classes than in others. The musical abilities can be compromised. Physical education can reveal bad co-ordination between right and left side of the body. The use

of multi-modal remedies might confuse rather than help and note taking might be difficult because of the demands on attention to be divided between the auditory and visual modality (Bellis, 2002). The phonological ability is usually pretty good and specific abilities like math are often intact as long as it does not have to be combined with language (Bellis, 2002).

Until this point this thesis has been describing the physical background for APD, which is the dysfunction somewhere in the central auditory processes. Furthermore I have described different models of profiles; I have discussed causes, riskfactors and indicators, as well as problems concerning comorbidity. In the next chapters I will look into the screening process.

6 Screening procedure: an interdisciplinary approach

There are three parts of the screening process, which are the psychological-, the language- and the audiological screening. In the following chapter my primary focus will be on the audiological screening, because I found that this part needs more work before the APD screening can be implemented in the Danish health system. For this reason I will only describe the other two parts of the screening process briefly.

Apart from the primary literature used in the following chapter, I have been inspired by Andersen (2006), who took a unique pedagogic angle on the topic, which I find useful in the following presentation of the screening procedure.

Given the potential impact of APD on communication and academic outcomes, diagnosis and management of APD requires a multidisciplinary approach (Bamiou et al., 2006).

In the literature there is a lack of consensus concerning how the ideal screening procedure should be, but the screening should put as little pressure on the child as possible and should impose as little demands on the cognitive-, attention- or language abilities of the child as possible, when these are not the scope of the investigation. Each screening should be short, so that the child will not loose concentration. Chermak (2001) suggested a maximum duration of 8-12 minutes. A thorough anamnesis, psychology tests and possibly language tests can help to clarify the possible disorder of the child (ASHA, 2006) and ADHD, cognitive or language problems should be ruled out as cause of the child's difficulties (Bellis, 2002). For this reason a psychological- and a language screening should be done before doing the APD screening. In the United States there are special clinics that investigate for APD. In these centres there will typically be an audiologist, a speaking therapist and a psychologist.

6.1 The language screening

The speech therapist investigates the status of the impressive and expressive language, including whether the child can (Bellis, 1996):

- produce speech sound
- understand and use words
- understand and use sentences and grammar
- remember what is being said
- create sentences so they express thoughts and ideas

Existing tests can be used for this purpose. When a child has raised the concern of APD in its parents or teachers, because of poor language skills or poor pronunciation, it is important to note that there could be many other causes of these symptoms besides APD (Bellis, 1996).

If the results of the language screening for example show that the child seems to decode words correctly, but has mispronunciations this indicates that the problem is not auditory, but might be expressive in nature.

6.2 The psychological screening

The psychologist should investigate the child's (Bellis, 1996):

- cognitive abilities
- attention
- behaviour
- memory
- learning methods (does the child use the auditory modality, visual modality, motor modality and so on)
- academic strengths and weaknesses

The psychologist must discriminate APD from other disorders by using the phenotype, or by figuring out what kind of difficulties the child is experiencing. Because the symptoms in APD are very similar to the symptoms of for example ADHD, it is the psychologist's task to rule out any superior disorder as ADHD as the cause of the child's difficulties (Bellis, 1996).

6.3 The audiological screening

ASHA (2006) suggests that the auditory screening should begin with a test of the peripheral hearing, to rule out a peripheral hearing loss. I will begin with reviewing the content of a routine audiological investigation, beginning with the traditional hearing tests and proceeding to the electroacoustic- and electrophysical tests, which would be beneficial to use in the investigation. Then I will review the psychoacoustic tests that are often mentioned in the literature in connection to APD and investigate which of these should be included in a Danish audiological test battery for APD. The purpose is to find the test combination that makes the most efficient test battery. These results I shared with TAL (Teknisk Audiologisk Laboratorium) with whom I have been co-operating during the initial stage of the development of the Danish APD test battery. The co-operation was an agreement that I share my results and recommendations with them and they then develop a test battery that meets the recommendations, assuming that they themselves and

their other advisers agree on these. During the process they agreed to keep me updated and to send their suggestions to me, whereas I promised to offer comments and constructive criticism during the process.

In the final part of this chapter I will look at the possibility of early identification of APD by screening with questionnaires.

6.3.1 Traditional hearing tests

As mentioned earlier a child should be taken through a traditional hearing examination before central auditory tests are presented. The following are the routine examinations that the child should undergo initially (Wetke, 2006). The first four tests will usually show no abnormalities in children with APD.

- Otoscopy

- Impedance measurements, which will reveal any transmission problems in the middle ear. Tympanometry is a reliable way of finding possible fluid in the middle ear that would give a conductive hearing loss.

- Puretone audiometry is done to find the thresholds that are measuring the child's hearing sensitivity. Approximately from the age of 3 the child is capable of participation in play-audiometry. A child of 5-6 years of age can be expected to participate in puretone audiometry but the age limit of course depends upon the individual child (Wetke, 2006).

- Speech audiometry is used as cross check of the puretone audiometry. A child of 5-6 years of age is expected to participate in the speech audiometry test with the children-word lists, or from 6-7 years of age with the adult-word lists. This of course also depends upon the individual child (Wetke, 2006).

- Discrimination in noise (DN) initially seems relevant, since this is a key issue for the children, but it is important that this test does not stand-alone, when the central processing is investigated (Bellis, 1996).

Subsequently the child should undergo electroacoustic tests (Koefoed-Nielsen, 2006).

6.3.2 Electroacoustic tests

These tests measure acoustic signals inside the auditory meatus. The acoustic signals are generated spontaneously or as an answer to an acoustic stimulus. This could be OAE (otoacoustic emissions) or acoustic reflexes (ASHA, 2006). Abnormal test results in these tests can suggest problems in the brainstem[12] and in this case further testing should be initiated (Koefoed-Nielsen, 2006).

- OAE measures the echo of sound stimulus from the cochlea. Hereby it tests the integrity of the outer hair cells and thereby also the integrity of cochlea (Stach, 1998).

- The stapedius reflex in average lies 85 dB HL above the threshold. Measurement of the stapedius reflex can amongst others be used to identify middle ear problems (Stach, 1998). The nuclei in the superior olivary complex in the brainstem seems to be an important relay station in the reflex circle of musculus stapedius (Chermak and Musiek, 1997). For this reason the stapedius reflex might be able to reveal disorders at this level in the brainstem.

If peripheral hearing loss cannot explain the child's listening difficulties, it is relevant to carry on with electrophyisical examinations to identify possible disorders in the central nervous system.

6.3.3 Electrophysical tests

The following tests are all objective and will supplement and perhaps explain the observed behaviours of the child with APD. They measure on a very basic neurological level, but say nothing about if the child is able to use the heard information (ASHA, 2006).

Electrophysical tests build upon auditory evoked potentials (AEP), which are the electric waves from the synapses in the brain, that are created by the auditory processes as a response to the acoustic stimuli (Starch, 1998). In APD there is a deficit in one or more of the central auditory processes that generate AEP, and this creates the symptoms of APD (Chermak and Musiek, 1997).

The elechtrophysical tests investigate the neural activity in certain parts of the auditory system by measuring if the nerve fibres in the different areas fire their impulses simultaneously. The measurement of AEP retains those electrical impulses that arise from the auditory system, from all the other impulses that constantly occur within the brain (Starch, 1998). Chermak and

[12] This includes APD.

Musiek (1997) listed the following four electrophysical tests as relevant in the investigation of APD, in order to see if it is possible to find the source of APD from abnormal results in these tests. It is however likely, that these types of tests cannot in isolation provide information concerning the source of APD (Marriage, 2004), so additional testing should be done.

6.3.3.1 Electrocochleography (ECochG)

This test measures the integrity of the nerve fibres in the lateral end of the auditory nerve. An electrode is put as close to the tympanic membrane as possible or it is put through the membrane. A click is then send into the ear, which makes the auditory nerve react within 5 milliseconds after the onset of the stimulus and this reaction creates a measurable action potential in the auditory nerve. Furthermore cochlea creates an echo of the click[13] and an electrical response that mirror the acoustic envelope of the click. The measured action potential in the ECochG is the same as the first peak in the auditory brainstem response (Starch, 1998), which I will describe below.

6.3.3.2 ABR (auditory brainstem response)

This test mirrors the activity from the auditory nerve to the middle brain. Unlike the ECochG the ABR is not invasive. It is made with a brainstem audiometry, where the ABR is measured with electrodes placed on the skin. The auditory nerve and structures in the lower part of the brainstem generate ABR, which consists of 5 successive electrical wave peaks. The first peak occurs approximately 2 milliseconds upon the onset of stimulus and is generated by the auditory nerve where it leaves cochlea. The second peak is generated by the auditory nerve where it enters the brainstem. The third peak is generated the same place as the second peak and in nucleus cochlearis. The fourth and fifth peaks are generated in nucleus cochlearis, superior olivary complex and lemnicus lateralis (Starch, 1998). ABR can be followed much further than this, but the time window that is used in this test lies within the first 10-15 milliseconds.

6.3.3.3 MLR (middle latency response)

This test mirrors the activity in or nearby cortex. MLR is two successive wave peaks that lie at approximately 25-35 milliseconds and 40-60 milliseconds upon stimulus onset. MLR is most likely generated by a combination of projections in the primary auditory cortex and the cortical area it self (Starch, 1998). MLR vary more in small children than they do after 10-12 years of age. This variation reflects that the auditory system has not yet matured.

[13] This is also called Cochlea Michrophonia.

6.3.3.4 LCR (late cortical response)

This test mirrors the activity in the primary auditory cortex and association areas in cortex. Here the auditory perception is measured and this requires full co-operation from the listener. The responses are not fully present until the teenage years, wherefore it is more difficult to interpret the results in children. Abnormal or missing LCR indicates APD (Starch, 1998).

1. Mismatch Negativity (MMN) is an example of LCR, which is generated in the auditory cortex and is not dependent on the attention of the individual who is being tested. The individual must be awake, but inattentive to the sounds. Letting them watch a video at the same time can for example do this. Two stimuli are used. One is a standard stimulus that occurs several times. The other stimulus is rare and it changes the memory response and creates a negative fluctuation - an MMN (Katz, 2002).

2. P300 is another example of a LCR. The set-up is the same as with the MMN, but now active listening is required. The individual has to count the rare stimuli. This is not a purely auditory phenomenon, but also contains cognitive elements.

All of the above mentioned examinations are already in use in the Danish audiological departments (Wetke, 2006). However the last part of the screening process is the psychoacoustic testing, which are still not ready in Denmark.

6.3.4 Psychoacoustic testing

ASHA recommends the use of psychoacoustic tests to measure the central auditory processes. The basis of the six auditory abilities that needs to be measured is 1. Localisation and lateralisation of sound, 2. Auditory discrimination, 3. Recognition of auditory patterns, 4. Temporal aspects of auditory processing, 5. Degrading auditory presentations in competing signals and 6. Degrading auditory presentations in degraded signals (ASHA, 2006).

To be able to participate in these tests the person has to use listening functions that are placed centrally in the auditory system. It is assumed that these tests are only applicable to children of at least 7 years of age, because the differences in the results on younger children are so profound, that it will be impossible to interpret them (Schminky and Baran, 2000).

In the following I will describe the psychoacoustic tests that are most often mentioned in the literature about APD. For each test I initially describe which functions in the individual that the test is aiming to assess, then I describe the test itself, and what kind of difficulties is related to the

tested area. Finally I will investigate which test combination is the most beneficial. Abnormalities in one or more of these tests can be expected if the child has APD (Koefoed-Nielsen, 2006).

6.3.4.1 Temporal processing

Auditory temporal processing has been defined by Musiek as the perception of the temporal characteristics of a sound or the alternation of durational characteristics within a restricted or defined time interval (Baran, 2006).

Temporal processing occurs in all parts of the auditory nervous system, but the primary and associative cortices of the left hemisphere seem to be especially important (Bellis, 1996). Temporal processing includes our ability to determine the order of sounds and to put sounds together in an order that creates meaningful combinations such as words and sentences. This is our ability to separate or dissolve acoustic sequences. Temporal processing is necessary to determine whether a tone sequence is going up or down in pitch (Bellis, 1996). The intonation of the parents' language is important to a child's language development.

Many speech sounds are recognised from rapidly changing spectral components. As an example, the place of articulation of an initial plosive is identified from the explosion and the fast formant transitions in the following vocal (Katz, 2002). The duration of the explosion also has meaning in that it makes us able to distinguish between aspirated and unaspirated sounds.

The temporal processing also helps us distinguish between words, where the only difference is the order of sounds. Therefore these problems can result in reading and writing difficulties.

The temporal ordering tests

Temporal ordering tests are monoaural and they review the child's ability to analyse an acoustic sequence in time and orally describe them, this being sound sequences, sound pattern's, short pauses in noise and forward and backward masking (ASHA, 2006).

In the following paragraph I describe the 3 most commonly used temporal processing tests.

- **Gaps-In-Noise (GIN) test:** The GIN test is a new test of temporal resolution. It is composed of a series of 6 seconds segments of broadband noise containing 0-3 silent intervals per noise segment (Baran, 2006). The interstimulus interval between successive noise segments is 5 seconds and the gap durations presented are 2, 5, 10, or 20 msec (Bamiou, 2004). Both gap duration and the location of gaps within the noise segment are pseudo randomised with regard to their occurrences. In addition, the number of gaps per noise segment is varied (Baran,

2006). The child's task is to count the number of pauses. This test is probably more sensitive to cerebral lesions than the brainstem- or auditory nerve pathology (Bellis, 1996).

- **Frequency Patterns-test**: This test investigates the process of frequency discrimination, perception of order and naming. In this type of test the listener has to discriminate between the different pitches and the order of the tones. In the test there are 120 pattern-sequences each composed of 3 tones, where one tone is different from the others. The choice of pitch, duration and stimulus internal vary from test to test. The listener has to hum or verbally state the sequence pattern (for example "high, high, low") (Chermak and Musiek, 1997).
  The test is useful to detect disorders in the hemispheres, but cannot determine in which hemisphere the problem lies. Furthermore the test is sensitive to dysfunction in corpus callosum, so the listener would have less problems humming the sequence than to verbally describe the sound pattern (Katz, 2002).

- **Duration Pattern-test**: In the Duration Pattern-test the listener has to distinguish between the duration of the sounds, rather than between the pitch. The listener has to hum or verbally describe the pattern (for example "long, long, short"). The test is sensitive to cortical lesions (Katz, 2002).

Interpretation of the results in temporal ordering tests

Co-operation between the hemispheres is necessary to hear sounds and following name the patterns. Test of temporal processing can be a good predictor of speech perception of the central level (Bellis, 1996).

The non-verbal part of the Frequency Pattern-test and the Duration Pattern-test measures the ability to perceive patterns and orders. Difficulties here indicate disorders in the hemispheres.

The verbal part of the temporal processing tests evaluates the processing between the hemispheres and can indicate disorders in corpus callosum (Katz, 2002).

6.3.4.2 Dichotic listening

It is fairly agreed upon that each hemisphere of the brain is dominant for certain tasks, however the degree to which each is dominant remains somewhat debatable (Baran, 2006). For speech and language processing, it is clear that for most people the left hemisphere is dominant, often to the extent that the right hemisphere cannot handle the processing of speech and language stimuli. In this situation, the neural representations of speech and language information arriving at the right hemisphere, must be transferred from the right hemisphere to the left hemisphere, to

engage the critical speech and language processing mechanism in the left hemisphere in order to process and understand the information appropriately. This requires an intact corpus callosum. (Baran, 2006).

Dichotic describes a situation, where both ears are presented to stimuli at the same time, but the stimuli are different in each ear (Bellis, 1996). These tests assess the ability to separate or integrate different stimuli that are presented to the ears simultaneously (ASHA, 2006).

Stimuli are most efficiently transported contra laterally from the stimulated ear to the opposite hemisphere that is stimuli from the right ear are most efficiently transported to the left hemisphere and vice versa. Since the left hemisphere is often dominant in relation to language processing, this means that linguistic stimuli that is presented in the left ear, has to travel via the right hemisphere and corpus callosum to the left hemisphere (Katz, 2002).

Corpus callosum is one of the latest structures to mature. Until the child is approximately 11 years old there will be a so-called "right ear advantage" (REA), where monoaural linguistic stimuli scores higher on the right ear than on the left (Katz, 2002). This is important to remember when the results are being analysed.

Dichotic listening is divided into binaural separation, binaural integration and binaural interaction. Binaural separation is for example used when we talk on the phone in a room full of noise. A normal hearing individual will in most cases be able to ignore the stimuli from the free ear and focus the stimuli from the ear where the phone is. Binaural integration can also be used when talking on the phone, if we want to hear both what is being said on the phone and what is happening next to us (Bellis, 1996). Below I will describe a few procedures to test this area.

Dichotic speech tests

Dichotic Listening tests are commonly employed in the evaluation of children and adults suspected of auditory processing problems, especially in search of interaural asymmetry (Jerger, 2006). The principle in Dichotic Speech tests is that both ears receive different stimuli simultaneously.

- **Binaural separation**: Also called focused listening. Here the listener has to focus on the stimuli from one ear while ignoring the stimuli in the other ear. An example of a test of this type is the Competing Sentence-test, where two different simple sentences are played at the same time, one in each ear. The child then has to focus on and repeat the target sentence that might be played with 35 dB SPL, while ignoring the sentence in the opposite ear, which is played with 50 dB SPL (Chermak and Musiek, 1997).

- **Binaural integration**: Also called divided attention. Here the listener has to process information that is being sent into the ear simultaneously, but where the stimuli in each ear are different. A way to test this is to send two different numbers simultaneously into each ear and make the child repeat all four numbers (Bamiou et al, 2006). Simple numbers from 1-10[14] are not very linguistically challenging as words are, so beginning with monosyllables can raise the level of complexity (Jerger and Musiek, 2000). Another option is the so-called CV-syllables, which consists of a consonant followed by a vowel. Katz's SSW-test is an example of this type of test.

Interpretation of results in dichotic speech tests

Dichotic speech tests are sensitive to unilateral dysfunctions in the central auditory nervous system from the place where the crossings of the hearing pathways occur. That is from trapezoid body, which lies on the same height as superior olivary complex and upwards (Zemlin, 1998). Because of the more effective contra lateral pathway, a right hemisphere disorder will show itself as a deficit in the left ear. On the contrary a disorder in the left hemisphere or in corpus callosum will show itself as a deficit in the right hemisphere or bilaterally. This occurs because the contra lateral pathway from the right ear does not function, and because the transportation from the left ear via right hemisphere and corpus callosum slows down in corpus callosum on the way to the left hemisphere.

6.3.4.3 Monoaural Low Redundancy Speech: Auditory Closure

When the listening conditions are compromised we have to guess what the full message might have been and fill in the missing parts of the speech on our own. This ability is called "auditory closure" and is measured with a Monoaural Low Redundancy Speech Test. These tests measure the listener’s ability to create a whole from a degraded acoustic signal that is the ability to perform auditory closure. We are capable of performing auditory closure because of the internal and external redundancy (Bellis, 1996) and we probably use this ability several times a day without even being aware of it. The idea in these tests is to remove the existing external redundancy in the speech signal, so that the perception depends upon the child's internal redundancy.

Description of Monoaural Low Redundancy Speech Tests

The child is presented to a binaural speech signal presented one by one, and then has to repeat the word. The test results often correlate with speech discrimination ability in a noisy classroom

[14] Bamiou (2006) said that numbers in general are less linguistically challenging than monosyllables, but I assume that this depends on whether it is complex- or simple numbers, therefore I added “simple numbers from 1-10”.

or where the speech signal is distorted because of reverberation (Cleveland, 1997) this shows the importance of auditory closure ability in our daily life.

Low redundancy is obtained by degrading the signal. Changing it in time, frequency or intensity does this. Another way to do it is to present stimulus together with a competing signal or in noise (ASHA, 2006).

Interpreting the results of Monoaural Low Redundancy Speech Tests

Difficulties in these tests show poor ability in auditory closure and this indicates a deficit in the ability to use internal redundancy. This means that the repeated representation of the signal through the auditory pathways is reduced or does not even exist (Bellis, 1996). The child is therefore dependent upon the signal to be clear and distinct.

The child has to perceive a degraded speech signal by using his/her internal redundancy. This is particularly difficult for a child with APD. The child's internal redundancy is faulty and can therefore not compensate for the missing external redundancy in the speech signal (Cleveland, 1997).

6.3.4.4 Binaural interaction

The binaural interaction tests (MLD[15], localisation, lateralisation and detection of signal in noise (ASHA, 2006)) evaluate the binaural (or dichotic) processes, which depend upon the intensity or temporal aspect of different acoustic stimuli. In connection to speech the binaural interaction causes what we hear in one ear to be combined with what we hear in the other ear. The lower part of the brainstem, where superior olivary complex is located, is most important for the binaural interaction that is receiving and processing of binaural input (Jerger and Musiek, 2000).

Binaural interaction is the ear's ability to co-operate. This co-operation is the keystone in our ability to locate a sound source. This ability is retained from the time- and intensity difference that exists when the sound is perceived in each ear.

Locating sound is partly a safety-issue, for example this ability makes us able to detect where a car is coming from. Further more the binaural interaction in the auditory system also takes part in the ability to connect the parts of a signal that arrives from each ear and to make whole out of it. This ability is for instance used when listening under adverse conditions, for example in noise.

Description of binaural interaction tests

These tests are testing CANS' ability to process different, but to each other supplemental information, that is presented to the ears. Either pieces of the signal scattered between the ears

[15] Masking Level Difference.

will arrive non-simultaneously and after each other, for example vowels in one ear and consonants in the other, or the combined signals will be presented simultaneously in both ears, but so that each ear only hears a degraded signal, for example high frequency components in one ear and low frequency components in the other. In both examples the listener has to arrange the full signal via binaural interaction, which the lower part of the brainstem seems to be in charge of (Chermak and Musiek, 1997). Below I will mention different ways of measuring binaural interaction.

- **Localisation and lateralisation:** The brain constantly tries to locate sounds in the room. Some scientists believe that localisation and lateralisation play an important role in the ability to listen in noise (Bellis, 1996), others think that it might not be a direct connection, but may be just a link between the ability to locate and the ability to listen in noise (Frisna, 2005).

  The Superior olivary complex is the first place in the hearing pathways that receive both ipsilateral and contralateral input, which makes these nuclei unique in connection to the ability to listen bilaterally (localisation and lateralisation), and these nuclei also play an important role in the perception of altered speech. The auditory nerve and the lower part of the brainstem are highly involved in lateralisation and localisation, but the actual perception of localisation occurs in cortex (Bellis, 1996).

- **Masking Level Difference (MLD)**: As mentioned earlier the lower part of the brainstem has an important role when listening in noise and MLD represents the 's ability to discriminate signal from background noise. The binaural interaction can be measured with the MLD, which will reveal disorders in the lower part of the brainstem (Chermak and Musiek, 1997).

  When a tone is presented binaurally and in phase, the listener feels that it is located between the ears. If the tone is presented binaurally but out of phase, the listener feels that the tone is located by the ears, as opposed to between the ears. If a tone is then presented binaurally and in phase, while noise is presented binaurally and out of phase, then the tone is felt to be between the ears, while the noise is felt to be out by the ears. In this way the tone can easily be discriminated from the noise. If then the tone and the noise is presented binaurally and in phase, both the tone and the noise is felt to be between the ears and this makes the tone more difficult to hear (Bellis, 1996). This measurement shows how well the listener is able to use the binaural interaction to separate sound sources and in this way improve the ability to discriminate speech from disturbing noise (Jiang et al., 1997).

Interpretation of binaural interaction test

Difficulties with these types of tests indicate a disorder in the lower part of the brainstem. Listening in background noise can be a problem in a child who has had lots of middle ear infections in the early years, which might have affected the development of the brainstem in a way that cannot be revealed on a normal puretone audiometry. Because of this these problems might stay unidentified. Even after the hearing went back to normal the binaural function might only return slowly (Bellis, 1996), which a MLD test will show.

6.3.4.5 Listening in Spatialised Noise Test (LISN)

This test is also a binaural interaction test, but I have chosen to address it separately. It is a brand new test, which is still so new that there is only one study describing it (Cameron et. al, 2006), but Jerger (2006) stresses the importance of this study. I find that it could be extremely useful for the further development of a test battery in Denmark, which I will discuss further later on. For this reason I have chosen to describe this test more thoroughly than the other tests.

Cameron, Dillon and Newall (2006) describe this new test called the Listening in Spatialised Noise Test (LISN).

The LISN is an adaptive speech test, which was developed in order to provide a valid measure of speech understanding in background noise. It can be administrated in any audiological clinic with headphones, using standard audiometric equipment and a personal computer, and it is sensitive enough to detect auditory figure-ground discrimination deficits[16] in children with suspected APD who may be having difficulties understanding speech in the classroom (Jerger, 2006).

Cameron, Dillon and Newall (2006) pre-recorded speech monoaural speech signals (children stories) from two female authors and one male author. The speech signals were treated so that the binaural head related transferfunctions[17] (HRTF's) are simulated. The resulting output signal simulates the pinna cues and the interaural time difference characteristics of a sound emanating from the designated location.

On playback the distracter sentence differed from the target stories in respect to the vocal quality of the speakers and/or the perceived physical location in the auditory space, because the target stories recorded by Female 1 were all synthesised with HRTF's recorded at 0 degree

[16] Auditory figure-ground test consists of words in competing babble- noise.

[17] HRTF's are sets of measurements that represent the transformation of a sound wave as it travels from a particular location to the eardrum.

azimuth. The distracter sentences recorded by the various speakers were synthesised with the HRTF's recorded at 0 degrees, -90 degrees and +90 degrees azimuth (Jerger, 2006).

Cameron et al. studied ten children at risk for APD because of abnormal academic performance at school that was not related to either intellectual or attention deficit. In addition to several APD tests now in clinical use, they evaluated the LISN. In this virtual sound field created under earphones, the children were instructed to attend to continuous discourse (a story) and to indicate, in a three alternative forced choice adaptive procedure, when the story was either easy to understand, just understandable, or too difficult to understand. At the same time, distracter sentences were presented either from 0 degrees azimuth or at +/- 90 degrees azimuth. The distracter sentences were read by either the same female talker who read the story or by one of two different female talkers. This procedure yielded a number of both absolute and relative measures including (Jerger, 2006):

1. Low-cue signal-to-noise ratio (SNR) (ability to understand the story using only minimal cues).
2. High-cue SNR (ability to understand the story when abundant cues are available).
3. Tonal advantage (ability to take advantage of differences between voices of story talker and distracter-sentence talker).
4. Spatial advantage (ability to use spatial cues to understand the story).

According to Jerger (2006) only few children fell outside the normal range on traditional APD tests: On the dichotic digits test, none were abnormal. On the Pitch Pattern tests, only one was abnormal. Finally, on the Gap Detection tests, only three were abnormal. On the low-cue SNR measure of the LISN battery, where there is no spatial dimension, no child was outside normal limits (two standard division criterion) (Jerger, 2006). This is an interesting finding because the majority of the so-called low-redundancy speech measures that form the basis of APD are based on the principle that just making the listening task difficult will separate APD children from normal children (Jerger, 2006).

The spatial advantage measure of the LISN battery showed the most striking difference between children at risk for APD and control children. Nine of the ten APD children were outside the normal range, and the tenth were just at the fringe. This was by far the most dramatic effect noted in the study (Cameron et al., 2006). It suggests that difficulty understanding speech in background competition, arguably the cardinal symptom of APD, might perhaps be best understood as a perceptual deficit in the structuring of auditory space. Cameron et al. conclude the following:

> *"Of those children with APD, there may be a high proportion who have deficits in the binaural processing mechanism, that normally use the spatial distribution of sources to suppress unwanted signal."*(Cameron et al. (2006), pp. 319 c. 2, l. 13-18).

Comments to the study of the LISN

First of all I find that the reliability of the study is a problem. It simply has too few participants.

Another essential problem is the lack of consensus about the diagnosis of APD. In this study they used children at risk of APD and the criteria they used were that the child had to have persistent listening and learning difficulties in the presence of no intellectual, behavioural or standard audiological deficit to otherwise explain his or her dysfunction (Jerger, 2006). It should be noted that no consensus has been made about these criteria.

On the other hand it the LISN test of auditory figure-ground discrimination has substantial real-world validity and the component scores can offer some insight into the nature of any APD present in the children. Results on the LISN indicate that many of the children with APD may have deficits in the binaural processing mechanism, which normally use the spatial distribution of sources to suppress unwanted signals (Jerger, 2006).

Jerger (2006) concludes after reviewing this study:

> *"Perhaps future efforts to devise diagnostic test batteries should focus on this fundamental aspect of listening behaviour, rather than on hypothesised, and obscurely defined, language processing deficits."* (Jerger, 2006, pp. 305, c. 2, l. 12-16).

In my opinion this is a very promising study which deserves further investigation.

6.3.5 Choice of psychoacoustic tests

When choosing psychoacoustic tests it is important to be aware of intervening variables. Behavioural tests can be compromised by many factors including the chronicle and mental age of the child, attention, memory, language abilities, cultural- and social background, motivation, decision processes, visual definition and motor abilities. Therefore the tester always need to be aware of the non-auditory demands (for example language and cognition), when choosing a test and during the testing of the child (Jerger and Musiek, 2000).

A test battery for evaluation of the auditory processing must investigate the integrity of the central auditory nervous system, to determine if there is an auditory processing disorder. For this purpose it is necessary to examine different auditory performance areas. When concerning children, it is also necessary to consider level of maturity (ASHA, 2006).

As I mentioned earlier, ASHA lists the following five areas that they feel cover the processes that are the basics of the central auditory function. In each of these areas the following tests are recommended:

- Temporal processing tests including Gap Detection-test, Pitch Patterns-test and Duration Patterns-test.
- Dichotic speech-tests including binaural integration and binaural separation.
- Monoaural Low Redundancy-speechtest including auditory closure ability.
- Binaural interaction tests, including MLD.
- Electrophysical tests

It is recommended to choose one test from each of the five categories, because the battery should investigate different processes and different levels in CANS (Bellis, 1996). Scientifically there seems to be a certain agreement on this recommendation (Jerger & Musiek, 2000; Bamiou, 2004; Chermak, 2001), and I will continue using this recommendation.

A test battery for children should consist of as few tests as possible without compromising the effect. Furthermore the test should put as little demands as possible on the language- and cognitive abilities, since it is the auditory system that is being investigated, not the cognitive- and language abilities.

To my knowledge there are no studies concerning the most efficient combination of tests. Therefore the recommendation must fall back on the recommendation from ASHA (2006), which assures that all levels and processes in CANS are investigated.

I sent these results to TAL together with descriptions of the different tests. TAL then decided that since there is no evidence of which tests in each category should be used, and since most of the tests are not difficult to develop, they would make more tests in the different categories.

6.3.5.1 TAL final reply

The suggestion, by source of Christian Brandt (2006), looked like this (Please note that descriptions of the different test types are presented earlier in this thesis):

Temporal ordering tests:

a. Gaps in noise, with pauses of 5,10,20,50 ms.
b. Pattern recognition with pulse duration of 250ms and 500ms. Frequency 1000Hz.
c. Pattern recognition with frequencies of 1122Hz and 880Hz.

Dichotic speech tests:

a. Binaural separation

1) Sentences in competing sentences.
2) Auditory figure ground.
3) Competing words.

b. Binaural integration
   1) Dichotic Digits test.

Monaural Low Redundancy speech test: auditory closure.

a. Degraded Speech test. Low pass 1000Hz.

Obviously this list is lacking a test in Binaural interaction, which was recommended to be MLD, but TAL cannot use this test in the test battery, because a private firm called Interacoustics is already developing this test, and TAL is not allowed to compete with private firms. One might think that they should then just leave it out, since it is already being developed, but this would create a practical problem.

When the different clinics purchase this test battery, it will be unsatisfying if the battery is not complete and the clinics would have to purchase a separate test with another firm, therefore TAL asked if I know of any alternative tests that can be used. For this purpose I suggested the newly developed LISN test which I described earlier in this thesis. The test might be more difficult to develop than the others, and it is so new that I have not been able to find more than one article describing it, but I think it might be the best offer of another test of binaural interaction. At this point I do not know if TAL is going to put the test in the battery or not, but they replied with interest. I assume that they wish to address the issue of incorporating the MLD test further by getting a dispensation from the rule, since this test is the obvious and easiest choice.

6.3.6 Testing with questionnaires

In the above I have suggested what a test battery for APD should consist of, but a child should be at least 7-8 years old to be able to participate in psychoacoustic tests (Jerger and Musiek, 2000). ASHA (2006) suggests that questionnaires can be used for the child's primary persons (parents, personal in the institutions, teachers etc.), who can give an impression of the child's difficulties in different situations from a systematic observation of the child and its listening behaviour. It should be noted that questionnaires have also been developed for older children, but since older children can also participate in psychoacoustic testing, I find the questionnaires for the children below the age of 7 to be of most interest.

The possibility of using questionnaires have not had much focus in research, probably because these types of questionnaires are not specific enough to distinguish between APD and

other disorders, and therefore they need to be used with caution. Focusing on the tests only however leaves a big hole in the investigative process.

When a child has APD it is crucial to identify the problem as early as possible, preferably in kindergarten because if the child enters school and has not been helped, then this child will risk suffering many personal defeats and will already be lacking behind in school at the age of 7, where the testing of the child can begin. Another important reason for focusing on the questionnaires is that if these questionnaires point towards APD it is possible to start treatment already at this early point even though they cannot definitively conclude on the diagnosis. For these reasons I find it extremely important that research looks at the possibility of using questionnaires for the kindergarten children. I decided to contribute to this process by trying out some of these questionnaires. The questionnaires are available on “APD-gruppen’s” homepage, the necessary psychological and language tests already exists and are being used for other purposes today and the audiological tests for evaluation of the temporal processing are under development and need to be standardised.

6.4 Concluding on the investigative and diagnostic process

In the near future it will most likely be possible to screen children for APD in Denmark. If the child's difficulties can not be explained only by peripheral hearing loss or abnormalities in the general functional level of the child, APD should be considered and a thorough investigation should be made.

First of all it is important to note that the information obtained from the inter-disciplinary work group is of great value in understanding the strengths and weaknesses and using them in choice of treatment, but the inter-disciplinary effort can not be used diagnostically - only the audiologist can give the diagnosis (Bellis, 2004).

7 Pilot study

7.1 Introduction

Questionnaires have been used abroad and have shown good results[18] (Jerger & Musiek, 2000; Mathiesen, 2006), and these questionnaires have been translated into Danish by Mathiesen, who is a member of the Danish national interest group, "APD-gruppen". When I approached Mathiesen to see these questionnaires, they were not yet completely done and I was asked to give my comments on them. This was a difficult task because I did not have any experience to build my assumptions upon, but I corrected a few things and asked for permission to use the questionnaires[19] in a pilot study to improve them and give empirically based criticism. The APD-group gave their permission and as I began working on the project, I came upon the following Donald Bradbent quote from 1958:

> *"The great value of practical problems is that they force upon us difficulties which experiments done for theoretical reasons may ignore"*. By source of Jerger (2006, pp.25, 1-4)

Keeping this in mind I began working on the questionnaires meant for kindergarten children under suspicion of suffering from APD. This set of questionnaires consists of one questionnaire meant for the parents of the child, and one questionnaire meant for the primary pedagogue of the child. Both questionnaires need to be filled out together with a person from the PPR- office[20].

My goal was to determine any problems that might be imbedded in the translated questionnaires and suggest corrections based on empirically founded criticism.

7.2 Theoretical background

Two important steps need to be taken before submitting these questionnaires to a pilot study:

1. Quality assurance: Does the questionnaire live up to the current theoretical knowledge about how to make a quality questionnaire?
2. Topic relevance: Are the questions asked in the questionnaire relevant in connection to the topic that they are aiming to address?

[18] I assume that by "good results" the authors mean that the questionnaires have showed relatively good specificity and sensitivity in the process of identifying children with APD.
[19] The questionnaires can be found in appendix (original version).
[20] Pædagogisk Psykologisk Rådgivning (Pedagogic, Psychological Consultency). In this project I acted as the professional PPR-person.

7.2.1 Theoretical quality assurance

There are certain pros and cons to consider with the type of interviews that these questionnaires are meant for, where the interviewer visits the subjects personally. The most obvious ones being the possibility of having open questions and being able to correct and guide the subjects, on the other hand the time consumption, the interviewer-effect and the geographic limitations should be considered (Stax, 2003a). Considering the area that these questionnaires are meant for, it seems reasonable to use this type of interview technique, since the amount of subjects who needs to be submitted to the questionnaires are limited and since the possibility for guiding the subjects is important.

Olsen (2006) made a listing of quality assuring questions that should be considered when making a new questionnaire. I find this listing useful in my evaluation of the present set of questionnaires. This listing is divided into 6 main areas: Supervisory issues, understanding of questions, recollection of information, context effects, editing responses and pilot testing. Without using Olsen's listing directly, I will use these main divisions in my evaluation of the present set of questionnaires. This evaluation is a short outline, were I judge on the basis of my present knowledge of theory. When I interpret the results from the pilot study, things might look different.

- **Supervisory issues**: This category concerns the aims and method of the questionnaires (Olsen, 2006). The questionnaires aim to investigate kindergarten children who are under suspicion of having APD and help the process of confirming a possible diagnosis. This information however is not presented very well in the questionnaires. I will get back to this issue later.
- **Understanding of questions**: This category covers the verbalisation of the questions, which needs to be clear (Olsen, 2006). Presently I find no reason to criticise the understanding of the questions asked in the questionnaire.
- **Recollection of information**: When the subjects understanding of the questions has contributed to clarify the information in the question, then the subject needs to recall the relevant answer and it is important to minimise the demands of the recollection process (Olsen, 2006). I find that the questions in these questionnaires are kept relatively simple and short, but where further explanation is needed this has been done in a simple and logic manner. This makes me conclude that efforts has been made to put as little demands on the working memory as possible and I find that the relevant information should be recalled when the questions are asked.

- **Context effects**: This is a topic were consensus does not exist (Olsen, 2006), but the area that I have chosen to focus on within this category concerns the order of the questions. Looking through the questionnaire at the present time I find no reason to criticise the contexts of the different questions amongst each other.
- **Editing responses**: This category concerns the subject's interpretation of the recollected information. This can be affected by sensitive issues or issues of anonymity.

  There is no real need for anonymity in these questionnaires when used in real life, but there is a need to make the parents feel safe, because the questionnaires are sensitive of nature, and the subjects will be vulnerable due to their situation.

  The questions that are especially sensitive of nature have been made as neutral as I see possible and beyond that it is the responsibility of the interviewer to make the situation comfortable enough for the parents to feel safe.
- **Pilot testing**: This has not been done and so the questionnaires do not live up to this demand, but this is about to change.

A technical possibility that I have considered, which belongs under this headline is, if the response options in the parents' questionnaire should be expanded, so that they are similar to the four options in the pedagogue's questionnaire. I have not been able to find any guidelines in the literature concerning this issue and for this reason I am not making this change. I decide to initiate my pilot study using the response options as they are, and see if this creates any problems in the process.

7.2.2 APD relevance

Knowing the source of these questionnaires I expect that they live up to the necessary criteria, and when I compare the questions to the theory in this thesis, I find that the questions are relevant and that they cover all aspects that can be expected to be covered. For this reason I chose to leave the topic here and continue with my pilot study.

7.3 Terminology and translation

Before I begin reviewing my findings I need to specify how I refer to the questionnaire in question. The questionnaire for the parents and pedagogues of children suspected of suffering from APD is referred to as "the parents' questionnaire" and "the pedagogue's questionnaire" respectively. When I refer to specific questions within the questionnaire, I do so for each

questionnaire separately by mentioning the numbers of the questions on the original questionnaires, which are attached below each paragraph.

After corresponding with my professor, I originally decided to leave the questionnaires untranslated, but during the writing process it became clear that this would cause confusion in the reading of this thesis, since the comments were of course written in English. I decided to make a translated working version of the questionnaires, which I use in the running text of this thesis. It should be pointed out that the translated working versions of the questionnaires are only that – a translated working version and ***not*** a finished product, consequently they should ***not*** be used in fieldwork, but are only meant to ease the reading of this thesis. The real product is the questionnaires that can be found in the appendix.

7.4 Method

7.4.1 Delimitations and subjects

The questionnaires have been made for several age groups, but I choose to focus on the questionnaires made for kindergarteners. I see the greatest need for these questionnaires because of the diagnostic gap that otherwise is left uncovered until the child is old enough to participate in testing. This need is reinforced by the profits that the child would get from receiving help to overcome some of the problems at this early stage, and so avoiding to fall behind in the first years of school.

The actual responses, which I got from the questionnaires, are beyond the scope of this project. I chose this delimitation for two reasons. The first reason is that for such results to be valid, one would need to submit the material to a standardisation, and it seems irresponsible to begin standardising a material that has not been submitted to a pilot study. This could result in a useless standardisation, because the material that is being standardised might be full of problems that would need correction. If this correction would take place after the standardisation, it would make these numbers useless because the corrections would change the condition under which the standardisation was made.

Originally I wanted to look into the possibilities of making such a standardisation on the present material, but this lead me to the second reason why I chose my previously mentioned delimitation. It turned out to be virtually impossible to find an amount of participants that would make such results valid. Even though the offer to participate was made to 43 kindergartens which equals approximately 1900 potential kindergarteners in all of the municipality of Holstebro[21] only

[21] Ny Holstebro Kommune. Population: 56.000

35 children ended up accepting the offer and only 29 participated in my project. This gives a very low percentage of acceptance view on the basis of the potential amount of participants: 1,84% This is due to the filtering that takes place when the kindergartens have to accept before the parents are asked, and very few kindergartens did that. The reason for this could be that the consolidation of the counties which are taking place in Denmark at the moment and the structural changes in connection to that. When asked why they chose not to participate, several answered that it was because they felt they had too much going on already.

In the two kindergartens that are participating, the full amount of kindergarten children was given the offer, this being respectively 61 and 18 children, that is 79 children all together. From this number of children 35 chose to accept the offer, which gives me a response rate of 44,30%. From the 35 children who accepted, 34 where qualified to participate, but 5 opted out due to practical and personal issues, this resulted in 29 participants. The response rate among the parents was unexpectedly high. In this type of project where the parents should not only agree on letting their child participate, but also need to find time to come down and fill out the questionnaire together with me, it is expected that the percent of acceptance will not be very high.

Due to the lack of standardisation and the low number of participants I will focus on the pilot study only. The results of the questionnaires will not be discussed in this thesis, but can be found in the appendix.

7.4.2 Material

As mentioned earlier I was asked for my comments on the questionnaires when I first approached Mathiesen about my project. Even though I did not know it at the time, this has contributed to my understanding of why it is so important to submit new material to at pilot study before standardising it. When I was asked to correct the questionnaires I found only minor corrections to be necessary, which I don't find useful to document here, since the changes were so small and since they were made before the beginning of the project that I want to report here. As mentioned earlier, the set of questionnaires consists of one questionnaire for the parents to fill out in co-operation with a person from the PPR, and one questionnaire for that same person from PPR to fill out together with the primary pedagogue from the kindergarten. Below the two questionnaires can be seen in a translated working version. The working version is translated back to English to avoid language confusion when reading this thesis, and it is squeezed to avoid unnecessary space use. The actual questionnaires are attached in full-size in the appendix.

Figure 1: The parents' questionnaire – original version:

APD Gruppen – Denmark
WWW.APD.dk

This questionnaire needs to be filled out in co-operation between parents and Pedagogic/Psychological consultancy (PPR)

Questions for the parents in connection to investigation of Auditory Processing Disorder (APD)

The name of the child: _____
Age/social security number: _____
Date: _____
Interviewer: _____

		YES	NO
1.	Have you ever suspected that the child might have problems with hearing?	□	□
2.	Have you had the child's hearing tested?	□	□
	• If yes, then where was it tested? _____		
3.	If the investigation was done, did it show normal hearing?		
	• On both ears Yes □ No □		
	• On the right ear Yes □ No □		
	• On the left ear Yes □ No □		
4.	Has the child had problems with the middle ear, for instance Infections?	□	□
	• If yes:		
	o What type: _____		
	o Age: _____		
	o How often: _____		
	o Duration: _____		
	o How was the problem solved: _____		
5.	Does the child have any present problems with his/her middle ear?	□	□
6.	Has the child been operated in his/her middle ear/received a new tympanic membrane?	□	□
7.	Do you experience that the child's hearing is better in some periods than in others?	□	□
8.	Does the child want the sound of the TV and radio turned up?	□	□
9.	Do you need to have direct contact with the child for him/her to react?	□	□
10.	Does the child often misunderstand what is being said?	□	□
11.	Do you often need to repeat what is being said?	□	□
12.	Does the child show difficulties in perceiving speech in background noise?	□	□
13.	Does the child express difficulties with hearing?	□	□
14.	How does the child react when he/she does not understand a message?		
	_____		
	_____		
15.	Does the child react sensitively to loud sounds?	□	□
16.	Does the child pull back from social events?	□	□
17.	Does the child prefer to be in charge when playing with other children?	□	□
18.	Has the child had or does it get help from a speech therapist?	□	□
19.	Does the child comment on his/her own hearing?	□	□
20.	Does the child enjoy listening to aloud reading?	□	□
21.	Is there anyone in the family who has- or had language related difficulties as children?	□	□
	• If yes, which (speech- or reading/writing difficulties)_____		
22.	Does the child have difficulties in reading/writing?	□	□

Further comments:

_____
_____
_____

Figure 2: The pedagogue questionnaire, original version:

APD gruppen - Denmark
WWW.APD.dk

This questionnaire must be filled out in co-operation between the personal and Pedagogic/Psychological consultansy (PPR)

Questions for the pedagogic personal in the kindergarten in connection to investigation of Auditory Processing Disorder (APD)
The name of the child: _____
Age/social security number: _____
Date: _____
Interviewer: _____

Circle the behaviour of the child: 1 = Never, 2 = Occasionally, 3 = Often, 4 = Always

1. Does the child have difficulties keeping attention on the person who is speaking?
   1. 2. 3. 4
2. Is the child dependent on being able to see the face of the speaker, to understand what is being said?
   1. 2. 3. 4.
3. Does the child get disturbed by noise or background noise?
   1. 2. 3. 4.
   - If yes, which sounds:_____
4. Does the child hear when he/she has the back towards the sound source?
   1. 2. 3. 4.
5. Does the child easily loose concentration?
   1. 2. 3. 4.
6. Does the child have difficulties understanding messages (especially polynomial messages)?
   1. 2. 3. 4.
7. Does the child have difficulties remembering a message?
   1. 2. 3. 4
8. Does the child often say “What?” and wants the message repeated?
   1. 2. 3. 4
9. Does the child answer when questions are asked to the group?
   1. 2. 3. 4.
10. Does the child have difficulty locating a sound source?
    1. 2. 3. 4.
11. Does the child have difficulties with rhyming and reel offs?
    1. 2. 3. 4.
12. Does the child often pull away from social events?
    1. 2. 3. 4.
13. Does the child disturb other children or ruin their games?
    1. 2. 3. 4
14. Do other children accept the child?
    1. 2. 3. 4.
15. Does the child give up easily in situations where communication is necessary?
    1. 2. 3. 4
16. Does the child enjoy participating when read aloud to?
    1. 2. 3. 4
17. Can the child retell a story?
    1. 2. 3. 4.
18. Does the child have difficulties initiating a game or an activity?
    1. 2. 3. 4
19. Does the child have language-related difficulties?
    NO/Few Partially Many Severe

Further comments:
_____
_____
_____

7.4.3 Design and Procedure

I began the project by formulating an information note meant for all pedagogic personal working within the kindergarten field. This note is attached in the appendix[22]. In the note I describe who I am and what I want to accomplish with this project. I gave an example with a child suffering from APD, to show what difficulties such a child might face, and I pointed out what their role would be in this project. Furthermore I described which children would be qualified to participate in the project and why.

With participation from the local PPR-office and Majlis Dybkjær, who is responsible for the institution area in Holstebro, the information note was sent out to the kindergartens and immediately I got my first response, but no more seemed to follow this response, so I began calling up the institutions personally. This only resulted in one more acceptance from a rather large kindergarten. On the basis of these two institutions I decided to start up my project.

I formulated a parent's information note and attached an acceptance slip, on which the parents had to fill out some statistically related information[23]. This note can also be found in the appendix. At the same time I put up a schedule[24] in the kindergarten, where the parents could choose a time to come down and fill out the questionnaire together with me.

In the first kindergarten I gave them three weeks to respond. This turned out not to be a good idea because it resulted in parents forgetting the note and needing several reminders from the pedagogues. Had I given them shorter time, they might just have filled out the note and brought it back the next day. I learned from this experience and in the next kindergarten I planned it so that they had one week to reply and then write themselves on a time for the following week. This time it went a lot smoother.

The next step was the filling out of questionnaires with the parents. With the permission of the parents and for the purpose of documentation I used a tape recorder in all of these interviews. I read the questions aloud and gave the answer possibilities present on the questionnaire. The parents then answered, often in more words and together we decided which answer possibility fitted their response best.

When all the parents' questionnaires where filled, the next step was filling out the corresponding questionnaires with the respective primary pedagogues. For this purpose I divided the children into groups depending on which primary pedagogue was in charge of the particular child. For this purpose I also used tape recordings. In one kindergarten two pedagogues had

[22] This note is written in Danish and has not been translated.
[23] This note is written in Danish and has not been translated.
[24] An example is attached in the appendix. This schedule is written in Danish and has not been translated.

approximately 3-4 children each, and in the other kindergarten 3 pedagogues had approximately 8 children each. Finally I ended my co-operation with the kindergartens by joining one of their meetings where I gave a short presentation of APD in acknowledgement of their contribution to my work.

From this point on the rest of the process was listening to tapes and finding the areas that caused most discussion. I took the amount of discussion as a sign of unclarity within the question or in the response possibilities. I also listened for any type of problem during the interview and for my own responses and whether they seemed reasonable or not. The results from this process will be reviewed below.

Furthermore I finalised the table with the questionnaire responses. As mentioned earlier the responses are beyond the scope of this thesis and will not be discussed further, but for reasons of availability I decided to finalise a table and attach it in appendix.

7.5 Results

I reached my results by listening through my tape recordings from the interview sessions and looking through the filled out questionnaires. The tape recordings where made in order to be able to document my findings. Since I promised anonymity I have chosen to store the tapes and the filled out questionnaires with me. The examinator and censor of this thesis can acquire them by contacting me personally.

7.5.1 A manual is needed

The first and greatest problem that I encountered is also a very fundamental problem. What is my role in this interview? I chose to read the questions aloud, but was that beneficial? And when they ask questions how am I supposed to answer? Am I supposed to give them the answer possibilities or am I supposed to evaluate their answer and mark the possibility that I find closest to their answer?

If these questionnaires should end up giving valid results there has to be a manual for the professional PPR person. This manual must have guidelines for the professional's role in the interview session and it must have suggestions for answers to the most common clarifying questions. If the questionnaires are 100% clear, which of cause is a theoretical situation, then - theoretically- if an identical child with different parents and a different PPR person are answering the questionnaires, the answers should be identical if the questionnaires would be completely reliable. This is of course not a realistic situation, but it is useful to keep this in mind when trying to make the manual and the questionnaires as clear as possible. Without a manual the reliability

becomes a problem and that makes the questionnaires a lot less useful. Without good reliability the interpretation of the results would depend on the person interpreting them and that should not be the case, especially not when considering the level of knowledge about APD in Denmark at this point in time.

It would also be relevant to point out the aim of these questionnaires in this manual, so that they live up to Olsen's criteria on supervisory issues.

It is beyond the scope of this thesis to make a manual, but I will make suggestions for what such a manual should contain, based on any findings of uncertainty in the parents, pedagogues or in me, but also based on the questions that were asked in the process and on my replies to these questions, which were not always neither expedient nor useful. This stresses the necessity of a manual.

In this paragraph I have made a few basic suggestions for what should be said in the manual, this being clarifying information about the role of the professional in the process. I have made a few specific suggestions of clarifications, related to specific questions, but to ease the reading I have chosen to mention these when I go through the questionnaires chronologically in the paragraphs below.

7.5.2 The parent's questionnaire

The next area to consider is how the parents and the pedagogues understand the questions in the questionnaires. What works, what does not and what should be changed to make it work?

Like I mentioned under "Method" I took discussion about a question as a sign of vagueness or uncertainty in a question. This being both if the parents asked clarifying questions, if they did not know what to answer, came up with supplementary information or if they misunderstood the question. The original data source to the problem is therefore the parents, but the solution can be either changes in the questionnaire or guideline to the professional person.

The first question the parents are confronted with is if they ever suspected that the child might suffer from bad hearing. This question is followed by five to six other questions directly connected to the child's hearing. The questions following those (from question number 8 and onwards) are questions which in my opinion should be answered from a general perspective, without considering the hearing abilities of the child. But because they follow the questions that are directly related to the child's hearing, many of the parents tend to assume that they still have to consider the child's hearing when answering these next questions. This is a problem related to Olsen (2006)'s criteria of context effects. An example is question number 9 "Do you need to have direct contact with the child to get a reaction?" To this question many parents answered "no", but

several added (and more might have thought it) “not because of the hearing”. The problem I see here is that this question is erroneously perceived as “Do you need to have direct contact with the child to get a reaction, because of the child’s bad hearing?” I find this to be a serious misinterpretation because the questionnaires are created to try to find a possible pattern in child’s behaviour, which the parents might not be able to see. They might not have the knowledge to judge if certain behaviour is due to bad hearing or not. This misinterpretation can cause a problem if the parents’ answer really means “no, we don’t need to have direct contact with our child for him/her to react, because of a hearing problem”. They might think “That is just because he/she is stubborn and does not want to hear what we say – he/she hears what she wants to hear”. If that is what they think then this answer should have been “yes, we do need to have direct contact with our child for him/her to react”. This same problem affects all the questions from number 8 and onwards.

One solution for this problem is to change the order of the questions, so that they come before the questions directly related to the hearing.

A second solution is to add a sentence in the manual that points out that these questions should not be answered on the basis of the parent’s assumptions about the hearing of the child.

The third and the safest option I see is to combine the two above mentioned options, so that both a sentence is added in the manual and the order is changed. This is the option I will choose to recommend and I use this recommendation in my suggestion for an improved questionnaire, which can be seen below this paragraph.

Another problem was that there seems to be some courses of confusion in the form of the questions 1-6. There is a certain lack of logic between them, which only shows in some cases, but not all. This problem is also context related according to Olsen (2006). If the answer is “yes” in one of these questions, then the reason behind this answer is not identified and the answer to some of the following questions becomes evident. It gives a complexity of faults depending on the answers given by the parents, but to make the questions appear more logic in more cases I have changed the order of the questions and subquestions. I have added a question asking if the reason for the test showing bad hearing is still present in the child, or if the hearing loss was only temporary.

Finally I have added a sentence to make the user skip the two following questions if the answer to question number 3: “Did the investigation show normal hearing?” is “no”, the same has

been done for the added question, which in the new version has received number 18[25], where the user should skip to question 20[26] if the answer is "yes".

A general problem within the questionnaires was that some parents felt that their abilities as parents were in question. Some of the issues in the questions could be seen as raising issues, which is a sensitive topic. Examples here are question number 11: "Do you often need to repeat the things you say to your child", or number 17: "Does the child often want to be in charge when playing with other children?" Some parents felt like I was asking, "How well behaved is your child?" I suspect that this problem is mostly due to the fact that the participating parents did not have children in need of investigation and so their attitude towards the questions was different than it would have been if their child were in need of investigation. For this reason I decided not to make any changes in the questionnaire on the basis of this particular problem.

Another problem that I have noticed is that it is not really specified that the questions should be answered from the child's current situation. According to Olsen (2006) this issue belongs under "Recollection of information". In the process I have made the mistake of noting when the parents said "it was like that once", sometimes it was because of an earwax plug, sometimes because of fluid in the middle ear. When I take those things into account, the answers will show a wrong picture of the child. To solve this problem a sentence should be added at the beginning of the questionnaire and in the manual, to stress that we are asking about the child's current situation.

Furthermore I see a problem in the fact that these questionnaires are supposed to be used for a very wide age-group. The last question is " Does the child have difficulties with reading and writing?" This is not an appropriate question to ask the parents of a kindergarten child, especially not for parents of a 3-year-old. Though it is more relevant for the parents of a 5 or 6 year old, I still find it necessary to change for this age-group also. This problem belongs under the headline of "topic relevance" which I evaluated earlier in this thesis and initially found no reason to criticise.

To solve this problem I suggest the following questions to be used instead. "Attention towards written language: a. Does the child show any attention towards written language? b. Does the child make attempts to write? c. Does the child recognise his/her own name, any letters or other words? d. Can the child write his/her own name or any other words?" The parents should then cross "yes" or "no" according to the current level of the child.

[25] This number refers to the new version of the questionnaire, because the concerned question is a new addition and does not exist in the original version of the questionnaire.
[26] This number also refers to the new version of the questionnaire.

A problem that I found almost every time I filled out this questionnaire was - like most of the following problems in this questionnaire - a problem belonging to Olsen (2006)´s category of understanding the questions. The parents did not understand question number 10: “Does the child often misunderstand what is being said?” I needed to point out that I am not asking if the child does not hear or does not understand, but if the child thinks that they are saying something else than what they actually meant to say – that is a misunderstanding. The solution that I chose for this problem was to add; “so that the child thinks you are saying something else than what you actually meant to say”.

Question number 13: “Does the child express difficulties with hearing?” and question number 19: “Does the child comment on his/her own hearing?” are so much alike, that I have chosen to eliminate number 13 under the assumption that number 19 covers the content of this question. If the child “expresses difficulties” it would be mentioned if the parents are asked if the child “comments on his/her own hearing”.

In question number 14: “How does the child react when he/she does not understand a message?” it might be useful to add suggestions for possible reactions in the manual, since my results showed that several parents do not seem to know what to answer to this question. This is again a problem concerning Olsen (2006)’s category of understanding the questions, just like the following two problems:

Question number 16: “Does the child pull back from social events?” should be specified in whether the social situation is concerning children or adults and if it is concerning new acquaintances or in general. I assume that it is of most interest in connection to other children and I do not think the purpose is to find out if the child is a bit shy with new people. To solve this problem I have added “where more children are together” to this question, and maybe add in the manual that this question should not be answered in relation to meeting new people.

Question number 17 “Does the child prefer to be in charge when playing with other children?” will most defiantly benefit from adding “every time” to the sentence. Most parents will want to answer that the child has a balance in when they want to be in charge and when it is not necessary. Changing the meaning of the sentence by adding “always”, shows that it should only be answered positive if the child always wants to be in charge, but leaving “prefer” in the sentence stresses that the child might not always get to decide even though it always wants to.

Apart from the problems that I chose to discuss above, there are a few simple changes and additions that I did not find necessary to discuss in detail. This being the addition of a sentence between question 2 and 3 guiding the reader to skip forward to question number 4, if the answer

to question number 2 is "no". This being a change of words in a sentence to fit the addition that I made, and this being deletions of a few misplaced "YES" and "NO" in the questionnaire.

Here is my translated working version of the new and better questionnaire. The real questionnaire can be found in the appendix.

Figure 2: The parents' questionnaire – new version:

APD Gruppen – Denmark
WWW.APD.dk

This questionnaire needs to be filled out in co-operation between parents and Pedagogic/Psychological consultancy (PPR). To this questionnaire belongs a manual, which the professional should follow.

Questions for the parents in connection to investigation of Auditory Processing Disorder (APD)

The name of the child: _____
Age/social security number: _____
Date: _____
Interviewer: _____

This questionnaire must be filled out on the basis of the child's current situation, not on the basis of how it HAS been unless this is asked for specifically.

		YES	NO
1.	Has the child had or does it get help from a logopedien?	□	□
2.	Do you need to have direct contact with the child for him/her to react?	□	□
3.	Do you often need to repeat what is being said?	□	□
4.	Does the child often misunderstand what is being said, so that the child thinks that you mean something else than what you actually meant to say?	□	□
5.	Does the child show difficulties in perceiving speech in background noise?	□	□
6.	How does the child react when he/she does not understand a message? (See the most common reactions in the manual)		
	_____		
	_____		
7.	Does the child react sensitively to loud sounds?	□	□
8.	Does the child pull back from social events, where more children are together?	□	□
9.	Does the child always prefer to be in charge when playing with other children?	□	□
10.	Does the child comment on his/her own hearing?	□	□
11.	Does the child enjoy listening to aloud reading?	□	□
12.	Is there anyone in the family who has- or had language related difficulties as children?	□	□
	• If yes, which (speech- or reading/writing difficulties)_____		
13.	Attention towards written language:		
	a) Is the child interested in written language?	□	□
	b) Does the child try to write?	□	□
	c) Does the child recognise his/her own name, letters or other words?	□	□
	d) Is the child able to write his/her own name or other words?	□	□
14.	Does the child want the volume of the TV and radio turned up?	□	□
15.	Have you ever suspected that the child might have problems with hearing?	□	□
16.	Have you had the child's hearing tested? (if no, skip to question number 20)	□	□
	• If yes, then where was it tested? _____		
17.	Did the investigation show normal hearing? (If yes, skip to question number 20)		
	• On both ears Yes □ No □		
	• On the right ear Yes □ No □		
	• On the left ear Yes □ No □		
18.	If no, is the situation still the same or was the hearing loss only temporary, followed by normal hearing?	□	□
19.	Do you experience that the child's hearing is better in some periods than in others?	□	□
20.	Has the child had problems with his/her middle ear, for instance Infections?	□	□
	• If yes:		

- What type: _____
- When and how often: _____
- Age: _____
- Duration: _____
- How was the problem solved: _____

21. Does the child have any present problems with his/her middle ear? □ □
22. Has the child been operated in his/her middle ear/received a new tympanic membrane or drain? □ □

Further comments:

_____

_____

_____

7.5.3 The pedagogue's questionnaire

This questionnaire seems to have fewer problems than the above-mentioned questionnaire had and it should be noted that I did not find it necessary to change the order of the questions in this questionnaire, because the present order did not create any problems.

A problem that I mentioned in the previous paragraph, which is the same for this questionnaire, is the need to point out that we are discussing the child's current situation, not the past, unless this is mentioned specifically. Another repetition is the change I made in question number 12: "Does the child often pull away from social events?" where I added "with other children".

The biggest problem that the pilot study uncovered in this questionnaire was, that using numbers referring to the answer possibilities is much more problematic than it seems. This is an issue that I would have expected to encounter in my theoretical evaluation of the questionnaires, but I did not. One would think that remembering the four possibilities would be easy, but because the answer relates differently to each question, this task is difficult and it results in repeated pauses to look back in the pages to find the answer possibilities again and again. The reason for this is the negations within the questions, which results in that positive answers can be either 1= Never or 4 = Always. An example of this confusion can be seen when comparing question number 2: " Is the child depended on seeing the face of the speaker, to understand what is being said?" A positive answer here would be 1 = Never. In question number 9: " Does the child answer when questions are asked to the group?" Here a positive answer would be 4 = Always.

I see two possibilities of solving this problem. One is to change the questions so that the positive answer always lies in the same end of the scale. The second and in my opinion better solution, which is also the solution I have chosen is to write out the answer possibilities below each question.

Another problem I see is in question number 3: "Does the child get disturbed by noise or background noise?" It is not outlined if the answer should be related to noise in general, speech

noise in particular or only non-speech noise and this creates a problem related to Olsen (2006)'s category of understanding the questions. There is a possibility to write down which kind of noise it is, but for this to work there should be outlines in a manual, otherwise this is not useful. One could also solve the problem by adding different options, which I have chosen to do in my suggestion. The reason why I find this necessary is that there is a big difference between a child being disturbed by interesting things happening and a child not being able to stay concentrated due involuntary distractions. Some children are very alert because they do not want to miss out on anything. This shows a different characteristic in the child than when a child looses concentration every time a car passes by on the street outside the window.

Question number 10: "Does the child have difficulty locating a sound source?" can be difficult to answer, because the pedagogues might not know how this would manifest itself in the daily life - another problem from Olsens (2006)'s category of understanding the question. The solution I have chosen here is adding the sentence "This could show itself by clumsy behaviour, for example if the child often gets hurt on the playground by bumping into other children because he/she does not hear them coming".

An addition, which I made in question number 11 "Does the child show difficulties in rhyming and reel offs?" is that I added "or/and songs". I chose to do this because in most kindergartens they sing much more than they do rhymes and reel offs and because it shows somewhat the same ability. Of course in singing another aspect is added and so it should be noted in the manual, but I find it useful to put these things together.

A small addition that I made is adding an "or" in question number 8: "Does the child often say "What?" and/or want the message repeated?" The reason for this is that the child might use another phrase to ask for repetition. I also changed the sentence that is supposed to explain how to fill out the questionnaire. The previous sentence told us to circle the child's behaviour, but I assume that the meaning was to tell us to circle the answer that fits the child's behaviour best, in the different situations that the questions outline.

Figure 3: The pedagogue questionnaire – new version:

APD gruppen - Denmark
WWW.APD.dk

This questionnaire must be filled out in a co-operation between the personal and Pedagogic/Psychological consultansy (PPR). To this questionnaire belongs a manual, which the professional should follow.

Questions for the pedagogic personal in the kindergarten in connection to investigation of Auditory Processing Disorder (APD)
The name of the child: _____
Age/social security number: _____
Date: _____

Interviewer: _____

This questionnaire must be filled out on the basis of the child's current situation, not on the basis of how it HAS been unless this is asked for specifically.

Circle the response possibility that fits the behaviour of the child best.

1. Does the child have difficulties keeping attention on the person who is talking?
   Never Occasionally Often Always
2. Is the child dependent on being able to see the face of the speaker, to understand what is being said?
   Never Occasionally Often Always
3. Does the child get disturbed by noise or background noise?
   Never Occasionally Often Always
   - If yes, (x which types of sounds)
     - All sounds:……□ □
     - Speech:……□ □
     - Loud noises:……□ □
     - Sounds from interesting activities that the child wishes to participate in:..□ □
     - Other_____
4. Does the child hear when he/she has his/her back towards the sound source?
   Never Occasionally Often Always
5. Does the child easily loose concentration?
   Never Occasionally Often Always
6. Does the child have difficulties understanding messages (especially polynomial messages)?
   Never Occasionally Often Always
7. Does the child have difficulties remembering a message?
   Never Occasionally Often Always
8. Does the child often say "What?" and/or wants the message repeated?
   Never Occasionally Often Always
9. Does the child answer when questions are asked to the group?
   Never Occasionally Often Always
10. Does the child have difficulty locating a sound source? (This can for example show it self by clumsy behaviour, e.g. getting hurt by bumping into others on the playground, because the child does not hear them coming)
    Never Occasionally Often Always
11. Does the child have difficulties with rhyming, reel offs and/or songs?
    Never Occasionally Often Always
12. Does the child often pull away from social events with other children?
    Never Occasionally Often Always
13. Does the child disturb other children or ruin their games?
    Never Occasionally Often Always
14. Do other children accept the child?
    Never Occasionally Often Always
15. Does the child give up easily in situations where communication is necessary?
    Never Occasionally Often Always
16. Does the child enjoy participating in aloud reading?
    Never Occasionally Often Always
17. Can the child retell a story?
    Never Occasionally Often Always
18. Does the child have difficulties initiating a game or an activity?
    Never Occasionally Often Always
19. Does the child have language-related difficulties?
    NO/Few Partially Many Severe

Further comments:

_____
_____
_____
_____

7.6 Discussion

Initially I evaluated the questionnaires according to the theory of the field. Here I would have suspected to encounter information about response options, which would answer my questions about the change I made by using words instead of numbers as response options, and about the possible expansion of the response options in the parents' questionnaire, that I considered. Unfortunately I found nothing to support these changes. I also have not been able to find any support for keeping the response options the way they were. Since the use of numbers used as response options created problems in the pilot study I chose to make this change, while the amount of response options have not created any problems during the process and for this reason I chose to leave them as they were initially.

When reviewing the previous paragraphs one will note that there were not as many problems with the pedagogue's questionnaire as there was with the parents' questionnaire. A reason for this could be that the pedagogues, due to their education, are more able to understand what is meant by the questions and what the focus should be. The parents might need the questionnaires to be more carefully formulated so it describes very clearly what is meant and what the focus should be.

A very important issue that I want to point out is that the questionnaires cover a large age group and so when they are being interpreted it should be on the bases of the child's age, not just relating to the age group of kindergarten children. There is a very big difference in what you can expect from a 3-year-old and a 5-6 year old. This should be considered when doing a standardisation of these questionnaires.

7.7 Conclusion

When concluding upon this chapter, it is worth remembering that I actually already finalised these questionnaires once before. This was before I began the pilot project, when I first approached Mathiesen and the questionnaires were not completely done yet. This still amazes me, and it points out the importance of doing pilot studies and then I once more have to remember how Donald Bradbent struck the nerve of the issue when he said:

> *" The great value of practical problems is that they force upon us difficulties which experiments done for theoretical reasons may ignore"* (Jerger & Martin, 2006, pp. 25, l. 1-4)

Before I initiated the pilot study I took two theoretical steps. One to assure the quality according to the present knowledge about how to make the questionnaires. For this purpose I used Olsen (2006)'s listing of relevant topics that should be evaluated. Doing this I initially found only

one problem under the category of supervisory issues, but during the pilot study several problems also occurred in the areas of understanding of questions and context effects even though I previously had evaluated these two areas to have no problems.

The second step I took before initiating the pilot study was to hold the content of the questionnaire up against the theory of APD presented in this thesis. Doing so I found no reason to criticise, but the results in the pilot study showed an obvious topic-related irrelevance under the question concerning attention on written language.

In my pilot study I have reached results that show the need for a manual that describes the role of the professional person from the PPR. I have made some specific suggestions for what should be included in such a manual both in relation to the general perspective and in relation to some specific questions. Furthermore I have suggested changes for the parents' questionnaire and I have incorporated these changes in a finished suggestion for a new parents' questionnaire, which was attached above in a translated working version. Finally I have suggested changes for the pedagogue's questionnaire, which I have incorporated in a finished suggestion for a new questionnaire for pedagogues. This questionnaire was also attached above, in a translated working version. The finalised Danish questionnaires are both attached in the appendix in the right format, ready to be uploaded on the homepage from "APD-gruppen".

Up to this point in this thesis I have reviewed the prevalence of APD, the theory behind normal hearing necessary to understand the concept of APD and Indicators. I have discussed causes, risk factors, symptoms and profiles of APD, and comorbidity, the investigative process and audiological tests used in these processes. Furthermore I have reviewed the screening procedures stressing the audiological part of the procedure. I have reached a state-of-the-art agreement with TAL on the content of an audiological psychoacoustic test battery, which led me to realise the lack of materials that are needed to be able to identify APD in children below the age of 7. This brought me to my pilot study of the questionnaires that can be used to investigate for APD in kindergarten children. I analysed and concluded upon my findings and made suggestions for improvements, which are finalised and ready to be used.

So far this thesis has contributed to the problematic field of identifying the children, now I would like to shift the focus to what we can do to help these children when we have found them. In the next chapter I will look at possibilities of intervention.

8 Intervention in APD

8.1 Introduction

Given the potential impact of APD on listening, communication and academic outcomes, and considering the frequent comorbidity of APD with related language and learning difficulties, it is important that intervention be approached in a holistic manner. A multidisciplinary team approach to APD is thus recommended. Aspects such as the individual's language abilities, attention and memory all need to be considered when planning intervention. Due to the heterogeneous nature of APD, individualised rather than general intervention programmes are warranted (Bamiou et al., 2006).

On a seminar in London in June 2005 called "Current Trends in Auditory Processing Disorders 2005" Campbell[27] suggests 5 golden rules in the treatment of children with APD reported by Mathiesen and Jensen (2006):

1. An accurate diagnosis must be made.
2. Neuroplasticity – early identification is crucial – preferably before the child starts school.
3. Individually fitted treatment plans.
4. A multidisciplinary approach that focuses on the individual child is important.
5. It is crucial to secure transitions from the different areas in the child's life, such as kindergarten, school, home and other activities.

In Denmark we are still not ready with the tests that they have abroad, and consequently also not with the diagnosis, but that should not stop us from taking action against APD. A thorough anamnesis will clarify the difficulties of the child and from that knowledge the treatment can be implemented. The behaviour of the child will set the stage for certain measures and a thorough observation of the child will reveal if it is the right measures that have been taken.

In this chapter I will review the principles for the intervention in APD. I have chosen to focus on the conditions in the child's educational settings.

It is important to note that the intervention strategies described below have *not* been done in Danish yet. It is beyond the scope of this thesis to make such a transition, but since there are no

[27] Dr. Nicci Campbell from University of Southhampton.

standards or established praxis in Denmark I will review the foreign literature done on the topic. This can be used as an inspiration when making a Danish intervention program.

8.2 Specific intervention strategies for APD

According to Bellis (2004) the basic principles for treatment of APD are:

- Optimising the acoustic environment, i.e. improving the signal-to-noise ratios (SNR).
- Remedy techniques - direct therapy, i.e. auditory training, a bottom-up-approach.
- Compensational strategies, including linguistic- and cognitive strategies, i.e. training of the superior abilities, a top-down-approach.

All three approaches are necessary to achieve an effective treatment, and the approach should focus directly on the child's hearing deficit. Many activities in the treatment influence more than one of the parameters. Unfortunately no one knows exactly what treatment brings the best effect (Bellis, 2002).

Bamiou et al., 2006 divides intervention strategies into five main categories:

- Environmental modifications
- Signal enhancement strategies
- Teacher/speaker based adaptations,
- Formal and informal auditory training
- Compensatory strategies.

Bellis (2002) and Bamiou (2006) each suggested a way of dividing intervention strategies. I find it beneficial to combine these two suggestions, which I have done in the paragraphs below.

8.3 Optimising the acoustic environment

Bellis' first principle is optimising the acoustic environment. This should be the first step in any treatment of APD. It includes both a bottom-up-approach, which involves making the acoustic signal more accessible in the educational setting to minimise the auditory demands on the child as much as possible, but also a top-down-approach that involves teacher/speaker adjustments. The acoustic signal from the source must be as clear and structured as possible (ASHA, 2006). Optimising the acoustic environment does not remove the disorder, but it will give the child an environment where it is easy to listen.

Optimising the acoustic environment can be done in several ways. To give an overview I will use Bamiou (2006)'s division below.

8.3.1 Environmental modifications

Reverberation is the multiple reflections of sounds within a room that can prolong and distort the original sound components and may amplify background noise (Bamiou et al., 2006). The effect of noise and reverberation will result in degradation of the speech signal, due to masking of key elements, the smearing of temporal cues and the loss of speech energy over distance (Bamiou et al., 2006).

Architectural interventions can be used to improve SNR and reduce reverberation. Reverberation times and background noise levels can be improved by simple means of acoustic treatment, such as carpets, curtains, doors, rubber shoes on furniture legs, windows to reduce outside noise and soft covers on display tables. Also more sophisticated means, such as installation of noise absorbent partitions or screens within the classrooms. Covering hard reflective surfaces with absorptive material such as acoustic panelling and corkboards can reduce reverberation time (Bamiou et al., 2006).

8.3.1.1 Signal enhancement strategies

Personal- or soundfield FM systems are wireless assistive listening devices that receive distant auditory input, amplify and transmit the signal to the ear of the listener. A microphone worn by the speaker and connected to a transmitter picks up the speech signal of the speaker and converts this to an electrical signal, which is transmitted via FM bands waves to the receiver (Bamiou et al., 2006). The loss of critical speech elements is overcome since the distance travelled by the speech signal is reduced, while masking of the speech signals by noise is minimised (Bamiou et al., 2006).

There is a lack of outcome studies of APD intervention with FM amplification. According to Bamiou et al. (2006) beneficial effects for both teachers and students and high satisfaction with a soundfield FM system installed in the classroom have been reported. Children with learning disabilities due to the presence of APD who received a personal FM system at school showed significantly more improvement in measures of speech in noise intelligibility as well as auditory memory than the control group after four months (Bamiou et al., 2006).

Some scientists have suggested that FM systems can be used as the only treatment for APD and if this treatment works, then they argue that this is sufficient evidence for the diagnosis of APD. Bamiou et al. (2006) puts this issue to rest by stressing that FM systems may only be considered as part of the management process, and may not be indicated for all types of APD.

Children with good results in monoaural low redundancy tests and dichotic speech tests will typically not derive benefit from this intervention (Bamiou et al., 2006).

Careful audiological evaluation of the child and modification of classroom acoustics should precede the fitting of an FM system and consideration should be made to the age of the child, his/her motivation, and the setting where the device will be used among other factors. The child and the teachers should be educated about the use of the device, and the outcome of this intervention should be monitored (Bamiou et al., 2006).

8.3.1.2 Teacher/speaker based adaptations

Optimising the acoustic environment can also involve teacher/speaker based adaptations. Traditionally, teachers who come across children with APD have been advised to use clear and slow speech; however, it would be more precise to advise them to alter the pacing, emphasis and segmentation of their speech in order to highlight the key points of the message. These changes would also slow down the teacher's speech. The teacher may also use repetition or re-phrasing of a message, using additional visual or other cues, keeping the message short, showing something rather than describing it, and frequently checking for understanding (Bamiou et al., 2006). Remembering the chapter on APD profiles it becomes obvious that different strategies may be indicated for different profiles of APD.

Furthermore it is advised that teachers consider reducing the space used in the class during direct teaching sessions in order to minimise distance from the teacher to the students. Preferential sitting will also be of benefit for children with APD (Bamiou et al., 2006).

Bellis and Bamiou agree on the next division called auditory training.

8.4 Auditory training

The brain is plastic and can change when stimulated. This knowledge of the brain's ability to change, reorganise and build new and strong connections as a reaction to stimuli (Bellis, 2002), is what auditory training builds upon (Musiek et al., 1999). Auditory training is employed in order to improve the auditory system performance in the analysis of acoustic signals by capitalising on the brain's inherent capacity for plasticity and possibly also by recruitment and facilitation of other metacognitive or metalinguistic processes (Bamiou et al., 2006).

With auditory stimulation insufficient abilities can be habilitated. The plasticity of the brain is greatest in young individuals and especially children with APD might, after auditory training, no longer show symptoms or diagnostic indications of APD (ASHA, 2006). Therefore it is important to start treatment as early as possible, after the diagnosis has been made, so that the plasticity of

the brain is used as much as possible and the remaining functional deficits are reduced as much as possible (ASHA, 2006). Some children will still have difficulties listening in some situations and must learn to compensate for this auditory problem.

The literature concerning auditory- and cognitive neuroscience support a comprehensive training program, that both includes a perceptual bottom-up-approach, for example auditory training and clarification of the acoustic signal, and a cognitive, meta-cognitive and linguistic top-down- approach (ASHA, 2006). The top-down-approach is expected to be able to affect the bottom-up-abilities, which favours a combination of a perceptual bottom-up-training and a cognitive top-down-training (Chermak, 2001).

A variety of tasks can be used for auditory training purposes provided that these are age-appropriate, and are chosen on the basis of specific test findings. This requires a thorough diagnostic preparatory work. Tasks should be presented systematically and gradually made more difficult in order to be challenging as well as motivating. It is suggested that the task performance accuracy should be between 30% and 70%, and that the client should attain a minimum of 70% before proceeding to the next level of difficulty (Bamiou et al., 2006). If the assignments are either too easy or too difficult and without progressive development, the structural and functional changes of the brain will not occur. The training should not be done during school lessons (Bellis, 2002), but could be planned directly after school. According to the new executive orders on education of children with special needs for 2007, this is also the general recommendation for all types of speech therapy in Denmark (Frederiksen, 2006).

Apart from training those auditory processes, where deficits are present, it can be necessary to train for example the auditory memory, which is a process that can not be examined with the central auditory tests. Instead it could be the psychologists or others that work with the child, who notice a deficit there. According to Mathiesen (2006) Campbell stressed that the auditory memory is a key element in the work with children with APD.

Formal auditory training may include procedures performed using audiological equipment or computers, while informal auditory training does not require “high-tech” resources. Gain could be maximised with early intervention, repeated, intensive, systematic and progressive presentations, tailored to the needs of the individual child.

A major advantage of formal training is the ability to manipulate the acoustic stimuli with precision and this type of training does not require complex instruments, but can be done in a normal clinic (Bamiou et al., 2006).

The purpose of informal auditory training activities is to train fundamental auditory mechanisms and processes such as auditory closure, temporal patterning and prosody auditory discrimination, dichotic listening, interhemispheric transfer of information. While outcome studies other than single case studies are lacking, these are cost-effective procedures that have been long employed in children's education (Bamiou et al., 2006).

Recently computer programs have been developed where auditory training tasks are presented with an adaptive procedure. This may help maintain the task at an appropriate difficulty level and thus keep the client interested (Bamiou et al., 2006).

There is some recent evidence to suggest that formal auditory training by means of computerised games leads to improvements in phonological awareness and educational performance in these children (Bamiou et al., 2006). Examples of computer based commercially available auditory training programs include FastForWord, Phonomena and Earobics, which was presented by James Hall at the previously mentioned APD seminar that I attended in Kolding in 2005. To my knowledge there does not exist any standardised Danish versions of these programs. In spite of this there seems to be a potential in these programs, that can engage the children and provide repeated stimulation and intensive training with systematic variations in complexity level, which can lead to established abilities and automation of these in the child (Chermak, 2001).

In the next paragraphs I will let suggestions from three different authors supplement each other. This being Cambell from a seminar in 2005 by source of Mathiesen (2006), Bellis (2002) and Bamiou et al.(2006).

8.4.1 Auditory closure activities

Individuals with deficits in auditory closure skills, which as earlier mentioned is the listener's ability to create a whole from a degraded acoustic signal, tend to perform poorly in tests of monoaural low redundancy speech. Especially for the child with APD profile 1, it can be useful to train the use of context to fill out the parts of the speech that the child does not perceive. The purpose of auditory closure activities is to assist the individual in learning how to fill the missing part in order to perceive a meaningful whole (Bellis, 2002).

Small children can be made aware of the context by having to guess the missing word in known songs and rhymes. For children who are a bit older it could be words that are left out of sentences like "Beckham kicks the …. with his foot". These exercises can be made more difficult by adding noise so that the child's tolerance level will increase (Bellis, 2002).

Campbell also suggested auditory fill-out-activities, for example: Missing words, syllables and phonemes, speech-in-noise training or vocabulary/word building, for example to make a

qualified guess of what an unknown word could mean or a word that is difficult to hear could be (Mathiesen, 2006).

Bamiou et al. (2006) made the most resent suggestion in which they generally agree on the above-mentioned suggestions but make a few additions. Bamiou et al. (2006)'s final listing of activities looks like this:

- Missing Word, syllable and phoneme exercises where the individual is taught to fill in the missing part of the sentence or word.

- Reduced external redundancy exercises such as speech-in-noise training of different accents/misarticulations. By reducing the external redundancy of a signal a situation is created where information is missed. Auditory closure is thus necessary to fill in the "gaps" that are not heard.

- Vocabulary training where the meaning of a word is predicted from the context in which it is used and the word is then reinforced.

8.4.2 Temporal patterning and prosody training

Individuals with deficits in temporal patterning and prosodic skills often exhibit difficulty in temporal tests such as the Frequency or Duration Patterns Tests. Specific training in the recognition and use of prosodic aspects of speech, such as rhythm, stress and intonation is recommended. Prosodic training is most relevant for children with APD profile 2 that have difficulty perceiving the tone in speech, for example whether the speaker is angry or happy. The exercise could be a role-play. The best result occurs when the child both have to listen and has to produce speech (Bellis, 2002). Campbell suggested that prosodic training includes exercises training stress on single syllables, stress on word/sentences, intonation, identification of keywords, and reading aloud with intonation (Mathiesen, 2006).

Training of temporal processing skills involves listening to rhythms, stress and pitch. The exercise can for example be performed with clapping of the hands or by using speech sounds and it is most relevant for children with APD profile 2, where the child will have difficulties perceiving the changes in the speech. The exercise can for example be that the child has to repeat a clapping sequence or determine which clap is the loudest or what word in a sentence that has emphasis. A variation could be that every time the child has repeated a clapping sequence, an additional clap is added and the child has to repeat the new sequence correctly. This also trains the child's memory (Musiek et al., 1999). Gap Detection can also be trained.

Campbell by source of Mathiesen and Jensen (2006) suggested that training the temporal processing is training the ability to separate, analyse and imitate auditory patterns. At this point I am convinced that Mathiesen and Jensen's translation of Campbell's listing is incorrect. The original listing was: Different tempo (quick-slow), different strength (high – low), different rhythms. Since both tempo and rhythms are just sounds and pauses of different duration, since I assume that by "strength" they mean "intensity" and by "high-low" they mean "strong-soft" and last but not least, it seems that they left pitch out of their listing. I am convinced that their listing is supposed to be as follows:

- Different durations (long – short).
- Different intensities (strong - soft)
- Different pitch (high – low)

Bamiou et al. (2006) suggest that activities could include:

- Same/different judgements of non-speech stimuli differing in pitch, stress, loudness and interstimulus interval.
- Syllabic stress in words (e.g. *con*vict versus con*vict*)[28]
- Changing the emphasis can change the meaning of the sentence (e.g. "Put the *book* on the table" versus "Put the book on the *table*").
- Understanding intent (e.g. tone of voice, use of sarcasm, "punch-line" of a joke/story, direct speech, passive voice).
- Training in keyword extraction where the individual is taught how to listen for the key components of a message (these words are usually emphasised in speech).
- Reading aloud with intonation which reinforces the use of rhythm, stress and intonation in speech and language.
- Playing the Simon Says game, which requires the sequencing of sounds that generate patterns, which may help with sequencing skills. Replicating note sequences played on a piano, which can be altered in several parameters such as pitch, interstimulus interval, loudness, etc. can be used for same purpose.

Campbell adds interhemispheric training (Mathiesen and Jensen, 2006). This could be verbal to motor actions, left handed motor action to verbal action, motor action with both hands.

[28] This type of distinction exists in Danish, but is not common (standard-standart; billigst-billist).

Training with music, for example by listening to the lyrics, pattern recognition or physical activity like sports, games and dance (Mathiesen, 2006).

Under this point Bellis (2002) also mentions training the ability to listen to polynomial messages. The child can for example be asked to draw after instructions: Step 1: "Draw a square". Step 2: "Draw a square with a letter inside". Step 3: "Draw a square with a letter inside and a dot on top of the letter". The child can also be asked to do something relevant, like: "Go down the stairs, turn on the light, take your shoes and put them in the closet. This can be done in form of a game. An example of this exercise is the Token Test[29] (Musiek et al., 1999).

8.4.3 Auditory discrimination training

To Bellis (2002) this type of training is most relevant for children with APD profile 1. Individuals with auditory discrimination deficits typically experience difficulty with phonological awareness and speech-to-print skills.

Campbell stressed that phonological awareness is key elements in the work with children with APD (Mathiesen and Jensen, 2006). Phonological awareness refers to the ability to recognise and manipulate the various units characteristic of language, namely words, syllables and phonemes. Phonemic awareness and discrimination is the highest level of the phonological awareness continuum. Campbell suggested that phonemic training includes discrimination of phonemes, vocal training – co-articulations and phonological awareness training (Mathiesen and Jensen, 2006). The training should develop the processing ability of language sounds through phonemic analyses, phonemic syntheses and rhyming. The training should take place in a quiet room so that masking of sounds is avoided (Musiek et al., 1999). A Danish material "På vej til den første læsning - fonologisk opmærksomhed"[30] is an option.

Phonological awareness has traditionally fallen within the domain of the speech-language therapists and is considered to be the best predictor of reading and spelling success. Many of the computer assisted intervention programs now available are based on training individuals in temporal processing and auditory discrimination. In addition to computer-based programs, Bamiou et al. (2006) suggests the following activities:

[29] The Token Test is from 1969. It was developed to evaluate the verbal understanding of instructions with increasing complexity. The test can be used both for children and for adults and it exists in both a short and a long version.

[30] Translated "On the way to the first reading" by Ina Borstrøm and Dorthe Klint Petersen. The material was developed to phonemic training in the preschool class and the purpose is to give the children an easier beginning in the process of learning to read. In a study the material has proved it self to be able to help children of dyslectic parents by improving their phonemic awareness. (Petersen, 2000).

- Phoneme discrimination training where phonemes are first discriminated on sound level, then activities move to discrimination of phonemes on syllables level and word level (e.g. seat - sheet).
- Phonics and speech-to-print skills, which involve connecting phonemes to their corresponding printed letter symbols.

8.4.4 Dichotic listening training

Individuals with deficits in binaural separation or integration often show poor performance on dichotic listening tasks and exhibit difficulty in processing auditory information in the presence of competing signals (Bamiou et al., 2006). Bellis (2002) suggests training of the selective attention, which is the ability to listen to a message while another message is being ignored. This is often difficult for children with APD. This ability can be trained with dichotic listening, where the child's attention is directed towards the weakest ear (Bellis, 2002). Furthermore Bellis (2002) adds training of localisation. Children with APD often have difficulties identifying the location of a sound source. This ability can be trained by letting the child judge if a sound comes from the left or from the right. The complexity can be raised by moving the sound sources closer together.

Campbell added that the training can begin in a quiet environment with increasing amounts of noise being added and used for binaural integration/separation activities, for example with a competing signal in the opposite ear (Mathiesen and Jensen, 2006).
Bamiou et al. (2006) suggest that dichotic activities could include:

- Informal speech in noise training. Listening to lyrics of songs to help with listening in background noise. Training should start with familiar, slow songs, sung by one singer in the patient’s own accent, and gradually proceed to faster songs, different accents, more than one singer, and then to unfamiliar songs. The patient should read the lyrics after the song to check how well he understood these.
- Informal dichotic training: This training consists of listening with headphones on the weak ear (identified by dichotic tests) only to something that is of interest, such as talk on the radio or a book that is being read by an actor. The right ear should be left uncovered and exposed to some other competing sound, such as (with increasing levels of difficulty) the white noise of the radio in between stations, orchestral music, music with lyrics, or the television (the news, a serial or similar with people talking).
  Initially, the volume of the competing sound should be just audible, but the aim is to gradually turn the volume up/decrease the signal to noise ratio.

- Localisation training in quit and noise. Games such as “Blind Man’s Bluff” and “Marco Polo” are examples of games that can be played.

8.5 Compensatory Strategies

The goal is to teach the child compensatory strategies, so that the disorder’s influence on daily life can be diminished, by strengthening the superior central resources as language, memory and attention (ASHA, 2006). In several cases auditory training will not be able to eliminate all the difficulties the child is experiencing because of the APD. Therefore it can be beneficial to teach the child some compensatory strategies (Bellis, 2002), and Campbell pointed out that different compensatory strategies for the individual children are necessary (Mathiesen, 2006).

Compensatory strategies are used to assist individuals to overcome residual dysfunction and maximise the use of auditory information (Bamiou et al., 2006). Auditory processing is not the only activity in the brain when we listen. A cognitive factor always plays a part in the things we do. Listening actively is a metacognitive strategy, because the child consciously has to use its knowledge of listening and use all energy on listening. The child must learn to be conscious about for example its attention and understanding. It requires an active effort from the child to achieve the knowledge that is required to use conscious control over the processes that are required in listening. In many people the metacognitive processes occur automatically, in others it takes a conscious effort (Musiek et al., 1999). When the child has to learn to compensate for its hearing difficulties a metacognitive approach must be taken. The following is examples on metacognitive approaches that the child can take to become an active listener. They may seem obvious and straightforward, but they might not be for a child with APD. If the child had thought the following points to be obvious and easy it probably would have used them already, therefore it might be necessary to teach these approaches (Musiek et al., 1999). These strategies include (Bamiou et al., 2006):

- Active listening where the individual is taught how to become an active listener by taking responsibility for their own listening. “Whole-body listening” techniques can be used to develop an understanding that listening is an active process.
- Auditory vigilance training. The key element in this training approach involves a target stimulus presented at a random interval. For example, the parent reads a story, and the child is asked to raise his/her hand every time the target word/sound occurs - same in noise.

- Auditory memory enhancement. There are three different types of memory, namely short-term memory, long-term memory and sequential memory and provides suggestions for activities to enhance memory. The use of techniques that have been shown to enhance recall, such as imagery, spatial elaboration, generative processes, and organisational processes. It is also helpful to use a functional approach to ensure that a child with APD is able to remember his/her telephone number and address, days of the week, months of the year, alphabet and alphabetic principle, instructions in the classroom and sports fields, rules of games, and timetables.
- Auditory directives training. This can be performed in real life context, and in the form of game. The trainer (therapist/parent) gives a verbal directive that involves a motor task, which the therapist can observe and the child will enjoy. Feedback regarding performance is given to the child at the end of each training session.
- Metacognitive strategies can be used to assist individuals to improve their access to comprehend spoken language, e.g. self-regulation, problem solving, memory strategies and the use of anachronism or analogies, pictorials representation and verbal rehearsal or re-auditorisation.
- Linguistic and metalinguistic strategies such as:
    - Practising the rules of language such as tag words (first, last, next, before, after), adversative terms (but, however, although) and terms implying relationships, causal terms (therefore, because), examination terms (list, discuss, explain).
    - Formal schema induction (to predict relationships among elements in a message, e.g. “the first point I would like to make” suggests that a number of points will be made).
    - Content or contextual schemata (interpreting a message based on the context).
- Curriculum modifications. These may include pre-teaching or pre-viewing material, or pre-teaching the task demands through explicit instructions and repeated practice across different contexts and settings, giving frequent breaks during the day, interspersing academic lectures with more hands-on activities, scheduling downtime after school.
- Cognitive strategies are more task-specific, and often refer to direct manipulation of the learning material itself. Examples of cognitive strategies are note-taking, repetition, guessing meaning from context, or using mnemonic devices. Since these strategies are not task-specific, it is quite likely that once taught, they may be employed to resolve

difficulties in varied communication situations. However, to my knowledge, the efficiency of these intervention techniques has not been tested in the APD population.

An advantage in the metacognitive approach is that the child becomes capable of evaluating if the approach has an effect. If the child's conscious goal is always to hear what the teacher says, and it from this goal makes the measures necessary in the listening situations, it will always be able to evaluate the success of these (Chermak and Musiek, 1997). For this approach to succeed the child has to be motivated to make an effort to improve the listening abilities and it should be given an understanding of the nature of the listening difficulties and what causes them. As long as the child does not understand the cause of his/her problems, no one can expect that it is capable of doing something about them.

Not all of the above mentioned intervention options are relevant for all children with APD. The choice of intervention should depend on the symptoms that the child is showing, which I will clarify in the paragraph below.

8.6 Intervention is deficit specific

Intervention for APD is deficit specific. That means that it is based on identification and treatment of the primary deficit caused by a disease in a "bottom-up" manner. In addition, the disease related symptoms i.e. language, learning and communication are addressed through “top-down” intervention techniques. Top-down intervention refers to the use of the general knowledge shared by listeners in a communicative situation, which leads to the development of presuppositions and expectations, so that words heard in a certain context are interpreted on the basis of pre-existing knowledge. Bottom-up refers to the use of acoustic information (decoding) combined to form meaningful auditory signals and then passed on to the higher processes for further analysis: from letters/words to a complete message, i.e. attaching meanings (Bamiou et al., 2006).

Auditory training can be test driven, i.e. training tasks are chosen on the basis of test findings. Alternatively, auditory training can be profile driven (Bamoiu et al., 2006). The child is classified into an APD profile, according to the test results, and intervention is decided accordingly. Below I will briefly list the previously mentioned intervention strategies according to APD profile.

8.6.1 Intervention according to APD profile

Intervention strategies for Bellis/Ferre’s first profile, the Auditory Decoding Deficit profile include (Bamiou et al., 2006):

- Improving acoustic access

- Pre-teaching new vocabulary and concepts
- Use of visual and/or multimodality cues
- Repeating rather than rephrasing messages
- Phoneme training
- Compensatory strategies to improve listening and auditory closure skills
- Speech and language therapy

Intervention strategies for Bellis/Ferre's Prosodic Deficit profile include (Bamiou et al., 2006):

- Placement with a teacher who makes generous use of prosodic cues and multimodality augmentation
- Use of clear direct language
- Temporal patterning and prosodic training
- Reading aloud with exaggerated prosodic features
- Compensatory strategies to include social communication and judgement
- Explaining underlying intent,
- Topic maintenance and communication repair strategies
- Intervention by other professionals (e.g. vision therapy, mathematics tutoring, pragmatic therapy) may be indicated.

Intervention strategies for Bellis/Ferre's Integration Deficit profile include (Bamiou et al., 2006):

- Improving acoustic access
- Limiting multimodality cues
- Prosodic training
- Direct activities to target interhemispheric activities and binaural separation/integration training
- Compensatory strategies including active listening and recruitment of stronger, top-down language and cognitive functions as well as occupational therapy
- Tutoring in specific academic areas
- Other intervention depending on the type and degree of associated symptoms.

8.7 Efficiency of intervention

Recently, there has been a focus in virtually all-rehabilitative fields towards establishing the efficacy of intervention measures. In the area of APD, many advances has been made to

establish the efficacy of diagnostic test measures; however, relatively less attention has been directed at documenting outcome measures of APD intervention strategies (Baran et al., 2006).

The physiological basis for auditory training or intervention is brain plasticity, i.e. changes in neural circuitry and brain organisation can be achieved by appropriately stimulating the neural substrate of the CANS (Baran, 2006).

Baran (2006) used the following definition: The alteration of nerve cells to better conform to immediate environmental influences, with this alteration often associated with behavioural change. This definition suggests that behavioural changes in auditory performance should be associated with physiological changes in the CANS. This is an intriguing concept which has suggested a way in which clinicians and researchers may be able to document efficiency of intervention programs (Baran, 2006). There are but a few case control outcome studies of APD management. According to Bamiou et al. (2006), Jirsa found significant changes in the late cortical response measurement (LCR) following a structural training program for a group of children with APD. No change was seen in the control group (Bamiou et al., 2006).

According to Baran (2006) studies have shown that auditory training alters underlying neural activity and that changes in neural function can precede behavioural learning. Electrophysiological measures can be useful in documenting the positive outcomes of intervention programs. Baran et al. (2006) anticipates that utilisation of such objective measures of treatment efficacy will become much more commonplace as additional clinical research studies further elucidate the utility of these measures for this purpose.

Professor Dave Moore from Institute of Hearing Research, University Park in Nottingham has worked with auditory training and concluded on his studies, that auditory training improves auditory processing and that auditory training can improve language abilities for example phonological awareness (Mathiesen and Jensen, 2006).

Baran et al. (2006) worked with children with APD and determined that children who were trained on various kinds of dichotic stimuli using greater intensity to the weaker ear, maintain good performance in that ear and after some training, the intensity level of the stronger ear could be gradually raised and the poorer ear would maintain its high performance. This technique holds promise for a useful auditory training approach that can be readily used in a variety of settings (Baran et al., 2006).

Tallal et al. (1996) studied the effect of auditory training with a bottom-up-approach in children. This study showed that it is possible to improve the auditory abilities with a bottom-up-approach in the form of auditory training in children with language learning disabilities (LLI).

According to Bamiou (2006) Putter-Katz et al. compared central auditory test results before and after intervention in 20 children with APD. The children were divided into two groups: group 1 (with difficulties in speech-in-noise tests) and group 2 (difficulties in speech-in-noise and dichotic listening tasks). For a period of 13-15 weeks, the children received weekly training sessions of 45 min., targeting the main auditory deficit, as well as environmental modifications and compensatory strategies. After the training, group 1 improved on speech-in-noise scores only while group 2 improved on all tests (Bamiou et al., 2006).

I have not been able to find any studies showing that it is *not* possible to train children with APD. This fact and all of the above indicates, but does not prove, that it is possible to train children with APD so that they achieve a better auditory processing.

8.8 Pharmacological treatment

Until now no pharmaceuticals has shown a positive effect specifically on APD. Research has shown that pharmacological intervention can change physiological and behavioural aspects of hearing, including selective auditory attention and signal detection in noise. This shows a possible potential in pharmaceutical treatment of APD (ASHA, 2006), but for reasons of space I will not dig deeper into this area in this thesis.

8.9 Concluding on Intervention in APD

The clinician that deals with the assessment and management of APD in individuals suspected of suffering from the disorder is faced with both practical and theoretical challenges as well as scientific uncertainties. However, the field is rapidly expanding. While evidence-based guidelines for the diagnosis and management of APD are still lacking, current scientific evidence indicates that there is a need for a multidisciplinary approach and that appropriate intervention is beneficial (Bamiou et al., 2006).

In this chapter I reviewed the different intervention strategies. By comparing and combining suggestions made by different authors I came to the following division:

1. Optimising the acoustic environment (improving the SNR) by environmental modifications:
    a) Signal enhancement strategies
    b) Teacher/speaker adaptations
2. Auditory training direct therapy as formal training or as informal training. This should include:
    c) Auditory closure activities

d) Temporal patterning and prosodic training
e) Auditory discrimination training
f) Dichotic listening training

3. Compensatory strategies

Intervention should always be individual and deficit specific, which can be done either according to test findings or by using the APD profiles. Here I suggested some specific guidelines to what profile usually benefits from what training.

I pointed out that outcome studies are lacking, but that several findings have been reported that point towards improved audiological skills in individuals with APD as a result of intervention. Finally I stressed that no pharmacological treatment has been found.

9 Discussion: APD-screening in Denmark?

In this thesis I have found a lack of procedure concerning APD in Denmark, but abroad vast amounts of research has been done on the topic. I have reviewed the literature on the diagnostic process using tests and questionnaires and I have given some guidelines and suggestions for a Danish questionnaire. I have reviewed the literature on intervention and the effect of intervention, so how should this knowledge be implemented in Denmark?

During the writing of this thesis I had the privilege of working with the professionals from the audiological department in the university hospital in Århus[31]. They showed great interest in APD and wanted to begin the process of making APD-screening a reality in their department. They asked me to help them with this process and I will do so by using the audiological department in Århus as an example of what needs to be done to get APD implemented. Then I will provide a broader perspective by generalising my recommendations in a checklist, that can be used as guidelines not only for the audiological department in Århus, but also for other audiological departments in Denmark that are planning to take the same initiative.

9.1 Initiating APD screenings in Århus

The audiological department in Århus is one of Denmark's biggest audiological departments, where one of the three Cochlea Implant Centres is also located. In this department they have audiologists employed as well as ear-nose-throat doctors and audiology assistants. To my knowledge they are presently short of a speech and hearing therapist who would otherwise also have been a part of the existing team of professionals working in the department.

The investigative procedure that I recommended earlier was that initial language screenings, psychological screenings and traditional tests of peripheral hearing should be done locally, but since screening of APD requires specialised knowledge, I find it most reasonable to organise the more complex part of the screening in APD centres. This could very well be the same audiological departments that are presently hosting the CI centres, because they already have several of the professional groups employed that are necessary in the process of APD investigations.

To make APD screening possible in the audiological department in Århus it would be necessary to employ a speech and hearing therapist and a psychologist, whose work could otherwise also be bought from someone working outside the department. Depending on the

[31] Århus Sygehus.

workload it might be necessary to employ more people from the other existing work groups as well.

The next step would be the founding of an APD team and the personal that are chosen to be part of this APD team should join a re-training program in APD so that they posses the required knowledge. Then the appropriate test material should be purchased.

Most of the equipment needed already exists in the department, but the psychoacoustic test battery must be purchased and fitted in the present audiometers by knowledgeable technicians.

When this has been done the screening can begin, but it is not enough that the audiological department is ready to receive these children. The knowledge about APD is not yet great in Denmark and it is likely that the suspicion of APD might not occur. This is simply because the personnel do not posses the knowledge about APD and the traditional audiological tests do not reveal the disorder. The knowledge of APD must be spread through out the relevant professional groups. But how do we do that, and who are the relevant professional groups?

9.2 What personal should be involved?

When a child is exhibiting problems the first people that notice the problems (apart from the parents) are the health visitors, the pedagogues in the kindergarten and the teachers in school. These professionals will then refer to the local PPR for either psychological- or language evaluation or ask the child to see a doctor. Often the child will exhibit problems similar to those of hearing loss and therefore the child might be referred to the audiological department or otolaryngologist.

It is essential that these groups of professionals be informed about APD symptoms in order for the suspicion to occur. They must be able to initiate the APD investigative process and refer to an APD centre, where evaluations of the tests done locally can be evaluated and a thorough investigation can be carried out.

9.3 How do we spread the knowledge?

The first step was taken in the summer of 2004, when a group of speech and hearing therapists, psychologists and audiologists formed an interest group. They wanted to spread the knowledge of APD in Denmark and to promote research in this area both concerning diagnosis and treatment. In short they wanted to be a Danish counterpart for ASHA's APD Task Force.

The group hosted a Danish seminar about APD, which I attended, where the previously mentioned American scientist James Hall, gave a talk and his agenda was to inspire us in our

work of getting the test battery implemented. Several of these types of courses have been held in the last years and the amounts of participants have been increasing. This indicates that the interest group is successfully spreading the knowledge of APD in Denmark, but we have a long way to go before all the relevant professionals can be expected to possess enough knowledge about APD for the suspicion to occur.

A criteria for finding these children must be that all educations and studies of audiology teach this disorder and its symptoms, and that re-training courses will be offered to the personnel that are in contact with kindergarten- and school children. It will be necessary with re-training for *many* groups of professionals (ASHA, 2006).

To be able to diagnose APD it is necessary to be familiar with the general neuro-physiology, cognitive psychology and especially auditory neuro-science (ASHA, 2006). This knowledge is necessary in the audiological departments where the APD centres might be located, but this is not necessary knowledge for the local speech therapist and psychologist who just need to be aware of the symptoms, so that they can refer the child for further investigation. Therefore individual re-training courses should be made for the different professional groups, focusing on the topics that are relevant for those groups.

Below I have made a listing of what steps need to be taken, for APD screenings to be initiated in an audiological department. In this listing I have incorporated a step called “information”. It is my intention that this step will help spread the knowledge to the relevant professional groups in the area that the audiological department services.

9.4 Checklist

The following checklist is a listing of the steps that any audiological department must take when implementing APD in their department.

Professionals: Does the department possess the relevant professionals and do these professionals possess the required knowledge?	A Speech and hearing therapist to administrate language evaluations and/or interpret tests done locally.
	Psychologist to do psychological evaluation and/or interpret and evaluate tests done locally.
	Audiology assistant to carry out the testing. Audiologist or otolaryngologist to evaluate the audiological tests and diagnose APD.
Equipment: Does the department possess the relevant technical equipment and test materials?	The relevant material for testing impressive and expressive language abilities must be available. This includes testing if the child is capable of the following: producing speech sounds, understand and use words, understand and use sentences and grammar, remember what is being said and create sentences so that they express thoughts and ideas.
	The relevant psychological test material must be available to test the following in the child: cognitive abilities, attention, behaviour, memory, learning methods, academic strengths and weaknesses.
	The relevant audiological equipment is already available in existing audiological departments, but it is important to make sure that the audiometers are capable of using the psychoacoustic test battery, which of course must also be purchased.
Information: Are all the areas that we expect to cover with this service aware of our new initiative? Do they know that they should refer to us when suspecting APD and do they possess sufficient knowledge of APD?	Informative pamphlets, booklets or simple letters must be sent out to all audiological departments, ear-nose-throat doctors and PPR offices in the area that are going to be offered this new service of investigation and diagnosing APD. This will also help spread the knowledge of APD in Denmark since the places that do not know of the disorder, might be inspired to participate in re-training programs.

The development in the field of APD in Denmark is moving quickly at this point in time, but we still face great challenges before APD can be considered implemented in the Danish health system. Luckily it seems that knowledgeable professionals are accepting the responsibility throughout Denmark and I expect that we will soon be able to identify and help the children who suffer from this disorder.

10 Conclusion

In this thesis I have presented the problematic field of APD. I have reviewed the theory behind normal hearing and the auditory processing necessary to understand the concept of APD. I have outlined the development of scientific consensus or lack of it, by discussing the comorbidity that exists with other disorders and the problems that this entails. I found no consensus on whether or not APD is an independent disorder or on diagnostic markers and consequently not on definitions. The state-of-the-art conclusion is that ASHA's definition on APD should be used at the present time, and that APD can coexist with superior disorders and peripheral hearing loss, but is not caused by these. Then I reviewed the current knowledge of causes and risk factors for APD, which is another area that needs more research.

Then I reviewed the theory about dividing APD into profiles and concluded no models have been universally accepted, wherefore I concluded that the profiles should not be seen as definite, but rather as a reminder of the different difficulties that can be present in a child with APD, so that planning of the treatment will consider these differences.

Reviewing possible indicators of APD I found that there is no unique pattern that indicates if a child has APD, but there is a list of factors that can raise the suspicion.

Then I addressed the issue of investigation and diagnosing. This chapter shows a lack of consensus between scientists about how the ideal screening procedure should be, but a thorough anamnesis, psychological screening and a language screening should be done as well as an audiological screening.

Concerning the audiological screening which I chose to emphasise over the psychological- and language screening, I found that this screening should begin with a routine audiological investigation, beginning with the traditional hearing tests: otoscopi, impedance measurements (tympanometry), puretone audiometry, speech audiometry and discrimination in noise (DN).

Then I proceeded to the electroacoustic tests, which should be OAE (otoacoustic emissions) or acoustic reflexes, and then I described the electrophysiological tests that are beneficial to use in the investigative process. This is electrocochleography (ECochG), ABR (auditory brainstem response), MLR (middle latency response) and LCR (late cortical response). Finally I reviewed the psychoacoustic tests and investigated which of these should be included in a Danish audiological test battery for APD. I found five types of tests that ASHA feels investigates the processes that are the basics of the central auditory function. I sent these results to TAL together

with a description of the different tests and the suggestion that TAL then came up with looked like this:

Temporal ordering tests:

a. Gaps in noise, with pauses of 5,10,20,50 ms.
b. Pattern recognition with pulse duration of 250ms and 500ms. Frequency of 1000Hz.
c. Pattern recognition with frequencies of 1122Hz and 880Hz.

Dichotic speech tests:

a. Binaural separation
    1. Sentences in competing sentences.
    2. Auditory figure ground.
    3. Competing words.
b. Binaural integration
    1. Dichotic Digits test.

Monoaural Low Redundancy speech test: auditory closure.

a. Degraded Speech test. Low pass 1000Hz.

Obviously this list is lacking a test in binaural interaction, which I had recommended should be MLD, but since TAL is not able to put this test in the test battery I suggested the newly developed LISN test. At this point I do not know if TAL is going to put the test in the battery or not, but they replied with interest. This concluded the first part of my objective in this thesis, which was to present APD and describe testing possibilities with primary focus on the audiological perspective and in co-operation with TAL, make a suggestion for a psychoacoustic test battery to investigate APD in school children.

Because children below the age of 7 can not participate in the tests used in the audiological screening procedure, I chose that the second part of my objective should be, to submit a set of questionnaires for investigating APD in kindergarteners to a pilot study. My goal with this pilot study was to determine any problems that there might be imbedded in the translated questionnaires and to suggest corrections based on empirically founded critic points. I have reached results that show the need for a manual that describes the role of the professional person from the PPR. I have made some specific suggestions for what should be included in such a manual both in relation to the general perspective and in relation to some specific questions. Furthermore I have suggested changes for the parents' questionnaire and I have incorporated these changes in a finished suggestion for a new parents' questionnaire. Finally I have suggested changes for the pedagogue's questionnaire, which I have incorporated in a finished suggestion for a new questionnaire for pedagogues. The finalised Danish questionnaires are both attached in the appendix in the right format, ready to be uploaded on the homepage of "APD-gruppen". This was the second part of my objective in this thesis.

In the third part of the objective in this thesis, I shifted the focus from the problematic field of identifying the children that suffer from APD to intervention possibilities. I found that intervention strategies can be divided into the following basic principles:

1. Optimising the acoustic environment (improving the SNR) by environmental modifications
    a) Signal enhancement strategies
    b) Teacher/speaker adaptations
2. Auditory training direct therapy as formal training or as informal training. This should include:
    c) Auditory closure activities
    d) Temporal patterning and prosodic training
    e) Auditory discrimination training
    f) Dichotic listening training
3. Compensatory strategies

Intervention should always be individual and deficit specific, which can be done either according to test findings or by using the APD profiles. But there is a general lack of outcome studies to show the efficiency of intervention, even though several reported findings point towards such efficiency.

In the final and fourth part of the objective I have discussed the field of APD in Denmark and made suggestions for steps that need to be taken in the process of getting APD screenings implemented in the Danish health system. In this chapter I found two pressing issues. First education of the relevant personnel and second, the location of the APD-screenings. I found the relevant personnel to be school health visitors, school doctors, school psychologists and speech therapists, because they typically are the people who get the children referred when there are problems in school. Furthermore I found it essential that the audiological departments and practising otolaryngologists who the child is often referred to, also have the necessary knowledge of the disorder. The audiologists in the audiological departments must acquire the necessary knowledge, just as the audiology assistants, speech and hearing therapists and other relevant personal should be taught about APD.

The second pressing matter I found, was the issue of where such APD screenings should take place. Because I found it useful to create APD-centres I suggested the same audiological departments as those who presently have the CI-centres.

Finally I exemplified my findings by using the audiological department in Århus and I made an outline of what steps needs to be taken for this particular department to be able to start identifying children with APD. This example shows the essence of what I hope to accomplish by writing of this thesis. I want to inspire other professionals who are working in the field to take

action against APD and lend a hand to those who wish to take the next step in the process and make the APD screening a reality in the Danish health system.

There are many things about APD that we do not know. We do not know what causes APD or which test combination is the most efficient. We do not know what type of intervention is the most efficient and we even have no consensus on diagnostic markers or a definition. We have great challenges ahead, but we have sufficient knowledge to be able to help children like Lisa and to let this knowledge be unused is in my opinion unethical. Every day children like Lisa are suffering unnecessary defeats that affect their self-esteems. They fall behind in school while the plasticity of their brain is continuingly decreasing. Irreversible losses take place every day as long as the affected children do not receive the help where we *are* capable of giving, but have not yet utilised.

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Glossary

ADD Attention Deficit Disorder.

ADHD Attention Deficit Hyperactivity Disorder. The new term in Denmark and Sweden is DAMP.

Apex The top or highest part of an object.

Backwards masking When a sound stimulus follows the primary sound stimulus so close temporally, that the hearing is not able to detect the primary stimulus as an independent signal.

Comorbidity When two or more developmental disorders or illnesses appear simultaneously.

Contralateralt In neurology it describes that a symptom is situated on the opposite side as the lesion that causes the symptom.

Deficit The Lack of an ability.

Envelope A contour of all the harmonics in a continuous spectrum.

Forward masking When a sound signal is played so close temporally to the following primary sound stimulus, that the hearing is not able to detect the primary stimulus as an independent signal.

Ganglion Accumulation of nerve cell bodies in the peripheral nervous system.

Hemifield The field served by one hemisphere of the brain.

Intelligence Quotient IQ. The relationship between an individual's intelligence age (measured in intelligence tests) and living age.

Ipsilateral In neurology it describes that a symptom is situated on the same side as the lesion that causes the symptom.

MRI Magnetic resonance imaging. A picture technique that mainly is used medically to produce high quality pictures of the inside of the body.

Pharmacology The science of drugs and their effect in the organism.

Phenotype Ability or appearance. The result of the inheritance and the environmental influence.

Pontine Reticular Formation = Pons

Ponto-medulla junction Where Pons and Medulla meet.

SCAN-C A test battery to screen for APD in children. It consists of the following 3 tests: Filtered word test, figures ground test and words in competing noise test.

Sensitivity	A tests ability to find the ill.
Spartiotopic structure	In audiology it describes that the cells are arranged in a manner that organises according to position and size.
Specificity	A tests ability to find the healthy.
Spiral Ganglion	See Ganglion
Synthesis	Building process
Timbre	The psychoacoustic perception of tone.
Tonotopic structure	In audiology it describes that the cells are arranged so that there is high- and low frequency resolution.

The explanations and definitions are mostly taken from:

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- www.ordbogen.com

APD-projekt i børnehaven: Info til personalet

Mit navn er Stine Borges. Jeg er i gang med et projekt, hvor jeg har brug for jeres hjælp. Projektet er et del af mit speciale fra audiologopædi-uddannelsen (tale-, høre- og læsepædagogik) ved Københavns Universitet. Projektet sker i samarbejde med APD-gruppen (www.APD.dk).

Baggrunden for projektet er, at nogle børn har svært ved at forstå de ting de hører, selvom deres ører ikke fejler noget. Disse børn har APD (Auditory Processing Disorder). Her er et eksempel:

> Lise på 7 år sætter sig hurtigt på sin plads i klassen og afventer lærerens instrukser. Hun stirrer på læreren og er klar til at lytte. Han siger: ”Før vi starter på kapitel 5 i historiebogen, skal I tage jeres hjemmeopgaver i matematik ud af jeres blå mapper og lægge dem foran jer på bordet. Jeg kommer rundt og henter dem lige om lidt.”
> Lise finder sin historiebog frem og ser nervøst på den. Hun kigger rundt på sine klassekammerater for at få et fingerpeg om, hvad det er meningen, hun skal gøre. Samme aften græder hun derhjemme og siger til sine forældre, at hun er dum og ikke kan finde ud af det i skolen. Næste dag ringer Lises mor til skolen og beskylder læreren for at presse hendes datter for meget og ødelægge hendes selvtillid.
>
> For de fleste børn var lærerens besked nem at følge, men for et barn som Lise var den nok til at give hende et nederlag. Børn bliver hver dag i skolen bedt om at høre efter, være opmærksomme og modtage beskeder og instrukser, men nogle af dem har svært ved det. På trods af normal hørelse har de svært ved at bearbejde og forstå talt sprog, især når der kommer meget information på én gang i et støjfyldt lokale. Disse børn betegnes ofte som ”lidt dumme” eller ”uopmærksomme”, mens den virkelige forklaring kan være, at de har APD.

Disse børn har man før i tiden haft svært ved at hjælpe, fordi det var svært at finde ud af hvad deres problem var. Nu har man udviklet nogle spørgeskemaer, som måske kan finde disse børn allerede i børnehavealderen. Disse spørgeskemaer skal først afprøves af på almindelige børnehavebørn, for at finde ud af om de virker og det vil jeg gerne have jeres hjælp til.

Hvis I vælger at sige ja til at deltage betyder det, at jeg kommer med nogle sedler om projektet til alle forældrene i børnehavegruppen. Hvis forældrene ønsker at deltage (og det håber jeg jo meget at rigtig mange gerne vil), skal de udfylde svarblanketten og aflevere den til _____, så jeg ved hvem der vil være med. Derefter hænger jeg et skema op i børnehaven med tidspunkter, som forældrene kan skrive sig på. De skal bruge ca. 15 min. på at udfylde et spørgeskema om deres barn, sammen med mig. Det kunne f.eks. være når de afleverer eller henter deres barn.
Når jeg har fået udfyldt forældre-spørgeskemaerne, vil jeg gerne have lov at bruge ca. 1 time f.eks. i forbindelse med et stuemøde, et personalemøde eller et andet tidspunkt der passer jer, hvor jeg udfylder et spørgeskema om hvert barn der deltager, sammen med en pædagog der er tilknyttet barnet.

Det er kun børn med en normal sproglig udvikling og hørelse der kan deltage.
På svarblanketten er der nogle spørgsmål der skal besvares inden vi går i gang med det egentlige spørgeskema. Disse spørgsmål er udelukkende til statistisk brug, så jeg er sikker på at den gruppe jeg får spørgeskemaer fra, er repræsentativ for den danske befolkning. I selve spørgeskemaerne kunne et spørgsmål f.eks. se sådan her ud:
"Har barnet svært ved at fastholde opmærksomheden på den der taler?"
"Har barnet svært ved at huske en besked?"

Der vil ikke blive nogen egentlig vurdering af de enkelte børn, men derimod en samlet vurdering af alderstrinnet. I vil derfor ikke få nogle resultater for børnene, men hvis I er interesserede, er I velkomne til at kontakte mig på tel. 22414882, eller på mail stineborges@hotmail.com og få et resume af specialet, når det er færdigt.
Jeg ser frem til at samarbejde med jer om at hjælpe børn som Lise.

Venlig hilsen Stine Borges

APD-projekt i børnehaven

Kære Forældre

I Uge 35 kommer jeg her i institutionen, og i den uge vil jeg gerne aftale et tidspunkt, hvor I kan afse ca. 15 min til at besvare et spørgeskema om jeres barn, sammen med mig. Det kunne f.eks. være når I henter eller afleverer barnet i børnehaven. Dette projekt er et del af mit speciale fra audiologopædi (tale-, høre- og læse- pædagogik) ved Københavns Universitet. Projektet laver jeg i samarbejde med APD-gruppen (læs evt. mere på www.apd.dk). For at kunne gennemføre dette projekt, har jeg brug for jeres hjælp.

Der findes nogle børn, der har svært ved at forstå de ting de hører, selvom deres ører ikke fejler noget. Disse børn har APD (Auditory Processing Disorder). Her er et eksempel:

Lise på 7 år sætter sig hurtigt på sin plads i klassen og afventer lærerens instrukser. Hun stirrer på læreren og er klar til at lytte. Han siger: ”Før vi starter på kapitel 5 i historiebogen, skal I tage jeres hjemmeopgaver i matematik ud af jeres blå mapper og lægge dem foran jer på bordet. Jeg kommer rundt og henter dem lige om lidt.”
Lise finder sin historiebog frem og ser nervøst på den. Hun kigger rundt på sine klassekammerater for at få et fingerpeg om, hvad det er meningen, hun skal gøre. Samme aften græder hun derhjemme og siger til sine forældre, at hun er dum og ikke kan finde ud af det i skolen. Næste dag ringer Lises mor til skolen og beskylder læreren for at presse hendes datter for meget og ødelægge hendes selvtillid.

For de fleste børn var lærerens besked nem at følge, men for et barn som Lise var den nok til at give hende et nederlag. Børn bliver hver dag i skolen bedt om at høre efter, være opmærksomme og modtage beskeder og instrukser. Men nogle af dem har svært ved det. På trods af normal hørelse har de svært ved at bearbejde og forstå talt sprog, især når der kommer meget information på én gang i et støjfyldt lokale. Disse børn betegnes ofte som ”lidt dumme” eller ”uopmærksomme”, mens den virkelige forklaring på deres adfærd kan være, at de har APD.

Disse børn har man før i tiden haft svært ved at hjælpe, fordi det var svært at finde ud af hvad der var galt med dem. Nu har man udviklet nogle spørgeskemaer, som måske kan finde disse børn allerede i børnehavealderen. Disse spørgeskemaer skal først afprøves af på almindelige børnehavebørn og det vil jeg gerne have jeres hjælp til.

For at jeres barn kan deltage, skal I udfylde accept-papiret, der er hæftet sammen med dette ark og afleverer det på stuen I børnehavne. Det er kun børn med en normal sproglig udvikling der kan deltage. Dvs. har jeres barn gået, eller går til talepædagog, kan det ikke deltage (dette gælder ikke hvis jeres barn har gået til talepædagog pga. stemmeproblemer, f.eks. hæshed). Derudover må barnet ikke have nedsat hørelse.

I børnehaven hænger der et skema med tidspunkter, som I skal skrive sig på når I afleverer sedlen. Hvis I har problemer med at finde en tid der passer, kan jeg kontaktes på tlf. 22414882 eller I kan skrive til mig på mail stineborges@hotmail.com, så finder vi en løsning, der passer jer. Pædagogerne i børnehaven får også et skema, der minder meget om det I får, som de med jeres tilladelse udfylder.

Der vil ikke blive nogen egentlig vurdering af de enkelte børn, I vil derfor ikke få nogen resultater for jeres barn, men er velkomne til at kontakte mig og få et resume af specialet, når det er færdigt.

Jeg håber at I vil hjælpe mig, så jeg kan være med til at hjælpe børn som Lise.

Venlig hilsen Stine Borges

APD-projekt i Børnehaven: Tider til at udfylde spørgeskema sammen med Stine Borges

Vælg en tid og skriv jeres **navn og telefonnummer** på. Hvis I ikke kan finde en tid, som passer jer, så skriv navn og telefonnummer på linierne under skemaet, så kontakter jeg jer for at finde en anden tid og der passer jer bedre. De grå tider, forventer jeg ikke at folk vil bruge, men hvis I gerne vil have en tid i dette tidsrum, så skriv jer bare på og skriv hvornår I kommer.

	Mandag d. /	**Tirsdag d. /**	**Onsdag d. /**	**Torsdag d. /**	**Fredag d. /**
7.00 - 7.15					
7.15 - 7.30					
7.30 - 7.45					
7.45 - 8.00					
8.00 - 8.15					
8.15 - 8.30					
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15.45 - 16.00					
16.00 - 16.15					
16.15 - 16.30					
16.30 - 16.45					
16.45 - 17.00					

Vi vil gerne deltage, men kan ikke finde en ledig tid der passer os. Vi vil gerne kontaktes for at finde en anden tid: (navn og tlf.)

_____

_____

_____

APD Gruppen – Danmark

Original version
WWW.APD.dk

Skemaet skal udfyldes i et samarbejde mellem forældre og Pædagogisk/Psykologisk Rådgivning (PPR)

Spørgsmål til forældre i forbindelse med udredning af Auditory Processing Disorder (APD)

Barnets navn _____

Alder/cpr. nr: _____

Dato: _____

Interviewer: _____

	JA	NEJ
1. Har du/I haft mistanke om, at barnet har problemer med hørelsen?	☐	☐
2. Har du/I fået barnets hørelse undersøgt?	☐	☐

- Hvis ja, hos hvem_____

3. Hvis undersøgelsen er foretaget, viste den normal hørelse?

- På begge ører Ja ☐ Nej ☐
- På højre øre Ja ☐ Nej ☐
- På venstre øre Ja ☐ Nej ☐

4. Har barnet haft problemer med mellemøret, fx infektioner? ☐ ☐
   - Hvis ja:
     - Hvilken type: _____
     - Alder: _____
     - Hvor ofte _____
     - Varighed _____
     - Hvordan blev problemet løst: _____

		JA	NEJ
5.	Har barnet mellemøreproblemer nu?	☐	☐
6.	Er barnet opereret i mellemøret/fået ny trommehinde?	☐	☐
7.	Oplever du/I, at barnets hørelse er bedre i nogle perioder end i andre?	☐	☐
8.	Ønsker barnet at TV og radio skrues op i lydstyrke?	☐	☐
9.	Skal du/I have direkte kontakt med barnet, før det reagerer?	☐	☐
10.	Misforstår barnet ofte, hvad der bliver sagt?	☐	☐
11.	Skal du/I ofte gentage det, der bliver sagt?		☐
	☐		
12.	Har barnet vanskeligt ved at opfatte tale i baggrundsstøj?	☐	☐
13.	Giver barnet selv udtryk for at det har svært ved at høre?	☐	☐

14. Hvordan reagerer barnet, når det ikke forstår en besked?

_____

_____

15. Reagerer barnet følsomt over for høje lyde? ☐ ☐

16. Trækker barnet sig fra sociale sammenhænge? ☐ ☐

17. Vil barnet helst bestemme, når det er sammen med andre børn? ☐ ☐

18. Har barnet fået eller får det talepædagogisk hjælp? ☐ ☐

19. Kommer barnet selv med bemærkninger om sin hørelse? ☐ ☐

20. Kan barnet lide at deltage i højtlæsning? ☐ ☐

JA **NEJ**

21. Er der nogen i familien der har eller har haft sproglige vanskeligheder som børn?
☐ ☐

- Hvis ja, hvilke (tale- eller læse- og skriveproblemer)_____

22. Har barnet svært ved at læse/skrive? ☐ ☐

Yderligere kommentarer:

_____

_____

_____

_____

_____

APD Gruppen – Danmark

2. version

WWW.APD.dk

Skemaet skal udfyldes i et samarbejde mellem forældre og Pædagogisk/Psykologisk Rådgivning (PPR). Til skemaet hører en manual, som den professionelle bør følge.

Spørgsmål til forældre i forbindelse med udredning af Auditory Processing Disorder (APD)

Barnets navn _____

Alder/cpr. nr: _____

Dato: _____

Interviewer: _____

Dette spørgeskema skal udfyldes udfra barnets nuværende situation og ikke i forhold til hvordan barnets situation HAR været, med mindre der spørges specifikt til dette.

	JA	NEJ
1. Har barnet fået eller får det talepædagogisk hjælp?	☐	☐
2. Skal du/I have direkte kontakt med barnet, før det reagerer?	☐	☐
3. Skal du/I ofte gentage det, der bliver sagt?	☐	☐
4. Misforstår barnet ofte hvad der bliver sagt, sådan at barnet tror der menes noget andet end hvad der faktisk blev sagt?	☐	☐
5. Har barnet vanskeligt ved at opfatte tale i baggrundsstøj?	☐	☐

6. Hvordan reagerer barnet, når det ikke forstår en besked?
(se evt. de mest typiske reaktioner I manualen)

_____

_____

7. Reagerer barnet følsomt over for høje lyde? ☐ ☐

8. Trækker barnet sig fra sociale sammenhænge, hvor flere børn er sammen? ☐ ☐

9. Vil barnet helst være den der bestemmer, værd gang det er sammen med andre børn?
☐ ☐

10. Kommer barnet selv med bemærkninger om sin hørelse? ☐ ☐

11. Kan barnet lide at deltage i højtlæsning? ☐ ☐

12. Er der nogen i familien der har eller har haft sproglige vanskeligheder som børn?
☐ ☐

- Hvis ja, hvilke (tale- eller læse- og skriveproblemer)_____

13. Opmærksomhed på skriftsprog:
   a) Har barnet interesse for skriftsprog? ☐ ☐
   b) Forsøger barnet at skrive? ☐ ☐
   c) Genkender barnet eget navn, bogstaver eller andre ord? ☐ ☐
   d) Kan barnet skrive eget navn eller andre ord? ☐ ☐

14. Ønsker barnet at TV og radio skrues op i lydstyrke? ☐ ☐

15. Har du/I haft mistanke om, at barnet har problemer med hørelsen? ☐ ☐

16. Har du/I fået barnets hørelse undersøgt? (Hvis nej, spring til spørgsmål 20) ☐ ☐

- Hvis ja, hos hvem_____

17. Viste undersøgelsen normal hørelse? (Hvis ja, spring til spørgsmål 20).
- På begge ører Ja ☐ Nej ☐
- På højre øre Ja ☐ Nej ☐
- På venstre øre Ja ☐ Nej ☐

18. Hvis nej, er situationen stadig den samme eller var høretabet kun midlertidigt, efterfulgt af normal hørelse?

☐ ☐

19. Oplever du/I, at barnets hørelse er bedre i nogle perioder end i andre? ☐ ☐

20. Har barnet haft problemer med mellemøret, fx infektioner? ☐ ☐

- Hvis ja:
  - Hvilken type: _____
  - Hvornår og ofte: _____
  - Alder: _____
  - Varighed: _____
  - Hvordan blev problemet løst: _____

21. Har barnet mellemøreproblemer nu? ☐ ☐

22. Er barnet opereret i mellemøret/fået ny trommehinde eller dræn? ☐ ☐

Yderligere kommentarer:

_____

_____

_____

_____

_____

APD gruppen - Danmark

Original Version

WWW.APD.dk

Skemaet skal udfyldes i et samarbejde mellem personalet og Pædagogisk/Psykologisk Rådgivning (PPR)

Spørgsmål til personalet i børnehaven i forbindelse med udredning af Auditory Processing Disorder (APD)

Barnets navn: _____

Alder/cpr.nr: _____

Dato: _____

Interviewer: _____

Der sættes ring om barnets adfærd

1 = Aldrig
2 = Af og til
3 = Ofte
4 = Altid

1. Har barnet svært ved at fastholde opmærksomheden på den der taler?

   1. 2. 3. 4

2. Er barnet afhængig af at kunne se ansigtet på den der taler, for at forstå hvad der bliver sagt?

   1. 2. 3. 4.

3. Bliver barnet forstyrret af støj eller baggrundsstøj?

   1. 2. 3. 4.

   Hvis ja, hvilke lyde:_____

   _____

4. Hører barnet, hvis det står med ryggen til lydkilden?

1. 2. 3. 4.

5. Bliver barnet let ukoncentreret ?

1. 2. 3. 4.

6. Har barnet svært ved at forstå beskeder (især flerleddede beskeder)?

1. 2. 3. 4.

7. Har barnet svært ved at huske en besked?

1. 2. 3. 4

8. Siger barnet meget ”hvad”, og ønsker beskeden gentaget?

1. 2. 3. 4

9. Svarer barnet på spørgsmål der stilles til gruppen?

1. 2. 3. 4.

10. Har barnet svært ved at retningsbestemme en lydkilde?

1. 2. 3. 4.

11. Har barnet svært ved rim og remser?

1. 2. 3. 4.

12. Trækker barnet sig ofte fra sociale sammenhænge?

1. 2. 3. 4.

13. Forstyrrer barnet andre børn eller ødelægger deres leg?

1. 2. 3. 4

14. Accepteres barnet af de andre børn?

1. 2. 3. 4.

15. Bliver barnet let træt og giver op, i situationer der kræver kommunikation?

1. 2. 3. 4

16. Kan barnet lide at deltage i højtlæsning?

1.	2.	3.	4

17. Kan barnet genfortælle en historie?

1.	2.	3.	4.

18. Har barnet svært ved at komme i gang med en leg eller en aktivitet?

1.	2.	3.	4

19. Har barnet sproglige vanskeligheder?

NEJ Lidt	Delvist	Mange	Store

Yderligere kommentarer:

_____

_____

_____

_____

_____

_____

_____

_____

_____

APD gruppen - Danmark

2. version

WWW.APD.dk

Skemaet skal udfyldes i et samarbejde mellem personalet og Pædagogisk/Psykologisk Rådgivning (PPR). Til skemaet hører en manual, som den professionelle bør følge.

Spørgsmål til personalet i børnehaven i forbindelse med udredning af Auditory Processing Disorder (APD)

Barnets navn: _____

Alder/cpr.nr: _____

Dato: _____

Interviewer: _____

Dette spørgeskema skal udfyldes udfra barnets nuværende situation og ikke i forhold til hvordan barnets situation HAR været, med mindre der spørges specifikt til dette.

Der sættes ring om den svarmulighed der passer bedst til barnets adfærd.

1. Har barnet svært ved at fastholde opmærksomheden på den der taler?

   Aldrig Af og til Ofte Altid

2. Er barnet afhængig af at kunne se ansigtet på den der taler, for at forstå hvad der bliver sagt?

   Aldrig Af og til Ofte Altid

3. Bliver barnet forstyrret af støj eller baggrundsstøj?

   Aldrig Af og til Ofte Altid

- Hvis ja, (sæt x udfor hvilken type af lyde):
  - Alle lyde:……...☐ ☐
  - Tale:……...☐ ☐
  - Kraftige lyde:……☐ ☐
  - Lyde fra interessante aktiviteter, som barnet ønsker at deltage i:..☐ ☐
  - Andet: _____

    _____

4. Hører barnet, hvis det står med ryggen til lydkilden?

   Aldrig Af og til Ofte Altid

5. Bliver barnet let ukoncentreret ?

   Aldrig Af og til Ofte Altid

6. Har barnet svært ved at forstå beskeder (især flerleddede beskeder)?

   Aldrig Af og til Ofte Altid

7. Har barnet svært ved at huske en besked?

   Aldrig Af og til Ofte Altid

8. Siger barnet meget ”hvad”, og/eller ønsker beskeden gentaget?

   Aldrig Af og til Ofte Altid

9. Svarer barnet på spørgsmål der stilles til gruppen?

   Aldrig Af og til Ofte Altid

10. Har barnet svært ved at retningsbestemme en lydkilde? (Dette kan blandt andet ses ved klodset adfærd, f.eks. at barnet slår sig ved at støde ind I andre på legepladsen, fordi barnet ikke har hørt dem komme).

    Aldrig Af og til Ofte Altid

11. Har barnet svært ved rim, remser og/eller sange?

    Aldrig Af og til Ofte Altid

12. Trækker barnet sig ofte fra sociale sammenhænge med andre børn?

Aldrig	Af og til	Ofte	Altid

13. Forstyrrer barnet andre børn eller ødelægger deres leg?

Aldrig	Af og til	Ofte	Altid

14. Accepteres barnet af de andre børn?

Aldrig	Af og til	Ofte	Altid

15. Bliver barnet let træt og giver op, i situationer der kræver kommunikation?

Aldrig	Af og til	Ofte	Altid

16. Kan barnet lide at deltage i højtlæsning?

Aldrig	Af og til	Ofte	Altid

17. Kan barnet genfortælle en historie?

Aldrig	Af og til	Ofte	Altid

18. Har barnet svært ved at komme i gang med en leg eller en aktivitet?

Aldrig	Af og til	Ofte	Altid

19. Har barnet sproglige vanskeligheder?

NEJ/ Lidt	Delvist	Mange	Store

Yderligere kommentarer:

_____

_____

_____

_____

_____

_____

			Uddannelses niveau		Forælder skema																							Pædagog skema																		
deltagere	alder	køn	forælder 1	forælder 2	Q1	Q2	Q3a	Q3b	Q3c	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
1	3,4	m	4	4	0	0	-	-	-	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	1	1	1	4	1	1	1	1	2	4	2	2	1	4	2	4	-	3	1
2	5,6	m	2	1	0	1	1	-	-	1	0	0	0	1	1	0	1	0	0	0	1	-	0	0	1	1	1	1	1	3	4	1	1	1	2	3	2	1	1	1	4	1	3	2	1	1
3	3,9	m	1	4	0	0	-	-	-	1	0	0	0	1	1	0	1	1	0	1	0	0	0	0	1	1	0	1	1	2	4	1	1	1	1	2	4	1	1	1	4	3	4	-	1	1
4	4,8	k	2	1	1	1	1	-	-	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	1	1	4	1	1	1	1	4	1	1	1	2	4	1	4	4	1	1
5	5	k	4	4	0	0	-	-	-	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	4	1	1	1	1	3	1	1	1	1	4	1	4	4	1	1
6	4,4	k	1	4	1	1	1	-	-	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1	1	4	1	1	1	1	3	1	1	2	1	4	1	4	4	2	1
7	4,1	k	4	-	1	1	0	-	-	1	0	1	1	0	0	0	1	0	0	1	0	-	0	0	1	0	0	1	2	1	4	1	1	1	1	4	1	1	1	1	4	1	3	4	1	1
8	4,2	k	4	4	0	0	-	-	-	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	4	1	1	1	1	2	1	1	1	1	4	2	4	4	1	1
9	3,4	m	4	4	0	0	-	-	-	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	4	4	3	2	4	3	3	1	1	3	4	2	1	2	3	2	2	4	3
10	3,6	k	5	5	1	1	0	-	-	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	2	3	2	2	3	3	3	3	1	3	2	1	1	4	3	2	1	1	3
11	3,8	k	4	5	0	0	1	-	-	1	0	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	2	1	4	3	1	2	2	2	1	1	1	1	4	1	4	4	1	1
12	3,10	k	4	4	0	0	-	-	-	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	1	4	1	1	2	2	1	1	2	1	1	4	2	4	2	1	1
13	5,4	m	5	7	0	0	-	-	-	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	4	1	1	1	2	1	1	2	3	1	3	1	4	4	3	2
14	4,4	k	5	7	0	0	-	-	-	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	2	2	2	3	3	1	2	1	4	1	1	1	2	3	1	4	4	1	1
15	4,6	k	4	4	0	1	1	-	-	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	1	4	1	1	1	1	4	1	1	1	2	4	1	4	4	2	1
16	3,4	m	4	6	0	0	-	-	-	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	3	1	2	2	2	2	2	1	1	4	2	2	4	2	2	1	2	1
17	5,4	m	6	4	0	0	-	-	-	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	2	4	2	1	1	1	3	1	1	1	2	4	1	4	4	1	1
18	5,11	m	4	4	0	0	-	-	-	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	2	2	2	2	2	2	2	2	3	1	2	1	1	4	2	3	2	1	2
19	4	m	5	5	0	0	-	-	-	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	2	1	1	4	3	1	1	1	3	1	1	1	3	4	1	3	4	2	1
20	3,11	m	4	4	0	1	1	-	-	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	1	0	2	3	3	2	3	2	2	2	2	1	2	1	1	4	2	4	4	1	1
21	5,8	k	4	4	1	1	1	-	-	1	1	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1	4	1	1	1	1	3	1	1	1	1	4	1	4	4	2	1
22	4,1	m	4	1	0	0	-	-	-	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	2	2	1	4	1	2	1	4	2	1	2	1	2	3	2	3	3	1	1
23	5,9	m	5	5	1	1	1	-	-	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2	1	1	4	1	1	1	1	4	1	1	1	3	3	1	4	4	1	1
24	4,2	m	7	7	0	0	-	-	-	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	2	2	2	4	2	2	1	1	3	1	1	2	2	3	2	4	4	2	1
25	3,7	m	5	5	0	0	-	-	-	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	2	1	1	2	1	1	1	2	1	1	1	1	4	1	4	4	1	1
26	3,7	k	4	4	0	0	-	-	-	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	2	3	2	4	3	3	3	1	1	1	1	1	1	4	1	3	2	2	2
27	5,1	k	4	5	0	1	1	-	-	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	1	0	3	3	3	3	4	3	3	3	2	1	3	3	1	2	3	2	2	3	3
28	3,6	k	5	1	0	0	-	-	-	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	2	2	4	2	2	2	1	2	1	1	1	1	4	1	4	2	2	1
29	5,2	m	3	1	0	1	-	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	1	4	1	1	1	1	3	1	1	3	1	2	1	4	4	2	1

Numrerne er tilføjet for anunymitet.

År, måneder på forældreskemaets udfyldelsesdag, 2. skema er udfyldt maksimum 2 uger fra denne dato.

m= mand, k=kvinde

1= grundskole
2= almengymnasial uddannelse (gym/hf mm.)
3= erhvervsgymnasial uddannelse (hhx/htx)
4= erhvervsfaglig uddannelse (f.eks. håndværker eller kontoruddannelse)
5= mellemlang videregående uddannelse (f.eks. Sygeplejerske eller folkeskolelærer)
6= bachelor (fra universitet eller lignende)
7= lang videregående uddannelse

NB! I forældreskemaet er spørgsmål 2a,4a-e, 14 og 21a, samt yderligere kommentarer er kvalitative spørgsmål, som ikke kvantificeres.
I forældrerskemaet er 0=nej, 1=ja, - = ikke besvaret

NB! I pædagogskemaet er spørgsmål 3a samt yderligerekommentarer kvalitative spørgsmål, som ikke kvantificeres.
I pædagogskemaet er 1= aldrig, 2= af og til, 3= ofte, 4= altid, undtagen I spørgsmål 19 hvor 1= Nej/lidt, 2= delvist, 3= mange, 4= store, - = ikke besvaret.

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