

# **The Immediate and Long-term Effects of Altered Auditory Feedback (AAF) on the Characteristics of Persistent Developmental Stuttering**

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Technisch unterstützte Reduktion des Stotterns (TURS):

Die sofortige und langfristige Wirkung von  
modifiziertem auditivem Feedback (MAF) auf das chronische Stottern

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***Meiner Familie in tiefster Dankbarkeit***

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### **Abstract: Immediate effect study**

**Purpose:** The immediate effects of altered auditory feedback (AAF) and a placebo condition on clinical attributes of stuttering during scripted as well as spontaneous speech are investigated herein. The primary purpose is the extension of the evidence-base of the impact of AAF on the clinical characteristics of stuttering.

**Method:** Two commercially available AAF devices were used to create the delayed auditory feedback (DAF) and frequency altered feedback (FAF) effects. The participants consisted of thirty German-speaking people who stutter (PWS), aged 18 to 68 ( $M = 36.5$ ;  $SD = 15.2$ ). Each subject produced four sets of oral readings, three sets of monologs and three sets of dialogs. The participants were exposed to different experimental conditions (No device, Placebo, active AAF using Device A, and active AAF using Device B) while producing the speech samples. The recordings were then electronically analyzed to detect changes in select features of stuttering; frequency, duration, speech rate, articulation rate and core behaviors. The occurrence of these variables was examined across all speech samples collected within the four experimental conditions.

**Results:** A statistically significant difference in the frequency of stuttered syllables (%SS) was found while using both devices ( $p = .000$ ). Although individual reactions varied widely, the most notable reductions in %SS occurred within the reading ( $M = 2.33$ ,  $SD = 3.75$ ) and monolog ( $M = 2.26$ ,  $SD = 3.32$ ) samples. Thus, active AAF settings had the least impact on speech fluency during conversational speech ( $M = 1.49$ ,  $SD = 2.71$ ). In the analysis of stuttering type, it was found that blocks were the only core behavior that was reduced to a statistically significant degree ( $p = .001$ ). During the placebo condition (no active AAF parameters), the subject group also experienced a statistically significant decline in %SS ( $p = .028$ ).

**Conclusion:** This result indicates that the effects of AAF alone may not be the sole reason for fluency enhancements experienced when using a portable speech aid.

### **Abstract: longitudinal trail**

**Purpose:** The effects of a portable altered auditory feedback (AAF) device on the severity of stuttering over a three-month period were investigated. The main goal was to examine the usage behavior and fluency-enhancements displayed during extended device utilization.

**Method:** Qualitative data on implementation environments, utilization patterns and user satisfaction were collected weekly from a group of seven adults ( $M = 45.3$ ;  $SD = 11.4$ ) who stutter. For the analysis of quantitative changes in stuttering severity, speech samples were collected in person at the beginning and end of the trial period. Two phone conversations throughout the study provided additional conversational samples.

**Results:** Individual responses were quite diverse within both quantitative and qualitative measures. Group analysis revealed that conversational speech was overall significantly more fluent when a device was used. The percentage of stuttered syllables was significantly lower  $z = -2.201$ ,  $p = .028$ ,  $r = -0.18$  upon first using AAF (with device:  $Mdn = 1.53$ ; without device:  $Mdn = 3.53$ ) and during the personal conversation at the end of three months (with device:  $Mdn = 1.89$ ; without device:  $Mdn = 3.97$ ). However, during the two mid-trial phone conversations utilizing a device (T2 & T3), stuttering frequency remained largely unaltered T2:  $z = -.943$ ,  $p = .345$  ( $Mdn = 3.87$ ); T3:  $z = -1.57$ ,  $p = .116$  ( $Mdn = 3.00$ ). The analysis of weekly questionnaires and user diaries revealed that the device was most commonly used in familiar environments (63% at home). On average, the speech aid was utilized four to five times a week, with an overall satisfaction rate of 42%.

**Conclusion:** Some meaningful conclusions for clinical work with clients wishing to use AAF can be drawn from these results. While AAF has its limits in reducing stuttering, ability to use a device may be optimized if usage is acquired in a guided clinical process.

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### **PART I: INTRODUCTION**

The following text presents a clinical investigation into the immediate and long-term effects of portable altered auditory feedback (AAF) devices on the speech of adults who stutter. The examination of the specific effects these devices can have on the symptoms of stuttering forms the core of the presented investigations. The underlying theoretical background is constructed to provide the reader with relevant information necessary to comprehend the objectives and outcome of the presented studies. In order to establish foundational knowledge and emphasize the original research presented herein, the initial chapters (Chapters 1-4) focus on relevant clinical topics. The appearance of stuttering with its various symptoms, common assessment procedures and the associated complexities within the diagnostic process are presented, as familiarity with such topics is foundational in a clinical context. Further, specific theories on the origin of stuttering were selected and introduced in an effort to vindicate the common, evidence-based therapeutic interventions introduced in Chapter 4. Therefore, the many controversial and complex hypotheses on the etiology of stuttering are limited to those prominent theories, which appear valuable to the core understanding of stuttering in this context. Another important part of the theoretical background is a thorough review of the effectiveness of AAF and the consecutive beliefs on why modifications in audition may improve speech fluency. This information also directly relates to the core of the original research (Chapter 5 – 10) as it outlines the existing knowledge on AAF and explains the relevance of this technology in the management of stuttering. The presented information is intended to provide a systematic foundation to the comprehension of the studies presented herein. The main objective of the original research is an expansion of the evidence base on technological speech aids by exploring its specific effects on adults who stutter.

## **Chapter 1: The fluency disorder stuttering**

Stuttering is a speech disorder that was concisely defined as “a deviation in the ongoing fluency of speech, an inability to maintain the connected rhythms of speech” by Charles van Riper (1982, p. 11), one of its most prominent researcher. Even though the definition succinctly describes the heart of the disorder, finding an all-encompassing definition of this complex fluency disorder has since proven a challenge. Many book chapters (cf. Beech & Fransella, 1968; Conture, 1990; Silverman, 1996; Bloodstein & Bernstein Ratner, 2008) have been dedicated to the quest of finding a ubiquitous definition. The general consensus is that stuttering consists of *overt* (those who are observable) and *covert* (not directly apparent to the listener) symptoms (Rentschler, 2004). The overt verbal symptoms are most commonly referred to as core behaviors (van Riper, 1971). Core behaviors “account for the basics of the physical act of stuttering” (Ham, 1986, p. 36) and consist of repetitions, prolongations and blocks. In an attempt to end these involuntary disruptions in one’s speech, a person who stutters (PWS) may acquire so called secondary behaviors (van Riper, 1971). These secondary behaviors are learned reactions to the experienced core behaviors and may be overt (i.e. movements of extremities) or covert (i.e. fear of talking on the phone) in nature.

The reader needs to be aware that the term stuttering in this paper, refers to the developmental form, which first occurs within early childhood and for some remains a speech disorder for life. This developmental form of stuttering needs to be differentiated from other types of stuttering, such as neurogenic or psychogenic stuttering. Neurogenic stuttering, also referred to as “acquired stuttering” (Bloodstein & Bernstein Ratner, 2008), often occurs suddenly during adulthood as a symptom of a broader neurogenic condition such as stroke, head trauma or Parkinson’s disease (National Institutes of Health, 2010). As such, neurogenic stuttering is believed to be a speech-motor disorder with little variation of dysfluencies. Despite the sudden, late onset another means of differentiating developmental stuttering from neurogenic stuttering is to investigate the ‘adaptation effect’ (Canter, 1971). For this purpose, it is suggested to have a client with suspected neurogenic stuttering read the same passage repeatedly to determine if the frequency of dysfluencies diminishes with

each reading. If a stable amount of stuttering is present, this is seen as a feature of neurogenic stuttering (Mazzuchi, Moretti, Carpeggiani, Parma & Painsi, 1981; Koller, 1983). Secondary behaviors may occur over time, in some clients but are more likely signs of frustration rather than the signs of a deeply rooted emotional burden seen in many persistent developmental stutterers (Rosenbek, Messert, Collins & Wertz, 1978). There are very few accounts of the treatment of neurogenic stuttering (cf. De Nil, Jokel, & Rochon, 2007). If it is a direct result of a degenerative condition, those clients who desire treatment look for an immediate solution for their dysfluencies. Therefore 'fast solutions' of teaching clients robot-like speech by uttering each syllable individually (Helm, Butler & Benson 1978) or implementing an extremely slowed speech rate through means of delayed auditory feedback (DAF) with long delay times (Quinn & Andrews, 1977) have shown success in single-case studies.

Another rare form of stuttering that, contrary to the developmental kind, occurs abruptly, most commonly during adolescence and adulthood (Guitar, 1998) is psychogenic stuttering. It generally arises during times of "extreme environmental stress or interpersonal conflict" (Roth, Aronson & Davis, 1989, p. 435). Mahr and Leith (1992) suggest suspecting psychogenic stuttering if late-onset dysfluencies that coincide with the onset of a psychiatric condition are seen in a client. The core treatment for these clients should consist of psychological intervention focused on the central trauma or psychological condition to which the dysfluencies are a secondary symptom (Yairi & Seery, 2011). The psychopathological literature refers to such a physical consequence to a psychological disorder as a *conversion reaction* (Breuer & Freud, 1936). It is further suggested that traditional speech pathological treatments, which convey the use of speech techniques to reduce dysfluency, should be attempted but may not always be successful (Guitar, 1998). Yet, other sources claim that a differential feature of psychogenic stuttering may be the easy resolution of dysfluencies "almost by therapeutic suggestion" (Bloodstein & Bernstein Ratner, 2008, p. 210). This is contrary to the often lengthy treatment process for those clients with chronic developmental stuttering. Other authors describe the dysfluencies of psychogenic stuttering as persistent even during fluency-inducing conditions such as DAF, masking noise or singing in unison (Mahr & Leith, 1992). The outlook of recovering from psychogenic stuttering depends on the associated psychological

condition. It is currently believed, that a client has the best odds of recovery if a multidisciplinary treatment approach is chosen (Yairi & Seery, 2011). Published reports also show that psychogenic stuttering can continue for months or years (Roth, Aronson & Davis, 1989) or in some cases last a lifetime (Mahr & Leith, 1992).

For those with chronic developmental stuttering, the onset usually occurs within the 2<sup>nd</sup> and 4<sup>th</sup> year of life (Andrews, 1984). Recently, research more distinctly defined the most likely time during which first signs of stuttering develop as the timeframe between the 30<sup>th</sup>-36<sup>th</sup> month of life (Mansson, 2000; Yaruss, LaSalle, & Conture, 1998; Yairi & Ambrose, 1992). While the initial signs of stuttering usually occur gradually, with increasing severity of symptoms over time (see table 2), in roughly 1/3 of all cases dysfluencies occur sudden, literally overnight (Yairi, 1983; Yairi & Ambrose, 1992). For those children who experience steady increases in dysfluencies, repetitions are usually the first kind of core behavior that occurs and advances within the development of stuttering (Guitar, 1998). Repetitions may increase in number or type by including more than one repetition unit (Yairi, 1981). In these early stages of stuttering, secondary behaviors are uncommon. The most common types of dysfluency displayed by a stuttering child are so called “within-word dysfluencies” (Bloodstein, 1987; Conture, 1990). Such dysfluencies may include sound and syllable repetitions, prolongations and blocks, that markedly interrupt the typical verbalization of a word. One of the most unique features of stuttering is the high rate of spontaneous remission during the early stages of the disorder. A recent five-year longitudinal study followed 89 stuttering preschool children between the ages of 1.9 and 5.4 years (Yairi & Ambrose, 1999, 2005). Data collected at the five-year post initial diagnosis point revealed that 79% of participants had recovered naturally, without treatment. Other researchers reported similar natural recovery rates (Andrews & Harris; 1964; Mansson, 2006). A child that has been identified as a person who stutters (PWS) in the early stages of development, therefore roughly has a “20% chance of persistence” (Yairi & Ambrose, 2005, p. 168), meaning the prospect of becoming a chronic, possibly life-long stutterer. Natural recovery has not been documented in adulthood and generally occurs at a significantly smaller rate during school-age years (age 8 and up) (Sheehan & Martyn, 1966; Wingate, 1964). There are a number of vague predictive factors such as age

of onset (persistent stuttering is generally thought to have a later onset i.e. age 4 and up [Buck, Lees, & Cook, 2002]), gender (males are more likely to develop chronic stuttering, [Yairi & Seery, 2011]) and familial history of stuttering (Ambrose, Cox & Yairi, 1997). Such hallmarks are believed to increase the odds of developing persistent stuttering. However, among clinicians the question when to initiate treatment is often cause for disagreement. The complex issue of weighing the high odds of a spontaneous remission against the risk of developing persistent stuttering is one that continues to spark ethical discussions. While some argue that it is unethical to withhold therapy (Ingham & Cordes, 1998) others state that it is unethical to provide unnecessary treatment (Yairi & Ambrose, 2005; Yairi & Seery, 2011). Some speech-language pathologists are convinced that every child that has been diagnosed with stuttering should receive immediate direct treatment (e.g. Starkweather, Gottwald & Halfond, 1990). Others believe that immediate intervention is not always necessary but rather a monitored waiting period of up to 12 months may be more appropriate (Curlee & Yairi, 1997; Ryan, 2001a; Yairi & Ambrose, 2005).

With the high rate of spontaneous recovery during early childhood in mind, it is interesting to explore the prevalence of stuttering. The term 'prevalence' refers to the total number of cases - often expressed as a percentage - that suffer from a condition at any given time (Le & Boen, 1995). For stuttering within the preschool population a Canadian study by Beichtmann, Nair, Clegg & Patel found a prevalence of 2.4% (1986). Among school-aged children the figures vary between 0.35% (Brady & Hall, 1976) and 2.12% (Gillespie & Cooper, 1973) in the U.S. and 0.5% (Seeman, 1959) to 1.7% (Petkov & Iosifov, 1960) in Europe. The worldwide prevalence current literature generally agrees on is 1% for school-age children (Brady & Hall, 1976; Guitar, 1998) and slightly below 1% within the adult population (Andrews, Craig, Feyer, Hoddinott, Howie & Neilson 1983; Bloodstein, 1995; Yairi & Ambrose, 2005). While there is no cure for persistent developmental stuttering, it is considered a highly treatable condition, with a good prognosis for improvement if the time, effort and availability of evidence-based intervention are given (Bryngelson, 1938; National Institutes of Health, 2010; Starkweather, Gottwald & Halfond, 1990; St. Louis, 1997).

Research shows that stuttering\* is a very inconsistent speech disorder, as the frequency and intensity of core and secondary behaviors differs from person to person and situation to situation. A relatively stable component is the acquisition process of chronic developmental stuttering. Different symptoms are believed to occur at various developmental stages of the speech disorder. Therefore, current literature tends to define hallmarks of stuttering by splitting the umbrella term into more detailed incremental definitions of its various stages (cf. Table 1). This provides not only an attempt to recognize the complexity of its symptoms but also diversifies diagnostic attempts to describe a PWS. Based on this idea, Guitar (1998, p. 127) proposes a five-stage developmental hierarchy in which stuttering is distinguished from *normal dysfluencies* and classified into four constitutive stages (*borderline, beginning, intermediate* and *advanced stuttering* [cf. Table 1]). The characterization of each stage is based on the specific core and secondary behaviors exhibited. Each definition puts an emphasis on emotional and contributing components of every stage. Similarly, Bloodstein and Bernstein Ratner's definition (2008, p. 36-37) introduced a four-phase model on the various stages of stuttering. Factors such as kind and frequency of core behaviors, as well as presence of secondary behaviors, particularly covert emotional symptoms (i.e. awareness, anticipation, fear, and shame) are key to their definitions.

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\* Unless otherwise stated, the term 'stuttering' within this text refers to the chronic developmental form, which originates in early childhood and persists throughout adulthood.

Table 1: Models of developmental stages of stuttering

Author	Develop- mental stage	Core behaviors	Secondary behaviors
Bluemel, 1932	1. Primary stuttering	<ul style="list-style-type: none"> <li>• Exclusively easy repetitions</li> </ul>	<ul style="list-style-type: none"> <li>• None</li> </ul>
	2. Secondary stuttering	<ul style="list-style-type: none"> <li>• May include tense repetitions, prolongations &amp; blocks</li> </ul>	<ul style="list-style-type: none"> <li>• Child is aware of stuttering, leading to fear and avoidance of speaking</li> </ul>
Van Riper, 1954	Phase I	<ul style="list-style-type: none"> <li>• Effortless repetitions with occasional prolongations</li> </ul>	<ul style="list-style-type: none"> <li>• None</li> </ul>
	Phase II	<ul style="list-style-type: none"> <li>• Increasing repetitions with manifesting prolongations</li> </ul>	<ul style="list-style-type: none"> <li>• Occasional awareness</li> </ul>
	Phase III	<ul style="list-style-type: none"> <li>• Tense, effortful stuttering with all core behaviors displayed</li> </ul>	<ul style="list-style-type: none"> <li>• Full awareness leading to escape and avoidance behaviors</li> </ul>
Bloodstein, 1960a, 1960b, 1961	Phase 1	<ul style="list-style-type: none"> <li>• Repetitions of syllables and words that occur primarily on functional short words at the initial position in phrases</li> <li>• Up-and-down cycles in stuttering with possible complete amelioration for days or weeks followed by resumption of stuttering</li> </ul>	<ul style="list-style-type: none"> <li>• Little evidence of awareness and concern</li> </ul>

	Phase 2	<ul style="list-style-type: none"> <li>Stuttering becomes chronic; core behaviors include sound prolongations and blocks</li> </ul>	<ul style="list-style-type: none"> <li>Child identifies as stutterer with little or no evidence of concern</li> </ul>
	Phase 3	<ul style="list-style-type: none"> <li>Unstable occurrence of all core behaviors (stuttering comes and goes)</li> </ul>	<ul style="list-style-type: none"> <li>Development of first avoidance behaviors (word substitutions, paraphrasing)</li> </ul>
	Phase 4	<ul style="list-style-type: none"> <li>All core behaviors may be present</li> </ul>	<ul style="list-style-type: none"> <li>Strong emotional reactions (avoidance of speaking, shame, embarrassment)</li> </ul>
	Guitar, 1998		
	1. Borderline stuttering	<ul style="list-style-type: none"> <li>11 or more dysfluencies per 100 words;</li> <li>More than 2 units in repetitions</li> <li>Increasing number of repetitions and prolongations</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
	2. Beginning stuttering	<ul style="list-style-type: none"> <li>Rapid irregular and tense repetitions</li> <li>Possibly fixed articulatory posture in blocks</li> </ul>	<ul style="list-style-type: none"> <li>Escape behaviors (eye blinks, increases in pitch or loudness within dysfluencies)</li> </ul>
	3. Intermediate stuttering	<ul style="list-style-type: none"> <li>Blocks in which sound and airflow are shut off</li> </ul>	<ul style="list-style-type: none"> <li>Escape and avoidance behaviors</li> </ul>
	4. Advanced stuttering	<ul style="list-style-type: none"> <li>Long tense blocks; some with tremor</li> </ul>	<ul style="list-style-type: none"> <li>Escape and avoidance behaviors</li> </ul>

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### **1.1. Core behaviors**

Core behaviors of stuttering are generally divided into three symptom groups: repetitions, prolongations and blocks (van Riper, 1971). Since this classification system was introduced, various updated versions with more diversified sub-categories of each core behavior have emerged. Most of these detailed classifications are based on the three-group model by van Riper. However, in some cases the arrangement of core behaviors has been modified to describe those stutter-like symptoms commonly seen within a specific age range; such as preschool children (i.e. Ambrose & Yairi, 1999; Teesson, Packman & Onslow, 2003). Since the original classification described symptoms commonly seen in the “confirmed stutterer” (van Riper, 1971, p. 115), those core behaviors associated with a more advanced stage of the disorder have been excluded within the younger client group. The original scheme that has been utilized to identify stuttering symptoms by Wendell Johnson (1961) preceded the three-group system and is known as the *total dysfluency index*. At the time, this index was considered to be the “most comprehensive attempt to assess stuttering in depth” (Dalton & Hardcastle, 1977). Table 2 provides a summary of other symptom classification systems commonly found in the literature on stuttering.

For diagnostic purposes, the implementation of the three-group model by van Riper (1971) has become common practice. In order to be more specific and account for various subtypes of dysfluencies, a modified version of the van Riper model by Nicolosi, Harrymann & Kresheck (1978) has been chosen to identify dysfluency types within the studies presented herein. This model originally consists of seven core behaviors of which 5 were integrated into the DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, 4th. Edition, 2004) medical classification system in its definition of stuttering. The five core behaviors considered for the analysis of dysfluencies within the subsequent studies are: sound repetitions, syllable repetitions, sound prolongations, silent blocks and audible blocks. The interested reader is advised to refer to the audio examples provided as supplemental material (see Appendix 5) to this paper to obtain a better understanding of how these core behaviors present in clinical practice.

Table 2: Summary of classification systems of the core behaviors of stuttering

Author	Classification of Core Behaviors
Johnson, 1961	<ol style="list-style-type: none"><li>1. Part-word repetition</li><li>2. Word repetition</li><li>3. Phrase repetition</li><li>4. Interjections</li><li>5. Revisions</li><li>6. Disrhythmic phonations</li><li>7. Tense pauses</li><li>8. Prolonged sounds</li></ol>
Andrews & Harris, 1964	<ol style="list-style-type: none"><li>1. Simple repetitions</li><li>2. Prolongations</li><li>3. Hard blockings (with facial and body movement)</li></ol>
Van Riper, 1971	<ol style="list-style-type: none"><li>1. Repetitions</li><li>2. Prolongations</li><li>3. Blocks</li></ol>
Silverman, 1972	<ol style="list-style-type: none"><li>1. Interjection of sound or syllable</li><li>2. Part-word repetition</li><li>3. Whole-word repetition</li><li>4. Phrase repetition</li><li>5. Revision-incomplete phrase</li><li>6. Disrhythmic phonation</li><li>7. Tense pause</li></ol>
Shine, 1983	<ol style="list-style-type: none"><li>1. Whole-word repetition</li><li>2. Part-word repetition</li><li>3. Prolongation</li><li>4. Struggle behavior</li></ol>
Campbell & Hill, 1987	<ol style="list-style-type: none"><li>1. Hesitations</li><li>2. Interjections</li><li>3. Phrase/sentence revision</li><li>4. Unfinished word</li><li>5. Phrase/sentence repetition</li><li>6. Word repetition</li><li>7. Part-word repetition</li><li>8. Prolongation</li><li>9. Block</li><li>10. Other (this may include inappropriate breathing patterns)</li></ol>
Guitar, 1998	<ol style="list-style-type: none"><li>1. Sound repetition</li><li>2. Syllable repetition</li><li>3. Single-syllable word repetitions</li></ol>

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	<ol style="list-style-type: none"><li>4. Multi-syllable word repetitions</li><li>5. Sound prolongation</li><li>6. Blocks of the airflow and voice</li><li>7. Blocks with tremors</li></ol>
Yairi & Ambrose, 1999	<ol style="list-style-type: none"><li>1. Stutter-like Dysfluencies<ol style="list-style-type: none"><li>1.1. Part-Word Repetition</li><li>1.2. Single-Syllable Word Repetition</li><li>1.3. Disrhythmic Phonation</li></ol></li><li>2. Other Dysfluencies<ol style="list-style-type: none"><li>2.1. Interjection</li><li>2.2. Revision</li><li>2.3. Multi-syllable/Phrase Repetition</li></ol></li></ol>
Teesson, Packman, & Onslow, 2003	<ol style="list-style-type: none"><li>1. Repeated movements<ol style="list-style-type: none"><li>1.2. Syllable repetition</li><li>1.2. Incomplete syllable repetition</li><li>1.3. Multi-syllable unit repetition</li></ol></li><li>2. Fixed postures<ol style="list-style-type: none"><li>2.1. With audible airflow</li><li>2.2. Without audible airflow</li></ol></li><li>3. Superfluous behaviors<ol style="list-style-type: none"><li>3.1. Verbal</li><li>3.2. Nonverbal</li></ol></li></ol>
Conture & Curlee, 2007	<ol style="list-style-type: none"><li>1. Interjection</li><li>2. Revision</li><li>3. Phrase repetition</li><li>4. Multisyllabic whole-word repetition</li><li>5. Monosyllabic whole-word repetition</li><li>6. Broken word</li><li>7. Sound prolongation</li><li>8. Sound/syllable repetition</li><li>9. Disrhythmic phonation</li><li>10. Abandoned utterance</li><li>11. Insertion of schwa (neutral) vowel</li><li>12. Tense pause</li></ol>

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## **1.2. Secondary behaviors**

The acquisition of these learned reactions to the occurrence of core behaviors is believed to be based on conditioning processes of learning (Skinner, 1938). Various terms have been suggested to name these behaviors. They are sometimes referred to either as *accessory/associated* behaviors (Bloodstein, 1987) or *physical concomitants* (Wingate, 1964) but are most frequently referred to as *secondary*

*behaviors* (van Riper, 1971). Secondary behaviors are commonly divided into two groups: *escape* and *avoidance behaviors* (Guitar, 1998, p. 12). In the eyes of behaviorists, both avoidance and escape behaviors (such as physical concomitants or the use of filler words/sounds) manifest itself as a result of the operant conditioning process of negative reinforcement. The use of a physical movement (e.g. head nod) in reaction to a core behavior (e.g. block) may end this helpless state of being stuck in the forward flow of speech, and is therefore considered rewarding. Consecutively, the occurrence of this satisfying behavior is increased, resulting in the manifestation of a secondary behavior. Similarly, avoidance behaviors are secondary behaviors, which as Guitar explains are learned when “a speaker anticipates stuttering and recalls the negative experiences he has had when stuttering” (1998, p.13). As a result, the speaker will apply behavior, which was previously used to break out of moments of stuttering. For instance, the PWS may remember that substituting a word has ended a moment of stuttering. The behavior is perceived as rewarding, thus resulting in an increased occurrence of the behavior. The expectancy of a core behavior is now sufficient to cause these secondary behaviors (e.g. changing words, not speaking at all etc.).

Another view of the nature of secondary behaviors is based on the *fight or flight response* (Cannon, 1929) or *acute stress response*. The fight or flight response is the human system’s “primitive, automatic, inborn response that prepares the body to fight or flee from perceived attack, threat, or harm to our survival” (Mackesey, 2004, p. 2). The repeated endurance of core behaviors may be viewed as such a threat, triggering the fight or flight response. Non-physical escape and avoidance behaviors are reactions in line with a flight response as they intend to end the unpleasant situation as soon as possible without any further struggle. Secondary behaviors such as physical concomitants on the other hand are responses in line with a fight response. These movements are intended to counteract the core behavior by producing an opposing force.

### **1.3 The holistic presentation of core and secondary behaviors**

In recent years some clinicians have attempted to present a more wholesome picture of what life with chronic developmental stuttering entails (Yarrus, 1998; Yarrus & Quesal, 2004, 2006). This was achieved with the help of medical models such as the *World Health Organization's International classification of functioning, disability and health* (WHO-ICF, 2001), which aims at presenting the entirety of a disorder. The main aspiration of this medical model is the holistic portrayal of disorders by “shifting the focus from cause to impact” (WHO, 2012). In addition to the etiological factors and associated impairment of body function, the model proposes to take emotional factors/reactions and environmental factors into consideration in order to determine the activity limitation/participation restriction an individual experiences. For stuttering in particular the assessment process has shifted somewhat to account for these factors in a holistic manner. For a long time, the case history form or initial client/parent interview was the main source of obtaining information on social/environmental factors and ultimately level of participation. The impairment of body function for stuttering consists of the core and physical secondary behaviors a client displays. This can be assessed in a norm-referenced manner using the Stuttering Severity Instrument ([SSI-4], Riley, 2009) or a structured molecular analysis of speech samples (i.e. use of software such as Fluency Meter, Glück, 2003 [cf. Figure 6]). However, it used to be much more difficult to assess in how far these symptoms impact the client's quality of life. While there are a plethora of questionnaires (cf. Section 1.4.1.2. of this paper) attempting to accumulate the types of secondary behaviors exhibited, only the recently developed assessment tool OASES (Yarrus & Quesal, 2008) gives an associated impact rating, thus displaying the activity limitation a PWS experiences (for a more detailed description of the OASES please refer to Section 1.4.1.2.3 of this text). Numerous publications have shown that secondary behaviors or associated emotional reactions to the experienced core behaviors become the most impacting feature of stuttering in adolescents and adults (cf. Bricker-Katz, Lincoln, & McCabe, 2009; Prasse & Kikano, 2008; Sheehan, 1970). It is also likely that the emotional burden one carries by being a PWS, takes on ‘a life of its own’ by impacting the participation level to such a significant degree, that other disabilities (such as social phobia) result. (Iverach,

Menzies, O'Brian, Packman, & Onslow, 2011; Bricker-Katz, Lincoln, & McCabe, 2009; Iverach, O'Brian, Jones, Block, Lincoln, et al., 2009; Messenger, Onslow, Packman, & Menzies, 2004).

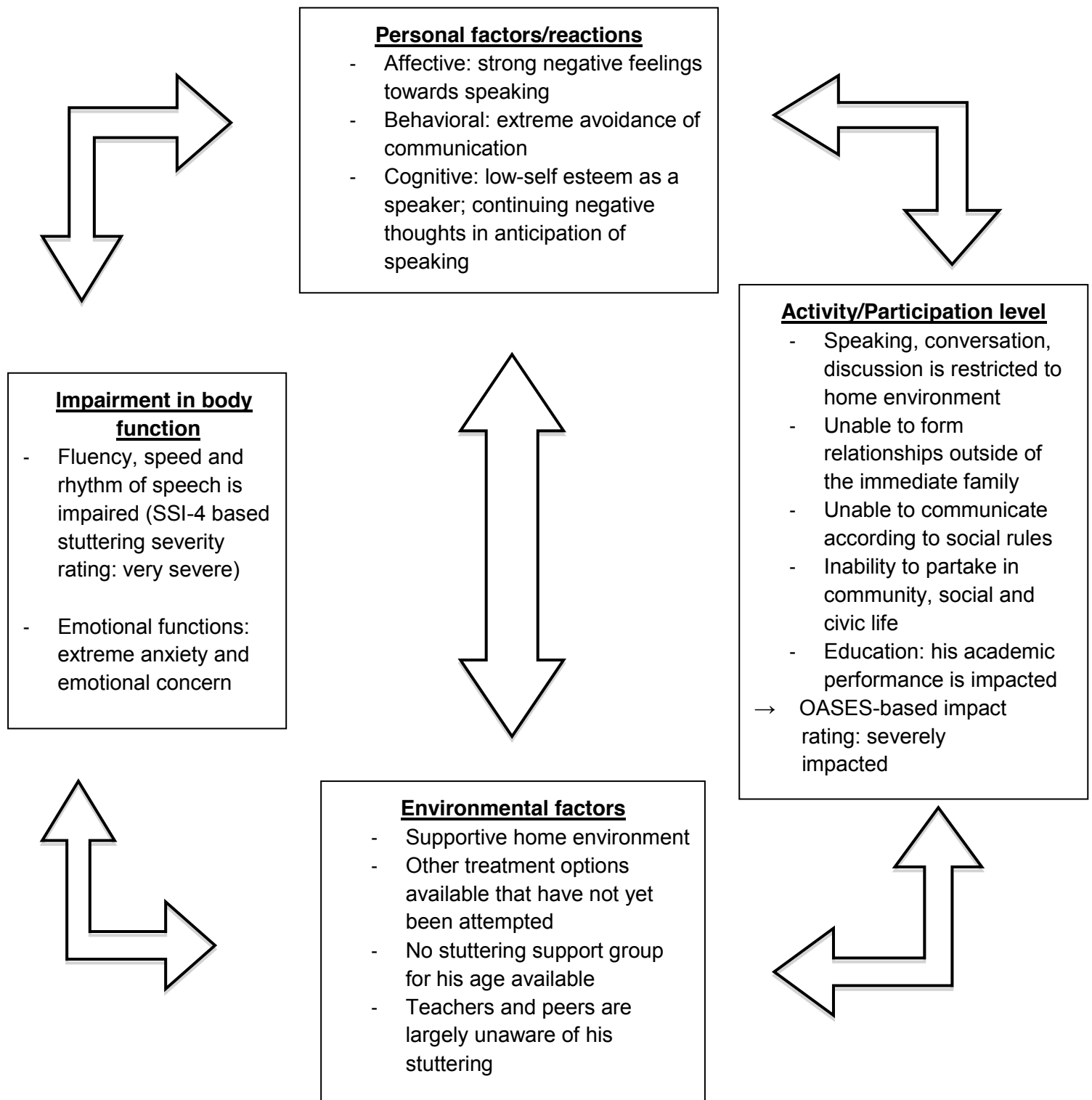
In an effort to conclude the introductory chapter on stuttering as a disorder, in a functional manner, the scope of persistent developmental stuttering is portrayed through a real-life case example. The following clinical case illustrates the complex relationship between core and secondary behaviors and concomitantly demonstrates what it can mean to live with stuttering.

*X.Y. (age 14 years, 2 months) began to show first dysfluencies when he was 3 years old. These initial dysfluencies mainly consisted of effortless multi-unit repetitions. After several months these repetitions increased in number and severity. X. started to display prolongations and gradually began to develop tense blocks. He became very aware that his speech differed from his peers and felt uncomfortable in preschool, as he feared comments and teasing from other children. He was always the last child to be dropped off, but the first one to be picked up at preschool as he made it very clear to his parents that he does not enjoy preschool. In an effort to reduce his fear, his parents often gave into his requests to stay at home. During the German school placement assessment at age 5, the evaluating physician found him to be unsuitable for a regular education classroom, due to his speech. Rather than keeping X. in preschool for another year - and hope for his speech to recover naturally - the family made the choice to place him in a school for children with speech and language impairments. Their hope was to receive regular treatment for his stuttering at such a specialized educational setting. At school, X. received weekly group therapy with several other children for 30 minutes. However, since he was the only child who stuttered, group intervention commonly focused on articulation therapy rather than X.'s individual needs. In subsequent years X. attended several treatments outside of school, including various inpatient, intensive speech-language programs, which helped for the moment but left him feeling lost once back in his natural environment. At age 10 X. transferred to a regular education middle school. At this point he hardly displayed core behaviors in public, due to strict avoidance of communicative situations. Even in non-communicative situations, X. was unable to*

*hold eye contact with others. His grades began to suffer because he either did not partake in oral classroom activities or pretended to not know the answers. As the need to speak increased, X. started to display extreme signs of anxiety by experiencing stomach cramps, accelerated heart rate or heat flashes whenever he anticipated communication. He often felt so overwhelmed by the prospect of having to speak that he was unable to leave the house to attend school or in some rare cases fainted in the classroom. At age 13 he rarely spoke to anyone except his parents. He was unable to answer or place phone calls and had no social contact with peers.*

Dynamic medical models such as the WHO-ICF provide a universal summary of a client's state of functioning with their disability (see Figure 1 for the WHO-ICF-based summary of example client X.Y.). Such a precise synopsis on the one hand is a helpful structure for the clinician when choosing individualized, multidimensional treatment components, which directly impact current needs. It may also serve as a motivational or even therapeutic tool for the client throughout a treatment process, as the participation level changes and core/secondary behaviors diminish.

Figure 1: WHO-ICF-based summary for client X.Y., who suffers from persistent developmental stuttering



## **1.4. Diagnosis**

### **1.4.1. Criterion-referenced tools**

The term *criterion-referenced assessment* was first introduced in 1985 when three prominent institutions, the American Educational Research Association (AERA), the American Psychological Association (APA) and the National Council of Measurement in Education (NCME), published the first edition of *Standards for Educational and Psychological Testing*. In this manual a criterion-referenced tool is defined as “a test that allows its users to make score interpretations in relation to a functional performance standard, as distinguished from those interpretations that are made in relation to the performance of others” (1985, p. 90). Specific to the assessment of stuttering *The Handbook of Stuttering* by Oliver Bloodstein and Nancy Bernstein Ratner outlines four common criterion-referenced processes, which are used in the assessment of stuttering: frequency of stuttering measurements, frequency of specific dysfluency types and mean duration of stuttered events as well as speech rate (2008, pp. 2-6). The measurement of stuttering within the studies presented in this text, have largely relied on criterion-referenced tools. The aforementioned four objective assessment categories, by Bloodstein and Bernstein Ratner, have been utilized within this investigation and are explained in more detail in the subsequent section.

#### **1.4.1.1. Measurement of core behaviors**

##### **1.4.1.1.1. Frequency of moments of stuttering/Frequency of specific dysfluency types**

Measures of stuttering frequency have been among the most prominent assessments in stuttering research since the 1930s (Bloodstein, Bernstein Ratner, 2008). Particularly, research conducted at the University of Iowa has utilized measures of frequency early on. Structured ways of obtaining speech samples and calculating the frequency of stuttering were first published as the *dysfluency category index* (Johnson, 1961). The formula that was introduced to compute the frequency of stuttering instances read: *Dysfluency category index = Total number of instances of dysfluency (ND) ÷ number of words or the verbal output (NW)* (Johnson, 1961, p. 5).

While this equation presents with rather flexible variables, the authors of the index preferred to measure the percentage of stuttered words, rather than syllables. The discussion on which unit to use (words versus syllables) when calculating the percentage of dysfluencies is ever present and has been addressed in many research papers (Johnson, Darley & Spriestersbach, 1963; Andrews & Ingham, 1971; Ham, 1986; Conture, 1990; Yaruss, 2000).

Yairi (1997) addresses the problem by referring to *the metric* in which data on stuttering frequency can be expressed. He outlines three different approaches to reporting the percentage of dysfluency “Percent of dysfluent words, number of dysfluencies per 100 words, and number of dysfluencies per 100 syllables” (Yairi, 1997, p. 51). The number of dysfluencies is the same as the count of stuttered syllables, if we assume that each dysfluent syllable is only counted as one instance of stuttering (e.g. my a-a-a-apple = 1 stuttered syllable) (Guitar, 1998, p. 165). Table 3 provides a summary of calculations that can be associated with the different *metrics* for the assessment of stuttering frequency.

Table 3: Summary of different frequency calculations and reports

Metric	Equation	Researchers reporting data in each metric
Percent of dysfluent words	Number of dysfluent words / words produced x 100	Meyers, 1986; Zebrowski, 1991
Number of dysfluencies per 100 words	Number of dysfluent syllables / words produced x 100	Johnson, 1961
Number of dysfluencies per 100 syllables/percent stuttered syllables (%SS)	Number of dysfluent syllables/ syllables produced x 100	Lincoln & Packman, 2002; Guitar, 1998; Riley, 2009

For this investigation the latter option “number of dysfluencies per 100 syllables” or “percentage of syllables stuttered (%SS)” (Guitar, 1998, p. 165; Lincoln & Packman, 2002, p. 59; Riley, 2009, p.5) was used. The main reason for choosing this metric is the fact that the Stuttering Severity Instrument – 4<sup>th</sup> Edition ([SSI-4], Riley, 2009) derives its frequency score from the formula for percent stuttered

syllables. Since the SSI-4 is used to obtain the subjects' stuttering severity, %SS was used for consistency. Secondly, it appears as though reporting results in %SS is the most comprehensive way of capturing each dysfluency. If the percentage of dysfluent words were employed, different symptoms occurring in the same word would not be accounted for. For instance, if a multisyllabic word such as 'concentration' was produced with a block on the first syllable, and a prolongation on the third syllable (\_\_\_\_\_concenttttttration) the second dysfluency would be disregarded. This doesn't only change the percentage of dysfluencies but may also invalidate the full scope of a client's core behaviors. Reporting dysfluencies using %SS enables a clinician to obtain a complete analysis of a client's core behaviors because every symptom is recorded, thus accumulating a more comprehensive molecular analysis.

### 1.4.1.1.2. Mean duration of moments of stuttering

Another characteristic of the core behaviors of stuttering, used to accumulate stuttering severity by norm-referenced tools (Stuttering Severity Instrument – 4<sup>th</sup> Edition [SSI-4], Riley, 2009; Iowa Scale of Severity of Stuttering, Sherman, 1952), is duration. Studies assume that the mean duration of moments of stuttering does not appear to be linked to other measures of core behaviors, such as frequency (Bloodstein, 1944; Johnson & Colley, 1945). However, this assumption was based on weak correlation coefficients ( $r = 0.17$ ,  $r = 0.54$ ) between the two variables. This means that a person who encounters dysfluencies at a high rate, may not necessarily remain in the moment of stuttering for a very long time and vice versa. Therefore, the usefulness of duration as a measure of stuttering severity has been questioned by some (Bloodstein & Bernstein Ratner, 2008, p. 3). However, duration is still functional as a measure of difficulty or struggle when experiencing dysfluency. In order to account for this variable, it has become quite common to derive an estimate of duration by calculating the mean of the longest dysfluencies. Riley (1972, p. 316) suggests estimating the duration of the three longest dysfluencies with or without the use of a stopwatch based on a 9-point scale (ranging from "fleeting" to "1 minute" in duration). Prior to the introduction of the SSI, duration was sometimes calculated using the mean of the longest 10 dysfluencies (Johnson & Colley, 1945).

Despite this common simplification and for the benefit of scientific accuracy, the combined mean of all recorded core behaviors has been used to calculate duration within the presented studies.

#### 1.4.1.1.3. Speech Rate

The main purpose of acquiring data on a client's speech rate is its close relation to the judged severity of listeners. It was found that listener's tend to rate one's stuttering as more severe, the slower the speaker's speech rate (Prosek, Walden, Montgomery, & Daniel, 1979). Another investigation shows that similar findings are true for objective measures of severity such as the SSI (Riley, 1972). Results revealed the trend that the higher the stuttering severity rating, the lower the measured speech rate (Andrade, Cervane & Sassi, 2003). This indicates that the assessment of speech rate must be closely related to other measures of severity such as frequency and duration.

Unlike the assessment of frequency, there appears to be relative unity in the scientific community as to how speech rate is measured. The current research literature identifies two ways in which speech rate is typically evaluated; words or syllables per minute (Guitar, 1998, p. 166). Within different languages, there are differences in boundaries of what is considered a typical speech rate for an adult speaker. For American English, the typical speech rate is considered to be 115-165 words per minute (Andrews & Ingham, 1971) or 198 - 354 syllables per minute (Roach, Arnfield, & Hallum, 1996). In the German language on the other hand, normal speech rates may range from 140 – 180 words per minute (McCoy, Tun, Cox, & Wingate, 2005) or 333 – 342 syllables per minute (Dankovicova, 1994). These slightly differing numbers among various languages are largely due to linguistic factors such as the presence of longer words.

#### **1.4.1.2. Measurement of secondary behaviors**

As mentioned in Section 1.1., secondary behaviors may manifest themselves in either overt (those who are observable) or covert forms (not directly apparent to the listener). In comparison to the covert or emotional secondary behaviors, there is a relatively small body of research on the nature and appearance of overt secondary

behaviors (Conture & Kelly, 1991). There is no assessment tool that solely focuses on the identification of overt secondary behaviors. However, some comprehensive fluency assessments such as the SSI (Riley, 1972) or the Iowa Scale of Severity of Stuttering (Sherman, 1952) take observable physical concomitants into consideration when determining severity. Covert secondary behaviors (e.g. fear, guilt, avoidance, shame) are widely known to construct the heart of the disorder, having tremendous impact on the overall quality of life of those suffering from chronic stuttering. Sheehan (1970, p. 15) depicted the complex relationship of *stuttering behavior* (overt symptoms) and *concealment behavior* (covert symptoms) in the now famous *Iceberg of Stuttering* analogy. In this illustration he compares the covert behaviors of stuttering with the vast majority of unseen ice underneath the surface of the ocean when looking at an iceberg. The smaller exposed amount of ice, forming the visible peak, serves as an analogy for the overt behaviors, which are noticeable to the listener. For the studies presented in this text, secondary behaviors did not serve as a dependent variable. Its importance to the disorder of stuttering is therefore only mentioned. Two common tools that assess covert secondary behaviors are briefly introduced within the following sections in order to create a comprehensive section on criterion-referenced assessment.

### 1.4.1.2.1. Perceptions of Stuttering Inventory – PSI (Woolf, 1967)

An example of a widely used criterion-referenced assessment tool for the assessment of covert secondary behaviors is the *Perception of Stuttering Inventory* ([PSI] Woolf, 1967). In this questionnaire the person who stutters is presented with 60 statements, illustrating behaviors commonly associated with secondary behaviors. The examinee is asked to check mark those statements that are typical for his/her speech (e.g. “Avoiding talking to people in authority”). Each statement represents a behavior, which is associated with one of the following concealments: struggle, avoidance, and expectancy. Woolf (1967) constructed this tool in hopes of receiving insight into the thought process of a PWS, when a moment of stuttering occurs. It was his goal to broaden the stutterers’ own understanding of their disorder and enable the clinician to formulate appropriate treatment goals (p.160). In order to interpret the scores, the checked items within each behavior subgroup (struggle,

avoidance, expectancy) are added. There are 20 questions corresponding to each of the three behaviors, for a total of 60 questions. According to the scoring guidelines a client's covert secondary behaviors "are low when seven or fewer than seven items are perceived as characteristic; when sixteen or more items are perceived as characteristic, the score is considered to be high" (Woolf, 1967, p. 162). It is further suggested that after rapport has been built between the client and clinician, the clinician may score the PSI on the client's behalf. Congruity of scores is considered an indicator of the client's awareness of their disorder, whereas a lack of such may be a sign of denial on the client's part.

### 1.4.1.2.2. Modified Erikson Scale of Communication Attitudes - S-24 (Andrews & Cutler, 1974)

Rather than looking at individual covert behaviors (e.g. shame, guilt, helplessness), this questionnaire is considering the impact of negative emotions on the client's overall attitudes towards communication. It is supposed to be used as an ongoing assessment, predominantly in the advanced stages of therapy (e.g. transfer or stabilization). Andrews and Cutler (1974) concluded that a decrease in covert secondary behaviors and concurrently an improvement in communication attitude are not related to the removal of symptoms but to everyday experience with normal stutter-free speech (p. 314). Therefore, their tool was created for clinician's to track changes in a client's internal processes, chiefly a positive mind-set towards communication. The questionnaire is supposed to be used repeatedly within certain time fragments (minimally: before, during and after treatment). The tool is especially useful if applied repeatedly during the progressed stages of treatment (e.g. transfer), in order to prevent relapse in times of increased focus on the client's independent therapeutic work, in situations of daily living. The original *Scale of Communication Attitudes* ([S-Scale], Erikson, 1969) consisted of 39 items. Andrews and Cutler (1974) limited the original questionnaire to 24 statements and named the revised tool *Modified Erickson Scale of Communication Attitudes* (S-24). They reduced the questionnaire by 15 items for various reasons, mainly because some items were not considered problematic at any point when the S-Scales were administered to trial groups at different times before, during and after treatment. The subsequent S-24

consists of items that reflected attitudes with the potential to be altered as a result of treatment. The S-24 entails statements reflecting both positive (e.g. “I usually feel that I am making a favorable impression when I talk”) and negative attitudes (e.g. “I do not talk well enough to do the kind of work I’d really like to do”) towards one’s own speech. The examinee has the option to either concur with a statement by check-marking it as *true*; or disagree with a statement by labeling it *false*. According to a pre-set answer sheet, each item receives a score of one if the answer reflects a negative attitude towards communication ([average score for non-stutterers;  $M = 4.14$ ,  $SD = 5.38$ ; average score for stutterers:  $M = 19.22$ ,  $SD = 4.24$ ], Andrews & Cutler, 1974, p. 316). Several studies have confirmed the value of the S-24 by using the tool to evaluate the communication attitudes of clients who have undergone treatment. Results show that the chance of relapse within 12 to 18 months post therapy increases if no S-24 based attitude change occurs (Andrews & Craig, 1988; Guitar & Bass 1978; Young 1981).

### 1.4.1.2.3. Overall Assessment of the Speaker’s Experience of Stuttering – OASES (Yaruss & Quesal, 2008)

The OASES was designed to capture the magnitude of the disorder from the perspective of the PWS. The idea was to go beyond the reflection of a person’s attitudes towards speech and/or stuttering and include influencing factors such as the role of the environment. In addition to these personal and environmental factors, which may have an impact on the severity of one’s stuttering, the OASES also assesses the consequences of such influences. This is achieved by asking questions about the activity, limitation or participation restriction caused by one’s stuttering. The World Health Organization’s (WHO) International Classification of Functioning, Disability and Health (ICF) describes every disorder using an interactive four-point system. The OASES is considered an ICF-based evaluation tool because it assesses these four points subjectively (impairment, personal factors/reactions, environmental factors and activity/participation level). In addition to an objective measure of stuttering severity (e.g. frequency of moments of stuttering), which is evaluated by the first category on the ICF scale (impairment in body functions),

stuttering can be assessed according to professional best-practice guidelines (ASHA, Scope of Practice, 2007). The OASES is a questionnaire, spread out into four sections that consecutively assess the aforementioned four ICF categories: General Information about Stuttering (Impairment), Speaker's Affective, Behavioral, and Cognitive Reactions (personal factors), Communication in Daily Situations (environmental factors), Impact of Stuttering on the Quality of Life (activity/participation level) (Yarrus, 2008). If applicable, the OASES can be administered every three months in order to track changes within the four assessment categories. The creators of the tool point out, its value as a "treatment planning tool" (Yarrus, 2008, p. 11), by enabling the clinician to ensure that meaningful, disorder specific aspects are targeted in treatment (e.g. a high impact score on the participating/activity section may indicate that there is an increased need for external transfer assignments).

When filling out the form, adult clients (18 years and over) are asked to answer questions on a five-point scale (e.g. "How often are you able to speak fluently", answer options: always, often, sometimes, seldom, never; OASES protocol, 2008, p. 2). The questionnaire gives the flexibility to skip certain items, which may not be applicable to specific demographics. After the questions on each of the four sections have been answered, the clinician computes the impact score by dividing the accumulated points by the number of answered questions. Based on this figure, a corresponding impact rating can be obtained, which correlates with the severity categories of the SSI (Riley, 1972); mild – severe.

### **1.4.2. Norm-referenced tools**

Norm-referenced assessment tools are often the first kind of measure a clinician employs in any given assessment process. Such a tool is supposed to answer the initial and most fundamental question in the assessment process: is a disorder present? It therefore "provides evidence regarding the existence of a problem" (McCauley & Swisher, 1984, p. 38) by comparing the performance of a single individual to a group of scores (normative sample). While there is often a plethora of norm-referenced assessment tools available for language (e.g. aphasia) or other speech disorders (e.g. articulation disorders), this is not the case for

stuttering. To date, the examining clinician only has one norm-referenced assessment tool available, when diagnosing stuttering; the *Stuttering Severity Instrument* (SSI, Riley 1972) now in its fourth edition (2009).

#### **1.4.2.1. Stuttering Severity Instrument, 4<sup>th</sup> Edition - SSI-4 (Riley, 2009)**

In an effort to develop a norm-referenced, objective tool to determine the sternness of one's stuttering in a comprehensive manner, Glyndon Riley introduced the SSI in 1972. There are a number of subjective tools, which assess the client's view of their own stuttering in the form of questionnaires, scales or self-reports. Riley felt that these tools were inefficient in measuring changes in severity throughout the course of treatment (1972). The SSI was and is the only norm-referenced, objective diagnostic tool that combines measures on core behaviors as well as ratings on secondary behaviors. The fact that the SSI stands alone in the category of norm-referenced tools comes to show the complexity of attempting to standardize stuttering. Many researchers have critiqued the SSI's various editions by pointing out general weaknesses in test design, validity, and reliability. The adult norms for instance have only been based on a small norm-sample ( $N = 60$ ), presenting a threat to the tool's validity. Others criticize poor reliability as obtained by two independent studies establishing poor interjudge agreement (Hall, Lynn, & Altieri, 1987; Lewis, 1995). Because of these weaknesses, researchers have pointed out a "need for caution" (Hall et. al, 1987, p. 171) or have even concluded that the use of the SSI is not suitable for the designation of stuttering severity (Hansen & Iven, 2010; Lewis, 1995). Table 4 contrasts the SSI-4 with the criterion-referenced OASES in order to exemplify the differences within norm- and criterion-referenced assessment tools.

Table 4: Comparison of a norm-referenced and criterion-referenced assessment tool for stuttering

Norm-referenced tool		Criterion-referenced tool	
Features (McCauley, 1996)	Stuttering Severity Instrument – 4 <sup>th</sup> Edition (SSI-4, Riley, 2009)	Features (McCauley, 1996)	The Speaker's Overall Experience of Stuttering (OASES, Yaruss & Quesal, 2008)
1. Ranks individuals	<ul style="list-style-type: none"> <li>Ascending ratings expressing increasing stuttering severity: <ul style="list-style-type: none"> <li>1 = very mild</li> <li>2 = mild</li> <li>3 = moderate</li> <li>4 = severe</li> <li>5 = very severe</li> </ul> </li> </ul>	1. Distinguishes specific levels of performance	<ul style="list-style-type: none"> <li>Determines the impact stuttering has on the individual's ability to function in every-day life</li> </ul>
2. Addresses a broad content	<ul style="list-style-type: none"> <li>Core behaviors: <ul style="list-style-type: none"> <li>Frequency</li> <li>Duration</li> </ul> </li> <li>Secondary behaviors: <ul style="list-style-type: none"> <li>Overt behaviors</li> </ul> </li> </ul>	2. Addresses a clearly specified domain	<ul style="list-style-type: none"> <li>Secondary behaviors</li> </ul>
3. Distinguishes among individuals	<ul style="list-style-type: none"> <li>Determines whether or not the observed core &amp; secondary behaviors are sufficient to diagnose stuttering.</li> </ul>	3. Covers content domain	<ul style="list-style-type: none"> <li>The impact of secondary behaviors on a person's overall ability to function are assessed on five levels: <ul style="list-style-type: none"> <li>General Impairment</li> <li>Affective, Behavioral &amp; Cognitive Functioning</li> <li>Communication in Daily Situations</li> <li>Quality of Life</li> </ul> </li> </ul>
4. Summarizes performance meaningfully using percentile and standard scores	<ul style="list-style-type: none"> <li>Total score (standard score)</li> <li>Percentile rank</li> <li>Severity equivalent</li> </ul>	4. Summarizes performance meaningfully using raw scores	<ul style="list-style-type: none"> <li>Raw scores</li> <li>Impact score (mean raw scores)</li> <li>Impact equivalent</li> </ul>

## **Chapter 2: Etiology of stuttering**

While Chapter 1 detailed the complexity of the fluency disorder, particularly in the context of assessment, Chapter 2 addresses the intricate nature of stuttering. To date, even with the largest and most thoroughly executed clinical trials (e.g. Kang, Riayuddin, Mundorff, Krasnewich, Friedman, Mullikinb, & Drayna, 2010), the ultimate cause of stuttering has not been found. While there are only ambiguous explanations for the origins of the disorder, there are several evidence-based hypothetical models attempting to explain the etiology of stuttering. It is believed that rather than having an exclusive explanation for why a person stutters; there may be a plethora of factors and circumstances within each individual, causing dysfluency. Due to the large volume of scientific theories attempting to clarify the nature of stuttering, only a few are going to be discussed within this chapter. The selected theories are all examples of explanations for the existence of confirmed stuttering in adults. Most of the presented models are also closely related to the justifications of why AAF may be an effective tool in the treatment of stuttering, forming a link to the hypotheses about the modes of functioning of AAF.

### **2.1. Individualized theories on the nature of stuttering**

The following section gives an overview of a well-researched form of individualized theories regarding the nature of stuttering; breakdown theories. This type of hypothetic explanation can be incorporated into multidimensional models when attempting to explain the origin of stuttering in a holistic manner. However, by itself the various breakdown theories are considered individualized, meaning that they link the core etiology of stuttering to a single breakdown.

### **2.1.1. Breakdown hypotheses**

The underlying concept of a *breakdown theory*, as the name implies, is the (temporary) malfunction of one or more of the many processes and structures involved in speech production. This collapse in the forward flow of speech can be caused by either environmental (e.g. stress) or intrinsic, constitutional factors (e.g. physiological deficits). While the more dated theories have focused on environmental factors as a sole cause of stuttering (e.g. *diagnosogenic theory*, Johnson, 1942), more recent explanations account for physical predispositions (e.g. *segmentation dysfunction hypothesis*, Moore & Haynes, 1980). Breakdown theories focus on the “moment of stuttering” itself, meaning that they aim at describing what happens while a dysfluency occurs (Bloodstein & Bernstein Ratner, 2008, p. 41). Most commonly breakdown theories are split into physiological and psycholinguistic hypotheses. Physiological theories all assume that a moment of stuttering is caused by a deficient body function. One of the most well researched physical breakdown theories have assumed that stuttering is a direct result of a cerebral imbalance (*cerebral dominance theory*) for speech and language tasks. Since the investigation of a cerebral imbalance in PWS has been documented thoroughly over the past decades, it serves as an exemplary illustration for physical breakdown theories. In recent years genetics have been researched as another possible source for an abnormal physical setup. However, the existence of the scarce evidence of specific genome mutations in PWS is just mentioned herein but not explained in great detail. Another type of breakdown theory, the so called psycholinguistic theories, assume that stuttering is a result of failures in linguistic processing mechanisms.

#### **2.1.1.1. Physiological theories**

The notion that stuttering may be a result of insufficient balancing between hemispheric functioning was first recognized in the 1930s as the so-called *Orton-Travis model* was introduced (Orton, 1928; Travis, 1931). This theory explained that PWS suffer from a hemispheric inequity in which neither side is responsible for the structures used for speech. It was further described that this imbalance was caused by a change of handedness (from left to right handedness) in early childhood. This

change in handedness supposedly prohibited the left hemisphere, which is typically responsible for speech and language tasks (Wada & Rasmussen, 1960; Kimura, 1961) from becoming the dominant hemisphere for such tasks. While this theory was widely accepted and “met with favorable receptions” (Bloodstein & Bernstein Ratner, 2008, p. 48) at the time, it soon became a rather unlikely explanation for the development of stuttering. One of the main reasons for the fading initial enthusiasm was the fact that the Orton-Travis model suggested, that a change in handedness (back from a forcibly right-handed dominance to left-handedness) would enable the left hemisphere to regain control over speech and language tasks, thus eliminating stuttering. Since the attempt to change the handedness of PWS failed as an effective treatment, the underlying theory accordingly was largely invalidated. However, the fact that inaccurate brain activation, regardless of the causes, may be to blame for the development of stuttering remained of interest. Geschwind and Galaburda (1985) revisited the idea of inefficient hemispheric activation in the 1980s. They assumed that a delay in left hemisphere growth during fetal development was the cause for an inaccurate cerebral activation for speech and language tasks. More specifically, their theory claimed that the brain tries to make up for this growth delay by forming neural networks responsible for speech and language functions in the right hemisphere. Since the right hemisphere is naturally not equipped to carry out speech and language tasks, it was concluded that inefficient speech and language processing may occur. This reasoning formed a progression of the original Orton-Travis model, as it accounts for cases of spontaneous recovery in early childhood. Geschwind and Galaburda explained that due to the plasticity of young children’s brains, it might be possible to have a reorganization of neural networks occur and develop accurate speech processing capacities in the left hemisphere, thus recovering from stuttering. Yet another, more recent investigation, which confirms the cerebral dominance theory, was proposed by Forster and Webster in 2001. It presents essentially a more cause-oriented reinvention of the Orton-Travis model as it identifies an over-activation of the right hemisphere as a result for a breakdown in speech fluency. It was found that this impacts the control over neural mechanisms in the supplementary motor area (SMA), responsible for speech-motor functions necessary to carry out fluent speech. In comparison to the original cerebral dominance theory

(Travis, 1931), the work by Forster and Webster specifically identify speech motor difficulties as the direct consequence of the cerebral imbalance, thus classifying stuttering as a speech motor disorder.

Numerous studies have concurred that a persistent excess initiation of the right hemisphere may cause stuttering. Over the years, different reasons have been cited for why this over-activation occurs (e.g. change of handedness, fetal growth delay of the left hemisphere). Various studies have identified numerous consequences of this over-activation. Among the most well investigated effects are a weakness in speech and language processing and deficient speech-motor functions.

All cerebral dominance theories agree that the ascendancy of the right hemisphere is linked to the presence of stuttering. Table 5 summarizes a number of recent studies that have investigated impaired skills/body functions associated with an over-activation of the right hemisphere. Finally, it is important to point out that researchers at present are not certain whether the over-activation of the right hemisphere and the associated impaired functions, are indeed a cause of stuttering or a consequence of the fluency disorder. Even though most physical breakdown theories have assumed that a dominance of the right hemisphere causes stuttering, it is also possible that this shift in hemispheric dominance for speech and language tasks occurs as a coping mechanism. In this case the neurological differences observed in PWS would be a response to the continued experience of dysfluencies rather than a cause (Sommer, 2011).

Table 5: Summary of studies investigating the impact of the cerebral dominance theory

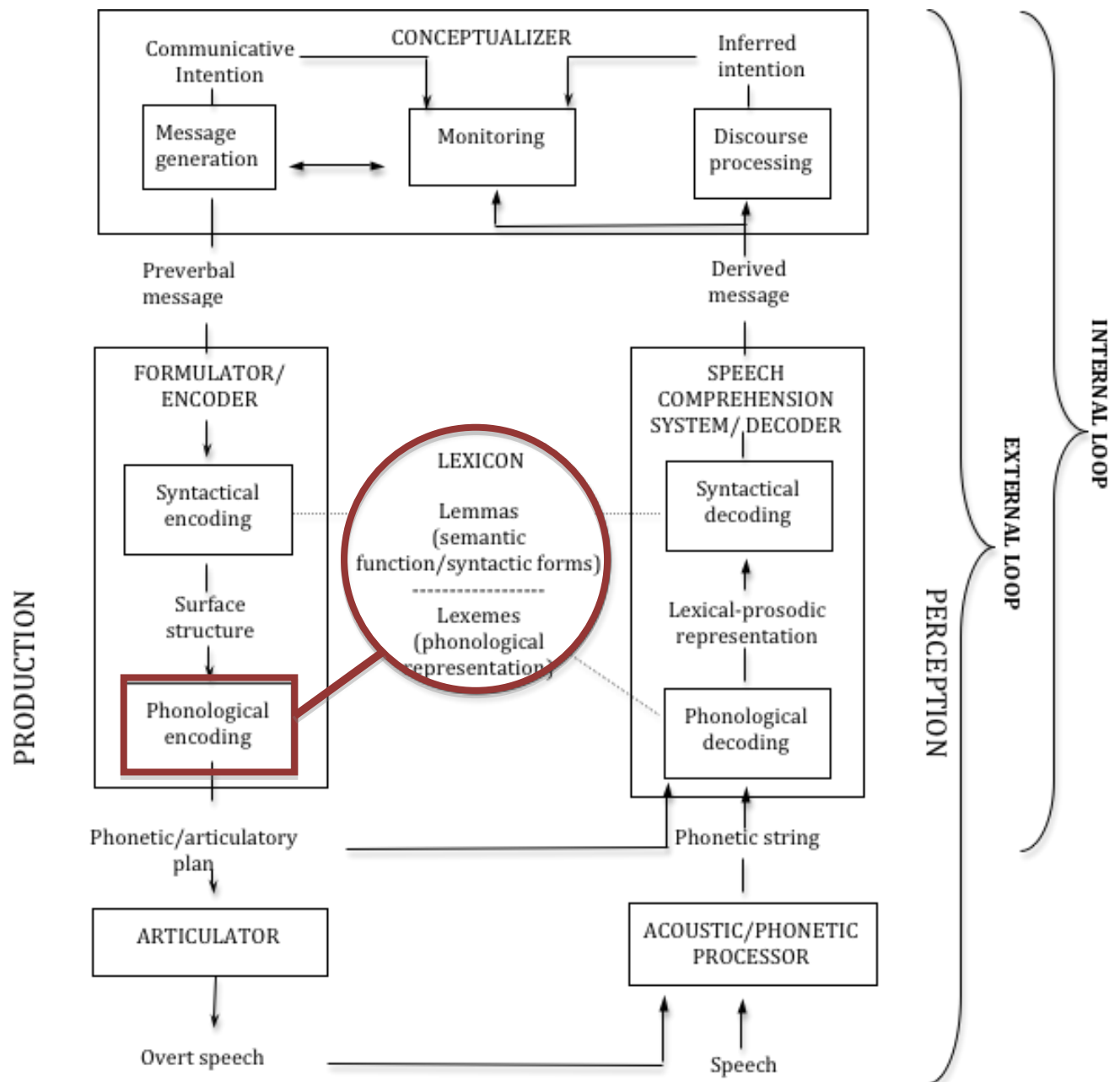
Researcher	Experimental method	Impacted body function
Moore & Haynes, 1980 Moore, 1984;	Electroencephalography (EEG) during connected speech and nonlinguistic stimuli	Auditory Processing
Hand & Haynes, 1986	Measurement of vocal and manual reaction times when presented with non-word and real-word stimuli	Linguistic processing
Rastatter & Dell, 1987	Measurement of vocal reaction times to a lexical decision task	Linguistic processing
Webster, 1988	Timed bimanual handwriting task	Motor control (suspected supplementary motor cortex [SMA] dysfunction)
Watson & Freeman, 1994	Quantitative regional cerebral blood flow [rCBF] during linguistic tasks (verbal story production)	Language Processing & Motor Control
Fox, Ingham & Ingham, 1996; Ingham, Fox, Costello, & Zamarripa, 2000	PET (positron emission tomography) during spontaneous speech	Motor control (basal ganglia fails to provide sufficient timing cues to SMA)
Kroll & DeNil, 2000	Positron emission tomography (PET scanning)	Internal speech processing → over-activation in motoric speech monitoring & control

### 2.1.1.2. Psycholinguistic theories

Based on the assumption that each speaker attempts the correctness of their speech, Levelt (1989) proposes the idea that there are two monitoring systems for speech: the internal loop and the external loop (cf. Figure 2). The latter one starts with auditory perception (acoustic/phonetic processor) of spoken language. The

internal loop on the other hand does not require the verbal production of speech. The *speech comprehension system*, which is central to the monitoring process, accepts both auditory perceptions of the phonetic string as well as the pre-verbal phonetic/articulatory plan. This proposed existence of a speech monitoring system is known as *Levelt's perceptual loop theory of self-monitoring* (Levelt, 1989). Its explanation is based on the Psycholinguistic Model of Speech Production and Comprehension (Levelt, 1989).

Figure 2: Levelt's psycholinguistic model of language production and comprehension



(Adapted version from Levelt, 1989; Bock & Levelt, 1994; Howell, 2004; Bernstein Ratner & Bloodstein, 2008. Red lines indicate the internal error sources as stated by the *covert repair hypothesis* [Postma & Kolk, 1993]).

In stuttering research it is often used as a basis for so called *psycholinguistic theories*, which assume that stuttering is caused by a flaw within the dynamic processes of this model. Table 6 provides a summary of researched psycholinguistic theories, which link the occurrence of stuttering to specific breakdowns within Levelt's model.

Table 6: Psycholinguistic theories and their hypothesized locations of breakdown within Levelt's model

Author/ Year	Model name	Presumed location of breakdown within Levelt's model		
		Decoder	Encoder	Specific error source
Harrington 1988		X	X	Lexical-prosodic representation & Acoustic/phonetic processor
Wingate, 1988	<i>Fault-line hypothesis</i>		X	Phonological encoding & phonetic/articulatory plan
Dell & O'Seaghdha 1991	<i>Dell's model of lexical retrieval in language production</i>		X	Phonological encoding
Perkins, Kent, & Curlee, 1991	<i>A theory of neurolinguis tic function in stuttering</i>		X	Formulator/ Encoder in general
Postma & Kolk, 1993; Kolk & Postma, 1997	<i>Covert repair hypothesis (CRH)</i>		X	Phonological encoding
Bernstein Ratner, 1997			X	Syntactical encoding
Bloodstein, 2002; Bernstein Ratner & Tetnowski 2006			X	Syntactical encoding

One *psycholinguistic theory*, the *covert repair hypothesis* (CRH) by Herman Kolk and Albert Postma (1993, 1997), provides an exceptionally detailed explanation for the incident of specific core behaviors of stuttering. The CRH assumes that through a process entitled *pre-articulatory editing* (Kolk & Postma, 1997) an error is detected within the internal monitoring loop. Such editing then leads to a specific internal repair reaction, creating interruptions in spoken language.

Postma & Kolk (1993) conclude that the core behaviors of stuttering (repetitions, prolongations & blocks) are most likely caused by phonological repairs (error source: *phonological encoding*). In order to understand the nature of these errors, one has to first be familiar with the process of phonological encoding. In this process the central part of Levelt's model the *Lexicon* is activated. The goal is to derive a word's phonological representation (*Lexemes*) from a syntactic/semantic depiction (*Lemmas*). The phonological representation of a word in the form of *Lexemes* contains both "segmental" (specific phonemes) and "metrical" (i.e. supra/segmental information: number of syllables, intonation of syllables) information on the target word (Kolk & Postma, 1997, p. 186). Once the information from the Lexicon has been retrieved, specific instructions on the production of a target word (*phonetic/articulatory plan*) can be forwarded to the *articulator*.

The CRH further suggests that the specific core behavior that results from a repair mechanism depends on the location of the error within the word plan (initial syllable vs. mid word vs. final syllable). An error would be any disruption within the phonological encoding process described above. Kolk & Postma (1997) proposed the idea that the system may react to an error with one of two possible mending mechanisms: *repair* (Kolk & Postma, 1994) or *postponement* (Kolk, 1991) strategies.

The most commonly employed strategy appears to be the *repair strategy*, as the authors directly connect it to the occurrence of four leading core behaviors: silent blocks, sound repetitions/prolongations and part-word repetitions. If an error occurs before a word is executed, it is assumed that the system repeats the pre-articulatory positioning, resulting in a silent block. Does the error take place after the initial sound production; the *restart strategy* put into place will result in either a sound repetition or a prolongation. The repair mechanism used is now audible because initial phonation of the word has already started (i.e. error location: /slow/ resulting dysfluency: /s-s-s-

slow/ or /ssssssslow/). Finally, should an error occur further along in the articulation process the associated dysfluency is assumed to be a part-word repetition (i.e. error location: /desk/; resulting dysfluency: /de-de-de-desk/ (Kolk & Postma, 1997).

The second repair mechanism, which may be engaged when an error is detected, is the *postponement strategy* (Kolk, 1991). With it the production process is stalled to allow more time for the completion of phonological encoding. According to the CRH this strategy can be used instead of a repair strategy when an error is detected after initial phonation has occurred. Instead of a sound repetition or a prolongation (repair strategy) the resulting dysfluency is now either an audible block (i.e. error location: /desk/; resulting dysfluency: /de\_sk/) or a non-initial sound prolongation (i.e. /dessssssssk/). The CRH establishes the existence of both mechanisms (repair & postponement strategy) but does not offer an explanation as to why different strategies may be used at different times or within different words. When considering an advanced stutterer, who presents with a wide spectrum of core behaviors (cf. table 1) it is obvious that both strategies must be employed.

Particularly interesting is the existence of a postponement strategy, especially when considering positive reports on fluency-enhancing conditions. For instance, Fluency shaping techniques or exposure to delayed auditory feedback (DAF) at high delays are often successful at reducing overt stuttering because they decrease speech rate. If verbal language (*overt speech*) is produced at a slowed pace, the entire system (cf. Levelt's model) has more time for its processing and production tasks. Much like a postponement strategy, such conditions force the system to slow its tempo, thus providing more time for processes such as phonological encoding. Conditions that slow speech rate may therefore serve as an external repair mechanism by regulating the pace at which language perception and production tasks are carried out. Consequently, core behaviors of stuttering may decrease because the covert repair mechanisms suggested by the CRH (repair & postponement strategies) are ideally no longer needed. The system is now able to synchronize weak skills such as phonological encoding with the internal monitoring for errors, resulting in non-interrupted (fluent) overt speech.

The *perceptual loop hypothesis of self-monitoring* by Levelt (existence of internal and external monitoring loops for language) is based on the assumption that

such monitoring is “a controlled process that requires attention” (Kolk & Postma, 1997, p. 197). Keeping clinical methods like the use of AAF in mind, the CRH offers another explanation for why AAF may cause improvements in one’s fluency. If speech monitoring is indeed a controlled process and a PWS’ attention was split, stuttering should decrease as a result of limited control for language monitoring. Arends, Povel & Kolk (1988) researched this hypothesis and found that the frequency and duration of dysfluencies was reduced significantly in severe stutterers when presented with a dual task (in this case a visual task). The exposure to AAF may present such an additional task, causing the individual to have less capacity to pay attention to language monitoring. Based on the same principle Bloodstein (1987) originated the so-called *distraction hypothesis* (p. 275-278), explaining that the introduction to any additional task will cause at least temporary improvement of dysfluency. However, this hypothesis has been disputed by other published works (Thompson, 1985) and has since not been investigated further.

When looking at both physiological and psycholinguistic breakdown theories it is quite evident, that some compelling arguments for the possible causes of stuttering are delivered. However, it is also clear that each theory in itself may not serve as an exclusive explanation for why stuttering develops and persists in some. Some theories, which are psycholinguistic in nature, recognize other factors when explaining the etiology of stuttering (cf. Bernstein Ratner & Tetnowski, 2006; Perkins, Kent & Curlee, 1991). This further supports the need for theories that recognize other factors and influences, besides neurological anatomy and linguistic abilities. In order to complete this basic summary of the etiology of stuttering, Section 2.2. briefly describes two of these multi-causal theories.

### **2.2. Integrated theories on the nature of stuttering**

The term *integrated theory* refers to those etiological models that take several factors into consideration when explaining the cause of stuttering. Two of these models are introduced within the following Sections 2.2.1. and 2.2.2.

### **2.2.1. The communication-emotional model of stuttering (C-E Model)**

The Communication-Emotional Model (Conture, Walden, Arnold, Graham, Hartfield, & Karrass, 2006) is based on four groups of contributors, assumed to cause stuttering and its associated severity: *distal* and *proximal contributors*, *exacerbation*, and *overt behavior*.

Conture et al. (2006) explain that distal contributors consist of both genetics and the environment. The authors believe that genetics play a vital role in the development of stuttering. An abnormal genetic setup may cause language synchronization difficulties (such as the acquisition and combination of age-appropriate semantical and syntactical knowledge). It is this lack of linguistic maturity in combination with inadequate environmental influences (e.g. high linguistic demands, fast speech rate of familiar speakers, frequent interruptions) that can cause first instances of stuttering. In this context the authors acknowledge the inconclusive state of current literature on the genetic involvement in the development of stuttering as well as the scarce evidence on the home environment as a contributing source. However, they conclude that “there can be little doubt that the environment influences the expression of genetically-driven behaviors” (Conture et al., 2006, p. 25).

The so called proximal contributors are all psycholinguistic in nature and refer to specific locations in a psycholinguistic model (in this case the authors also refer to Levelt, 1989), which may be prone to breakdown. As such, a proximal contributor may be the slowed ability for phonological encoding as described by some psycholinguistic theorists (Postma & Kolk, 1993; Kolk & Postma, 1997; Dell, 1991). On the foundation of distal contributors (genetics & environmental influences) and in response to specific linguistic weaknesses as reflected by proximal contributors, a third factor comes into play: emotions (exacerbation).

According to the C-E Model, exacerbation may occur in the form of emotional reactivity or regulation. The latter being a process initiated by the prefrontal cortex, dictating the system to stay with its original plan, despite involuntary disruptions (instances of dysfluency). Reactivity is the body's natural response to a perceived threat (see fight or flight reaction Chapter 1) in this case an anticipated or experienced moment of stuttering. The system may react with either a fight response, which in

developmental stuttering may be the attempt to revise a perceived mistake by repeating a word. In chronic stuttering the speaker may build up additional tension (e.g. secondary behaviors) in order to counteract dysfluency. In cases of anticipated treats, such as the pronunciation of difficult words, reactivity may result in an avoidance behavior such as a change of words. The later response is further shaped by another factor that is considered an exacerbation; emotions that are triggered by experience. The C-F Model concludes that experience increases the reactivity reflex shown by the system. This is also where *learning theories* (operant conditioning) are implied by the model, as the authors conclude that a reaction that was perceived as helpful (e.g. the built up of tension was perceived as helpful in overcoming the moment of stuttering) will occur more often, thus manifesting itself. All these contributing factors will result in overt behaviors, which are particular to each individual. The overt behaviors of stuttering may add to the exacerbating contributors by increasing the emotional reactivity.

The C-E model is a dynamic model (Mackey & Milton, 1987) since it offers several transforming contributors that may be involved in the development of stuttering. It implies that some of these contributing factors may modify over time (e.g. experience may change), thus accounting for the instability of speech fluency and dysfluency characteristic for stuttering. The model also accounts for various interactions and relationships between the individual contributing factors. It is further an example of a hierarchical model as the individual contributing factors add to the disorder in a systematic way. Distal contributors (genetics & environmental influences) for example form the basis of the hierarchy and are therefore the initial influences necessary for the emergence of developmental stuttering. However, the existence of such underlying factors within the model does not imply that they are the cause of stuttering. It is made very clear that such underlying factors only contribute to the development of stuttering if other influences are present (e.g. proximal contributors & exacerbation).

Many of the integrated/multifactorial models listed in Table 7 suggest that certain contributing factors are present prior to others (e.g. genetic deviations). However, some authors suggest that the optimal model that explains the etiology of stuttering should be completely free of such hierarchical/linear relationships between

factors. They consider such models as too narrow in capturing the dynamic nature of stuttering in the most suitable way. Therefore, models that are based on so called “nonlinear dynamics” have been introduced. In order to provide a complete picture of the diversity of existing integrated models, Section 2.2.2. offers an overview of a nonlinear dynamic model.

### **2.2.2. The dynamic multifactorial model of stuttering (DM-Model)**

The *dynamic multifactorial model* of stuttering by Anne Smith and Ellen Kelly (1996) explains that there are two dynamic parts crucial to the diagnosis of stuttering: observations and explanations.

According to the authors observations entail the method used to describe stuttering. They critically argue that the method of judging stuttering based on the “perceptual evaluation of the speech acoustic signal” has received too much attention in stuttering research. Much rather than analyzing specific core behaviors (for specific methodology see Chapter 1), they suggest that other measures of identifying stuttering are both more purpose-driven and more reliable (e.g. acoustic, kinematic or electromyographic measures, p. 207). Regardless of their personal opinion, the authors discuss the importance of revealing the individual methodology used to determine whether or not stuttering is present. They argue that the existence of stuttering is largely dependent on the methodology used by the examiner. They include a so-called *diagnostic space* into their DM-Model, which represents the fleeting space in which most examiners would agree that stuttering is present.

The second component of the DM-Model is explanation. Smith and Kelly are vague in determining the specific factors that they believe cause stuttering. In a reference to an earlier model introduced by Zimmerman (1984), they appear to recognize seven etiological factors: environment, genetics, organism, emotion, cognition, language, speech motor system. Even though their model is not specific on the exact influences involved, they explain that certain factors may be present in some and non-existent in others. It is also described that the weighing of the present factors is highly individualized within each person. The authors do not differentiate between underlying permanent influences (e.g. genetics or physical differences such as explained by the cerebral dominance theory) and transitory influences (e.g.

emotions or environment). It is much rather assumed, that all possible contributing factors are fleeting in both involvement and degree of influence, thus accounting for “sudden, dramatic shifts” (p. 208) in speech fluency.

This model includes an important dimension when analyzing stuttering; the way it is diagnosed. Many of the issues associated with specific methods used in the diagnosis of stuttering have been discussed in Chapter 1. While the authors certainly make a valid point in tying issues with diagnostic procedures into the broader question of establishing the existence of stuttering, their model still appears too imprecise. The main purpose of etiological models of stuttering is to clarify the nature of the disorder, thus enabling research to test new treatments or clinicians to optimize their available approaches to make their intervention more cause-oriented. While the authors have accomplished their personal goals of “recognizing the complexity of the disorder” (Smith, 1999, p. 33) it remains to be seen how valuable the DM-Model can be in a clinical context. The indistinct etiological accounts provided by this model give reason to believe that integrated or multidimensional models only enhance our knowledge of the nature of stuttering if they provide comprehensible details on the dynamics of the hypothesized influential factors. Table 7 provides a summary of a number of recent multi-factorial models, attempting to explain the origins of stuttering in a holistic manner.

Table 7: Summary of contemporary integrated etiological models of stuttering

Author/Year	Model name	Etiological factors considered
Starkweather, 1987	<i>Capacities &amp; demands model</i>	<ul style="list-style-type: none"><li>• Mix-match between:</li><li>• Capacities (motor, linguistic, cognitive and emotional)</li><li>• Demands (time pressure, pragmatic issues, and situational influences)</li></ul>
Perkins, Kent, & Curlee, 1991	<i>A theory of neurolinguistic function in stuttering</i>	<ul style="list-style-type: none"><li>• Linguistic components</li><li>• Paralinguistic components (genetics, environmental factors etc.)</li></ul>

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		<ul style="list-style-type: none"><li>• Time pressure</li><li>• Feeling of loss of control (emotional components)</li></ul>
Wall & Myers, 1995	<i>The three factor model</i>	<ul style="list-style-type: none"><li>• Psycholinguistic factors</li><li>• Psychosocial factors</li><li>• Physiological factors</li></ul>
Packman, Onslow, Richard, & van Doorn, 1996 Packman & Attanasio, 2004	<i>The variability model (V-Model)</i>	<ul style="list-style-type: none"><li>• Demands of oral language production (linguistic factors)</li><li>• Unstable speech motor system</li></ul>
Smith & Kelly, 1997	<i>A multi-factorial, nonlinear, dynamic framework for stuttering (DM-Model)</i>	<ul style="list-style-type: none"><li>• Diagnostics</li><li>• Explanation:<ul style="list-style-type: none"><li>○ environment</li><li>○ genetics</li><li>○ organism</li><li>○ emotion</li><li>○ cognition</li><li>○ language</li><li>○ speech motor system</li></ul></li></ul>
Guitar, 1998 (p. 85)		<ul style="list-style-type: none"><li>• Cognitive</li><li>• Social/Emotional</li><li>• Linguistic</li><li>• Environmental</li></ul>
De Nil, 1999	<i>Neurophysiological perspective of stuttering</i>	<ul style="list-style-type: none"><li>• Central neurophysiological processing</li><li>• Observable output (motor, cognitive, linguistic, social, and emotional factors)</li><li>• Contextual level (associated with environmental components)</li></ul>
Susca & Healey, 2000		<ul style="list-style-type: none"><li>• Cognitive</li><li>• Neurophysiological</li><li>• Social</li><li>• Emotional</li></ul>

		<ul style="list-style-type: none"><li>• Motoric</li><li>• Linguistic</li><li>• Genetic</li></ul>
Conture, Walden, Arnold, Graham, Hartfield & Karrass, 2006	<i>A communication- emotional model of stuttering (C-E Model)</i>	<ul style="list-style-type: none"><li>• Distal contributors (genetics &amp; environmental factors)</li><li>• Proximal contributors (psycholinguistic influences)</li><li>• Exacerbating contributors (emotions)</li></ul>

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### **Chapter 3: Established speech pathological treatments**

The following chapter gives a brief introduction to two evidence-based treatment approaches and explains some of the more common techniques used during both interventions. The role of various feedback forms (e.g. altered auditory feedback, visual feedback) in these traditional speech pathological interventions is explained as well. Further, a synopsis of studies investigating the effectiveness of both treatments and remarks on difficulties associated with the establishment of an evidence base for such treatments is given. The chapter concludes with reflections on the reality of coping with stuttering embedded in a closing case example.

Speech pathological treatments for stuttering are traditionally based on the structured acquisition and implementation of speech techniques. Since the 1940s the use of speech techniques has been documented in the literature on stuttering treatment. The early accounts described *chewing* or simulated chewing as a technique to alleviate stuttering (Froeschels, 1943). Speaking with nominal lip movement (Froeschels, 1950) or *shadowing* (Cherry & Sayers, 1956) speech movements of another speaker were other techniques described in the early stages of speech-language pathology as a scientific discipline. Even today the use of speech techniques is key in two of the most common evidence-based approaches: stuttering modification and fluency shaping.

#### **3.1. Fluency shaping**

Fluency shaping programs aim at increasing the fluent parts of speech, which exist in every person's speech including those who stutter. Focusing on skills needed to produce fluent speech, rather than concentrating on the skills necessary to reduce moments of stuttering, is how the desired fluency enhancement is achieved. Many techniques employed by fluency shaping programs focus on oral motor movements. Specific oral motor skills are introduced and established in the clinic before the so-called *transfer* is attempted (use of speech techniques in out-of-clinic contexts/environments). The process in which these oral motor skills or speech techniques are acquired is often very structured. Many clinicians also choose to use

technological feedback forms (e.g. altered auditory feedback [AAF] or visual feedback) in order to establish or maintain fluency techniques. In fact, it is sometimes claimed that the development of structured fluency shaping treatments was originally based on Goldiamond's accounts of the clinical use of delayed auditory feedback (DAF) (Goldiamond, 1965). *The Precision Fluency Shaping Program* (PFSP) by Webster (1974), also known as the *Hollins' Program*, is a fluency shaping approach, which heavily relies on the use of delayed auditory feedback (DAF). The speech technique of *articulatory control*, one of the skills acquired throughout the PFSP, consists of a thorough execution of speech motor movements through slowed articulatory pace (slowed speech rate). This slowed speech rate offers more capacity to focus on and carry out the necessary controlled articulatory movements to produce speech fluently. In order for clients to be able to produce their speech at an evenly slow speech rate, DAF is used. If DAF is applied with high delay times (100-250 ms) it is known to slow a speaker's speech rate (Goldiamond, 1965). This effect is used in fluency shaping to teach clients how to produce words in a deliberately slow and thorough manner, resulting in an artificial sounding, stretched speech output. In order to create more natural sounding speech, delay times are gradually decreased (down to 50ms). The goal is to learn how to execute speech movements in a controlled, deliberate manner, thus maintaining almost natural sounding speech. Table 8 provides a summary of structured fluency shaping programs, which employ a form of AAF in their systematic technique acquisition process.

Another common technique taught by fluency shaping clinicians is *controlled breathing* or *gentle voice onset*. An evidence-based (Euler, Wolf von Gudenberg, Jung, & Neumann, 2009; Neumann, Preibisch, Euler, Wolf von Gudenberg, Lanfermann, & Gall, 2005; Neumann, Euler, Wolf von Gudenberg, Giraud, Lanfermann, & Gall, 2003) fluency shaping program based in Germany (*Die Kassler Stottertherapie*) utilizes visual feedback to establish fluency inducing breathing patterns or *easy onsets*. Visual feedback falls into the category of biofeedback as it enables the observer to electronically monitor body functions. Visual feedback in fluency shaping approaches is often used to measure either vocal volume or vocal frequency. A key aspect of using the technique of easy onsets is the emphasis on

soft or breathy vocal onsets and light articulatory contacts at the beginning of an utterance (Ham, 1986, p. 338). Such purposely soft movements result in low speech volume and frequency. Visual feedback software therefore often accompanies the technique acquisition process, by measuring vocal sound pressure levels (in dB) and vocal frequency (in Hz) through a microphone and graphically displaying these measures on a computer screen. The user receives visual feedback (e.g. in the form of green and red lights) in response to each technique production, signaling whether or not critical values for volume, frequency or muscle tension have been exceeded. These programs are available in the form of portable feedback devices (cf. MyoTrac, Thought Technology, 2011) or as computer software (cf. Goebel, 1988).

Table 8: Summary of fluency shaping approaches utilizing forms of altered auditory feedback (AAF)

Author/Clinician	Method	Type of AAF supplement
Ryan & van Kirk, 1974	Monterey Programmed Stuttering Therapy	DAF
Schwartz & Webster, 1975	Precision Fluency Shaping Program	DAF
Rustin, Ryan & Ryan, 1987	Monterey Programmed Stuttering Therapy	DAF
De Nil, Kroll, Lafaille, & Houle, 2003	Adaptation of the Precision Fluency Shaping Program	DAF
Tasko, McClean, & Runyan, 2007	Group-based Precision Fluency Shaping Program	DAF

### **3.2. Stuttering modification**

The stuttering modification approach was developed in the 1930s by the so-called *Iowa-School*; a group of psychologists and speech pathologists at the University of Iowa. This group consisted of later prominent names, such as Bryan Byngelson, Richard Sheehan, Wendell Johnson and Charles van Riper. The latter published the first comprehensive account of the stuttering modification approach in his book *The Treatment of Stuttering* (1973). In this original description van Riper determined the treatment process to consist five stages: motivation, identification, desensitization, modification and stabilization. However, the first stage is usually considered mandatory in order to enter treatment, which is why many other publications on stuttering modification have reduced the treatment process to four stages (cf. Prins & Nicols, 1974; Tsiamtsiouris & Krieger, 2010). While treatment usually starts with the identification process, moving from one stage to another as well as re-visiting individual phases should be an individualized rather than static process. In contrast to the aforementioned fluency shaping approach, stuttering modification does not focus on the fluent moments of speech but on the moment of stuttering in itself. It aims at understanding one's own dysfluencies, forming the basis of being able to reduce them systematically, by using specific techniques.

*Phase 1 - Identification.* This process is commonly the initial stage of treatment. In it, a client becomes familiar with their core and secondary behaviors. In the initial stages of this phase, basic anatomic knowledge of the speech mechanism may be conveyed to the client. In consecutive sessions this understanding is used to locate areas of tension within a moment of stuttering. In order to create a comprehensive understanding of moments of stuttering, some clinicians also choose to have clients identify the specific core and secondary behaviors that typically occur within their speech. This is achieved through observational exercises both in and outside the clinic.

*Phase 2 - Desensitization.* Through systematic observations the client often becomes painfully aware of the full scope of behaviors that shape one's stuttering. This often requires parting from protective habits (such as secondary behaviors: escape and avoidance behaviors) the system has originally developed to shield one

from the emotional consequences of the core behaviors of stuttering. In structured conversations with the clinician, which may include strategies typically found in cognitive behavior therapy, the client learns to face and reduce negative emotions towards communication/speech. In another step speaking situations, which are challenging or generally avoided due to anxiety and fear of failure, are attempted hierarchically. Through means of operant conditioning techniques such situations are thoroughly prepared in conversations, often attempted hypothetically (i.e. role play) and eventually endeavored in real life. Before each situation is attempted, the client is asked to outline the anticipated outcome and later compare it to the actually experienced event, thus neutralizing fear.

*Phase 3 - Modification.* In this stage the client learns how to transform moments of dysfluency by implementing techniques. As with all stuttering modification techniques, the client learns to establish a new reaction to the perceived threat of a core behavior. The technique *cancellation* for example teaches the client to halt articulation as soon as a moment of tension is perceived. After this pause, which is used to identify the experienced core behavior, the client completes the stuttered word and repeats it in a deliberately articulated manner. This forms an alternative to the otherwise experienced fight or flight reactions of building up additional tension or avoiding a word upon perception of a core behavior. Another technique, which is usually attempted once a client is somewhat familiar with cancellations are *pull-outs*. This technique is essentially an advanced form of a cancellation as the client no longer uses a pause to identify moments of stuttering but learns to categorize dysfluencies and involved areas of tension rather quickly, thus being able to switch muscular tension of the involved articulators to ease out of the moment of stuttering. This shift in tension is often achieved using similar means as those described in fluency shaping approaches (e.g. *easy onsets*, *light articulatory contacts*). *Pull-outs* result in a more natural sounding speech pattern as the client no longer has to repeat a word but complete a dysfluent word in a more relaxed manner.

*Phase 4 - Stabilization.* This last phase is attempted once the client has gained confidence and has had some positive experiences as a speaker. In this stage all other phases come together, by attempting to use the acquired skills in real

life situations of growing difficulty. Stabilization is an ongoing process, which sometimes requires revisiting individual stages in depth. The client learns to maintain an attainable level of fluency with increasing independence.

In the initial illustration of the stuttering modification approach the use of delayed auditory feedback (DAF) was suggested during two of the above mentioned treatment phases; the desensitization and modification phase (van Riper, 1970, 1973). It was explained that the exposure to DAF could facilitate the process of reducing negative emotions when the client gets a chance to observe the reaction of non-stutterers to DAF. As described years prior, fluent speakers tend to experience stutter-like dysfluencies when their auditory feedback is modified through means of DAF (Lee, 1951). Van Riper suggested having the clinician use DAF during a session, giving the client a chance to observe another person's reaction to moments of dysfluency. This experience should enable the PWS to accept that the emotional distress they feel because of their stuttering is a normal human reaction to the perceived loss of control, as similar behaviors can be observed in fluent speakers. It was further suggested that it may be useful to have the client control the DAF signal, as the clinician speaks, giving the PWS a channel "to release some of his past hurt and frustration" (van Riper, 1970, p. 41).

Another use of DAF was seen in the documented fluency enhancing effect experienced by some PWS. The client was supposed to understand "that stuttering behavior is modifiable" (van Riper, 1970, p. 41). Experiencing the possibility of changing one's speech pattern enhances the client's motivation to engage in the therapy process, thus contributing to van Riper's prerequisite therapy stage; motivation. In terms of establishing the acquisition of modification techniques, the effortless, prolonged speech resulting from long DAF delays was recorded. The recordings were then played back to the client, and analyzed in comparison to their usual dysfluent speech pattern. Proving to the client that they can copy such semi-fluent speech patterns without the use of an assistive tool such as DAF further conveys to the client that it is possible to modify their own speech. Another use for DAF in the modification process was the improvement of a client's proprioception or ability to move articulators deliberately. Clients were instructed to ignore the altered speech signal perceived through headphones and instead focus on clear, intentional

motor movements as each word is articulated. In this context PWS were often taught to ignore the DAF signal by initially being exposed to occasional and unexpected masking noise (van Riper, 1973, p. 133). The thorough execution of motor movements was considered a foundational skill to the acquisition of stuttering modification techniques and therefore a vital skill to be attained throughout the treatment process.

### **3.3. Evidence-base for the utilization of speech techniques**

As discussed in Sections 3.1. and 3.2. fluency shaping and stuttering modification approaches both utilize different speech techniques to improve speech fluency in PWS. Both approaches have also been identified as evidence-based treatments for stuttering (Craig, 2007) In order to evaluate the true success of both treatments more closely, it becomes important to analyze the levels of evidence presented by the research literature. If the effects of any given treatment can be confirmed by scientific data which meet certain quality standards, such a treatment is considered evidence-based. Evidence-based practice (EBP) is the body of scientifically proven treatments for a specific disorder or profession, which should be applied primarily in order to put best practice principles into practice.

The term evidence-based practice was derived from the field of medicine “where such practices are standard and are known as evidence-based medicine (EBM)” (Bloodstein & Bernstein Ratner, 2008, p. 337). The various health-related sciences have introduced numerous systems to classify levels of evidence (Agency for Healthcare Research and Quality [AHRQ], 2002) for their respective fields. The American Speech Language and Hearing Association (ASHA) has published an adapted version of a four-step pyramid (see Table 9) upon which levels of evidence can be determined for speech pathological interventions (ASHA, 2011).

Table 9: American Speech, Language and Hearing Association (ASHA) levels of evidence (2011) adapted from the Scottish Intercollegiate Guidelines Network

Level	Description
Ia	Well-designed meta-analysis of >1 randomized controlled trial
Ib	Well-designed randomized controlled study
IIa	Well-designed controlled study without randomization
IIb	Well-designed quasi-experimental study
III	Well-designed non-experimental studies, i.e., correlational and case studies
IV	Expert committee report, consensus conference, clinical experience of respected authorities

In this system, level I evidence represents the ‘gold-standard’ of scientific investigating. It is considered *best practice* and therefore the most desirable form of evidence for any treatment. While the design of choice to establish such gold-standard results in many fields is the double-blind randomized controlled trial (RCT) (cf. Cook, Guyatt, Laupacis, Sackett, & Goldberg, 1995; Oxford Centre for Evidence-Based Medicine, 2011; Moscicki, 1994; Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000), it is often challenging to conduct such studies in the field of speech pathology and stuttering research in particular. In a double-blind study, both the clinician and the subjects are unaware of the type of treatment they receive. While it may be possible to conceal the active treatment phase to the therapeutically inexperienced subject, it is almost impossible to leave the practicing clinician in the dark as to the treatment they are supposed to implement. Since the clinician is commonly the active force in conveying the use of techniques to a subject, it proves rather difficult to have this person be blind to the speech technique they are implementing. Randomization is a more obtainable goal in designing a study aimed at collecting evidence on speech pathological interventions. The process of randomizing a treatment group usually entails splitting the sample of subjects according to no apparent pattern. This can result in several between-group designs such as the comparison of two treatment groups, a treatment and a placebo group or a treatment and control group. In a controlled study, a comparison group, which

receives no intervention or a placebo is always necessary. The outcome of a treatment is meaningful if the improvements outweigh natural improvements that would be experienced by an untreated group of individuals. However, PWS are usually interested in partaking in clinical trials because they would like to be exposed to a form of treatment they may not have experienced in the past, in hopes of reducing or controlling their stuttering. In this case, it would be unethical to deprive clients of such an experience by placing them in a non-treatment control group. Therefore, a cross-over/repeated measures design (Jones & Kenward, 2003) may be more appropriate when evaluating speech treatments, as compared to the standard parallel-group designs.

In an effort to show how difficult it is to reach gold standard evidence for stuttering treatments utilizing speech techniques, Table 10 shows a summary of level I and II evidence for fluency shaping and stuttering modification treatments. All listed studies additionally meet the top two criteria for evaluating stuttering research as determined by the *Handbook of Stuttering* (Bloodstein & Bernstein Ratner, 2008, p. 339). This publication suggests considering the sample size and type of measurement when determining the quality of a treatment's evidence. Accordingly, a treatment that is considered successful should show improvements in not only single-case studies but also in group research. Improvements in speech fluency should further be established by transparent gains in both quantitative (e.g. objective measures of speech such as percent stuttered syllables) and qualitative speech measures (e.g. listener ratings of severity or speech naturalness).

When looking at Table 10, the most distinct observation one probably makes is that there appears to be a lack of higher-level evidence for both fluency shaping and even more clearly for stuttering modification treatments. Indeed, a recent conference handout (Ryan, 2006) identified only two intensive treatment approaches as evidence based; *Gradual Increase in Length and Complexity of Utterance or (GILCU)* (Ryan, 2001b) and *Prolonged Speech* (Ingham, Kilgo, Ingham, Moglia, Belknap, Sanchez, 2001). Both are fluency shaping approaches. The third treatment that was determined evidence-based is a systematic, behavioral approach known as *the Lidcombe Program for Early Stuttering* (Onslow, Costa, & Rue, 1990).

One apparent reason why these three treatments have accumulated a high

level of evidence is the fact that they are either intensive treatments or highly structured interventions. All studies, which have established level I or II evidence are investigations evaluating such intensive programs. Reasons why intensive treatments often serve as an evidence base for a given therapeutic approach is that it is much easier to gather a large sample when evaluating intensive treatments, as these interventions are commonly carried out in a group setting. The treatment process is often standardized so each client experiences the stages of treatment within a pre-set time frame. This makes it easier to collect data on multiple participants during predictable or pre-determined time intervals. Stuttering modification therapy, however, is traditionally an approach that is “highly individualized” (Van Riper, 1973, p. 206). It is suggested that one-on-one sessions are supposed to be carried out individually at a recommended frequency of at least three times a week for the initial three to four months of therapy (Van Riper, 1973, p. 205). While group sessions are listed as a necessary addition, it appears that stuttering modification is commonly employed as an outpatient treatment rather than an intensive residential treatment. It is this format that enables the clinician to maintain the highest level of individuality in tailoring a specified treatment plan to each client. This appears to be true when consulting the literature, as there are very few intensive programs that utilize only stuttering modification principles (Blomgren, Roy, Callister, & Merrill, 2005; Natke, Alpermann, Heil, Kuckenberg, & Zückner, 2010). It has been noted in the research literature that the evidence-base for stuttering modification is extremely limited (Bernstein Ratner, 2005). Yet it remains a popular treatment approach in clinical practice (Kully & Langevin, 2005). This in part may be the case because clients who partook in a stuttering modification approach have been documented to be significantly less likely to have experienced a relapse than those PWS who underwent a fluency shaping treatment (Yarrus, Quesal, Reeves, Molt, Kluety, Caruso, McClure, & Lewis, 2002).

Table 10: Summary of levels of evidence (based on ASHA, 2011) for fluency shaping, stuttering modification and combined approaches

Fluency shaping			
Study	N	Method	Measurements
Ib: Well-designed randomized controlled study			
Öst, Götestam, & Melin, 1976	15	<ul style="list-style-type: none"> <li>• Rate reduction therapy (using a metronome) vs. shadowing vs. control condition</li> </ul>	<ul style="list-style-type: none"> <li>• Percent stuttered syllables (%SS)</li> <li>• Speech rate (number of words per minute)</li> <li>• Reactions to speech situations via self-rating                             <ul style="list-style-type: none"> <li>○ Administered pre- &amp; post treatment, as well as 14 month follow-up</li> </ul> </li> </ul>
Waterloo & Götestam, 1988	32	<ul style="list-style-type: none"> <li>• Controlled breathing vs. control condition</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of syllables stuttered (%SS)</li> <li>• Speech rate (spoken words per minute)</li> <li>• Self-ratings of fluency enhancement                             <ul style="list-style-type: none"> <li>○ Administered pre &amp; post treatment as well as 2, 3 &amp; 8 month follow-up</li> </ul> </li> </ul>
Carey, O'Brian, Onslow, Block, Jones, & Packman, 2010	40	<ul style="list-style-type: none"> <li>• Camperdown program for adults who stutter                             <ul style="list-style-type: none"> <li>○ 20 subjects: tele-health adaptation</li> <li>○ 20 subjects: face-to-face intervention</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Percent stuttered syllables (%SS)</li> <li>• Speech naturalness</li> <li>• Treatment satisfaction</li> <li>• Self-reported stuttering severity</li> </ul>

IIa: Well-designed controlled study without randomization			
Evesham & Fransella, 1985	48	<ul style="list-style-type: none"> <li>• Prolonged speech vs. prolonged speech &amp; construct therapy</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of syllables stuttered (%SS)</li> <li>• Speech rate</li> <li>• Communication attitudes</li> </ul>
Craig, Hancock, Chang, McCreedy, Shepley, McCaul, Costello, Harding, Kehren, Masel, & Reilly, 1996	97	<ul style="list-style-type: none"> <li>• Comparative study of three treatments &amp; one control:</li> <li>• Intensive program: airflow control, slowed speech rate, prolonged syllables</li> <li>• Home program: airflow control, slowed speech rate, prolonged syllables</li> <li>• Electromyography feedback (EMG)</li> <li>• No-treatment control group</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of syllables stuttered (%SS)</li> <li>• Speech rate</li> <li>• Improvement in %SS over time</li> <li>• Standardized measures on anxiety</li> <li>• Listener judgments of speech naturalness</li> </ul>
IIb: Well-designed quasi-experimental study			
Helps & Dalton, 1979	65	Prolonged speech vs. syllable-timed speech	<ul style="list-style-type: none"> <li>• Percentage of stuttered words (%WS)</li> <li>• Speech rate</li> <li>• Subjective ratings on communication attitude &amp; reactions to speech situations</li> </ul>
Howie, Tanner, & Andrews, 1981	36	<ul style="list-style-type: none"> <li>• Systematic reduction of speech rate</li> </ul>	<ul style="list-style-type: none"> <li>• Percent stuttered syllables (%SS)</li> <li>• Speech rate (syllables per minute)</li> <li>• Client ratings on communication attitudes                             <ul style="list-style-type: none"> <li>◦ All administered pre &amp; post treatment and 3 month follow-up</li> </ul> </li> </ul>

Barnard, 1987	20	<ul style="list-style-type: none"> <li>• Gentle/easy onsets</li> <li>• Prolonged speech</li> <li>• Soft articulatory contacts</li> </ul>	<ul style="list-style-type: none"> <li>• Dysfluencies per one hundred words in conversation and reading</li> <li>• Subjective communication attitudes</li> </ul>
Boberg & Kully, 1994	42	<ul style="list-style-type: none"> <li>• Prolongation</li> <li>• Easy onset</li> <li>• Soft contacts</li> <li>• Appropriate phrasing,</li> <li>• Continuous airflow/blending</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of syllables stuttered (%SS) during pre &amp; post treatment conversations</li> <li>• Subjective perceptions of speech performance</li> </ul>
Onslow, Costa, Harrison, & Packman, 1996	18	<ul style="list-style-type: none"> <li>• Systematic reduction of speech rate</li> </ul>	<ul style="list-style-type: none"> <li>• Percent stuttered syllables (%SS)</li> <li>• Speech rate (syllables per minute)</li> <li>• Subjective ratings on speech naturalness                             <ul style="list-style-type: none"> <li>○ All measures where collected using various speech samples both in and out of the clinic</li> </ul> </li> </ul>
Druce, Debney, & Byrt, 1997	15	<ul style="list-style-type: none"> <li>• Prolonged speech</li> <li>• Slowed speech rate</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of syllables stuttered (%SS)</li> <li>• Speech rate</li> <li>• Speech naturalness</li> <li>• Subjective stuttering severity rating</li> </ul>
O'Brian, Onslow, Cream, & Packman, 2003	16	<ul style="list-style-type: none"> <li>• Prolonged speech</li> </ul>	<ul style="list-style-type: none"> <li>• Percent stuttered syllables (%SS)</li> <li>• Speech rate (syllables per minute)</li> <li>• Speech naturalness: both subject &amp; unbiased listener rating</li> </ul>

Stuttering modification			
Study	N	Method	Measurements
IIb: Well-designed quasi-experimental study			
Blomgren, Roy, Callister, & Merrill, 2005	19	<ul style="list-style-type: none"> <li>Desensitization Therapy (Sheehan, 1970)</li> <li>Treatment based on the traditional 4 stages of stuttering modification</li> <li>Implemented modification techniques: pull-outs &amp; cancellations</li> </ul>	<ul style="list-style-type: none"> <li>Frequency (%SS)</li> <li>Stuttering Severity Rating (SSI-3, Riley 1994)</li> <li>Client self-evaluation of stuttering</li> <li>Measures of affective functioning</li> <li>Anxiety inventory                             <ul style="list-style-type: none"> <li>Taken pre &amp; post test and 6 months follow-up</li> </ul> </li> </ul>
Tsiamtsiouris & Krieger, 2010	8	<ul style="list-style-type: none"> <li>Combination of:</li> <li>Stuttering modification techniques according to Van Riper (1973)</li> <li>Avoidance Reduction Therapy (Sheehan, 1970)</li> </ul>	<ul style="list-style-type: none"> <li>Stuttering severity (SSI-3)</li> <li>Speech rate</li> <li>Frequency (%SS)</li> <li>Communication attitudes</li> <li>Overall assessment of own stuttering (OASES)                             <ul style="list-style-type: none"> <li>Administered: pre &amp; post treatment as well as one follow-up</li> </ul> </li> </ul>
Natke, Alpermann, Heil, Kuckenberg, & Zückner, 2010	18	<ul style="list-style-type: none"> <li>Treatment based on the traditional 4 stages of stuttering modification</li> <li>Implemented modification techniques: pull-outs &amp; cancellations</li> </ul>	<ul style="list-style-type: none"> <li>Frequency (stuttered time intervals)</li> <li>Client ratings on communication, attitudes, avoidance &amp; negative feelings                             <ul style="list-style-type: none"> <li>Administration pre &amp; post treatment, 1 &amp; 2 years follow-up</li> </ul> </li> </ul>

### Combined Approaches: fluency shaping & stuttering modification

Study	N	Method	Measurements
IIb: Well-designed quasi-experimental study			
Langevin & Boberg. 1993	10	<ul style="list-style-type: none"> <li>• Fluency shaping techniques</li> <li>• Stuttering modification techniques</li> <li>• Cognitive Behavioral Treatment Component</li> </ul>	<ul style="list-style-type: none"> <li>• Frequency (%SS)</li> <li>• Speech Rate (SPM)</li> <li>• Subject perception of own speech                             <ul style="list-style-type: none"> <li>◦ Administered: pre &amp; post treatment and 12-14 month follow-up</li> </ul> </li> </ul>
Irani, Gabel, Daniels, & Hughes, 2010	7	<ul style="list-style-type: none"> <li>• Eclectic approach utilizing both stuttering modification and fluency shaping techniques</li> </ul>	<ul style="list-style-type: none"> <li>• Stuttering severity (SSI-3)</li> <li>• Speech rate</li> <li>• Frequency (%SS)</li> <li>• Communication attitudes</li> <li>• Overall assessment of own stuttering (OASES)                             <ul style="list-style-type: none"> <li>◦ Administered: pre &amp; post treatment as well as one follow-up</li> </ul> </li> </ul>
Langevin. M., Kully, D., Teshima, Hagler, & Prasad, 2010	18	<ul style="list-style-type: none"> <li>• Fluency shaping techniques</li> <li>• Stuttering modification techniques</li> <li>• Cognitive Behavioral Treatment Component</li> </ul>	<ul style="list-style-type: none"> <li>• Frequency (%SS)</li> <li>• Speech Rate (SPM)</li> <li>• Client perceptions on:                             <ul style="list-style-type: none"> <li>• Communication Attitude</li> <li>• Perceptions of stuttering</li> <li>• Self-efficacy</li> </ul> </li> <li>• Speech performance                             <ul style="list-style-type: none"> <li>◦ Administered: pre &amp; post treatment, 1-5 year follow-up</li> </ul> </li> </ul>

### **3.4. The clinical reality of stuttering management in daily life**

As mentioned in Chapter 1 stuttering is a speech disorder that is not considered curable (cf. Cooper, 1993). However, it is also identified as a highly treatable disorder (cf. Bryngelson, 1938; National Institutes of Health, 2010; Startweather, Gottwald, & Halfound, 1990; St. Louis, 1997). The two traditional, evidence-based schools of speech pathological interventions – fluency shaping and stuttering modification – aim at improving the speech fluency of those who stutter (for a concise presentation refer to Sections 3.1. and 3.2 of this paper). There are also numerous other psychological and speech pathological treatments as well as technical speech aids or self-help systems available, which all aim at increasing the quality of life of PWS. In light of the complex symptoms of stuttering, its associated effects and the many treatment options available, the question how PWS incorporate these offers into their lives, and ultimately cope with stuttering, becomes interesting.

A small survey study by Crichton-Smith (2009) asked a group of adult stutterers who had received treatment as adults ( $N = 9$ ) and one that had not chosen to seek treatment in their adult life ( $N = 5$ ) about their communication management in daily life. Results revealed that only 8% of both groups speak without prior planning, meaning that they chose not to actively influence their speech fluency. A large percentage of both groups relied on intuitive changes in order to maintain fluency or end moments of stuttering (adult treatment group: 42%; adult non-treatment group: 69%). Intuitive changes include such measures as changes to pitch or vocal loudness and word or situational avoidance. For those who had experienced speech pathological treatment in their adult life, 28% relied on techniques acquired during treatment to impact speech fluency. In the non-treatment group only 4% reported to actively use speech techniques, acquired during childhood. Similarly, Vanryckeghem, Brutten, Uddin, & van Borsel (2004) administered a behavioral checklist to 42 adults who stutter and 76 non-stuttering adults. Results revealed that even though all stuttering subjects received speech pathological treatment at the time of the study, they showed individual speech strategies significantly more often than the non-stuttering controls. The strategies utilized most often by

those who stutter were reported to include word substitutions, hesitations and a lack of eye contact. Such results come to show that many PWS appear to continuously implement self-derived coping mechanisms in addition to the speech techniques acquired during therapy in an effort to manage their stuttering. Indeed the literature shows that clients who partook in an intensive stuttering modification treatment used the acquired speech techniques rarely; 2 years post treatment (Natke, Heil, Kuckenberg, Zückner, 2010). However, fluency was maintained to a statistically significant degree as compared to the pre-treatment measure. Such results come to show that evidence-based speech pathological interventions alone may not be enough to counteract a lifetime of stuttering and live comfortably with a fluency disorder in the long run it appears that for some, other supportive means are necessary to preserve a personally acceptable level of fluency and maintain a healthy attitude by learning to embrace the self-concept of being a stutterer.

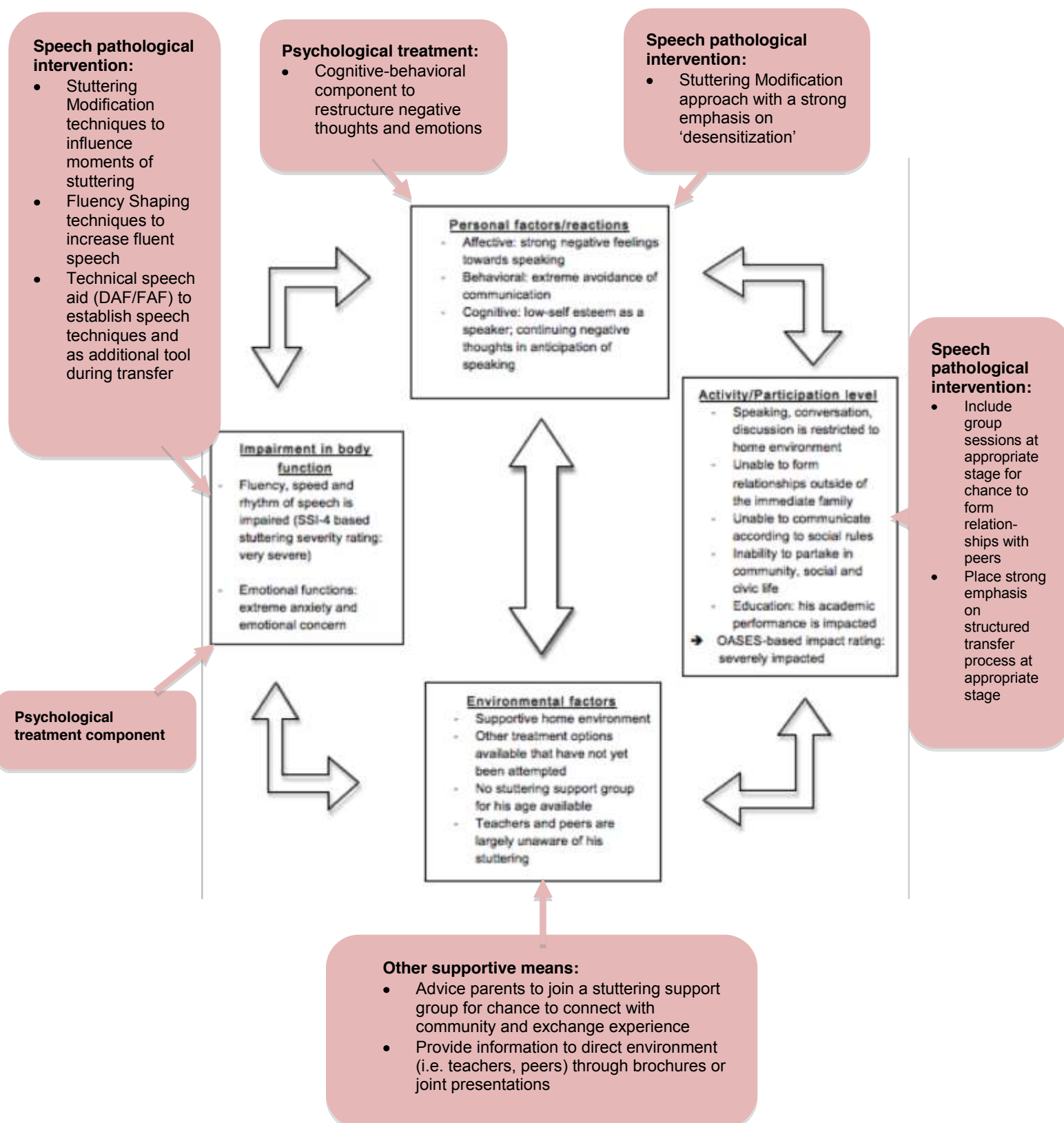
In order to achieve such lasting contentment, many PWS chose to cope with their stuttering by actively participating in a stuttering support group. Survey results show, that some PWS consider a membership in a support group particularly beneficial for the following reasons: sharing experiences in a non-threatening environment and getting the chance to speak in a caring surrounding (Hunt, 1987; Krauss-Lehrman & Reeves, 1989; Yaruss et al., 2002). Additionally, it has been reported that support group members feel they have experienced improvements in their self-esteem, overall comfort and professional competence because of regular meeting attendance (Ramig, 1993). Even though empirical evidence on the structure, goals and effects of support groups is sparse (Ramig, 1993; Yaruss et al., 2002), the existing data as well as personal accounts of PWS (cf. Hood, 1998; Fraser, 2007) all consider support group involvement to be a major contributor to long-term success in coping with stuttering. Many clinicians recognize the benefit of an active support group involvement and encourage their clients to partake as an essential part of an integrative treatment approach (Cooper, 1987; Fraser, 2007; Yaruss et al., 2002).

A 2003 study of PWS who reportedly recovered from persistent developmental stuttering throughout their adult lives were asked how they were able to overcome their stuttering (Anderson & Felsenfeld, 2003). Results

revealed that participation in a speech pathological intervention focused on the direct speech changes in the form of techniques was only one of the cited attributes responsible for a late recovery. The dominant features that were named, by those participants who consider themselves 'recovered', were of an emotional nature, including such personal attributes as "changes in confidence" and "increased motivation, expressed as a desire to make positive changes in speech" (Anderson & Felsenfeld, 2003, p. 249). Additionally, it was interesting to see how these 'recovered' stutterers defined recovery; as most acknowledged the fact that they are life-long stutterers with occasional dysfluency, but no longer considered this a burden or limitation in their daily lives. If recovery is defined as such – the ability to successfully live with a disorder – it equals coping. Clinicians are now faced with the question how to best identify and convey the individual coping skills needed to achieve this state of recovery. Considering the recent results by Anderson & Felsenfeld (2003) it appears as if an integrated (Guitar, 1998; 2006), multidimensional and possibly multidisciplinary treatment plan that directly addresses the many complex symptoms and effects of stuttering, may be the most likely approach in finding a way towards recovery.

In an effort to illustrate such an individualized treatment plan (see Figure 3), this chapter concludes with an exemplified intervention plan for the case example of client X.Y. introduced in Chapter 1 (Section, 1.4.3.).

Figure 3: Example of an integrated, multidisciplinary treatment plan for sample client X.Y., who suffers from persistent developmental stuttering



## **Chapter 4: Technical treatment components**

The following chapter gives an overview of the different kinds of altered auditory feedback (AAF) and provides a summary of documented research findings. Since the use of AAF in its various forms was first reported, clinicians have come up with numerous hypotheses on its effectiveness. Starting with historical perspectives and progressing to more recent evidence, the subsequent section summarizes the prominent theories as to why AAF may be able to reduce stuttering. In addition, the reader is introduced to research involving portable AAF units. The chapter concludes with a discussion of the shortcomings of many AAF research studies and introduces the purpose of the immediate effect and long-term study presented hereafter.

### **4.1. The development of altered auditory feedback (AAF)**

Altered auditory feedback is considered to be “a collective term for conditions involving the electronic alteration of the speech signal” (Lincoln, Packman & Onslow, 2006, p. 72). While exposed to the various forms of AAF, speakers perceive their own speech differently from the way they typically hear themselves. In the prominent literature on stuttering research, numerous forms of technical modifications in hearing one’s own voice are portrayed. Among the most thoroughly documented forms of AAF as a clinical tool in the treatment of stuttering are masking noise, delayed auditory feedback (DAF) and frequency altered feedback (FAF).

Masking was the first form of AAF to be documented in scientific publications. Accounts of successfully using masking noise in reducing stuttering appeared in the research literature as early as the 1930s (Bohr, 1963; Cherry & Sayers, 1956; Cherry, Sayers, & Marland, 1956; Donovan, 1971; Ham & Steer, 1967; Kern, 1931; Shane, 1955; Maraist, & Hutton, 1957; Stromsta, 1958). When masking is implemented, a client is exposed to white noise played through headphones while speaking. The purpose of this noise is the complete blockage of auditory information, thus forcing a speaker to rely on precise articulation in order to ensure the correctness of speech. Van Riper used masking noise to practice speech monitoring “primarily by

proprioceptive, tactile, and kinesthetic feedback” (van Riper, 1973, p. 126), a skill that is also necessary to employ stuttering modification techniques in the later phases of his treatment. Other researchers have concluded that masking simply distracts the PWS from their speech and the fear associated with being heard (Freund, 1932; Shane 1955). Initially, the user was in charge of triggering the masking noise by pushing a button. However, in 1976 the first masking device that automatically activated the noise by monitoring a user’s speech initiation through a laryngeal microphone was introduced (Dewan, Dewan, & Barnes, 1976). Even with these technological improvements, masking has not been able to manifest itself as a tool in stuttering treatment today. Over the years research on masking has faded because the health concerns caused by continuous exposure to noise outweighed the anticipated benefits. Some findings even described that clients were unwilling to use masking because “the continuous loud noise gave them headaches and reduced their hearing” (Perkins & Curlee, 1969).

A less invasive and currently still utilized form of AAF is delayed auditory feedback (DAF). While exposed to DAF, speakers will hear themselves slightly delayed through headphones or an earpiece. As mentioned in Chapter 3, several therapy programs include the use of DAF in the course of their intervention. The individual delay time in which the speech signal is delivered is measured in milliseconds (ms) and can vary between 30ms and 500ms. While initial studies on DAF experimented with long delays of 250ms and up, more recent studies have focused on shorter delays of up to 75ms. It was originally concluded that a long delay slows a speaker’s speech rate thus facilitating fluency (Goldiamond, 1965). More contemporary studies have found that increased fluency is maintained even when exposed to shorter delay times, which do not slow a speaker’s rate considerably (Sparks, Grant, Millay, Walker-Baston, & Hynan, 2002). Natke (2000) had previously concurred with this conclusion by establishing that even when exposed to shorter delays (around 50ms), a speaker tends to prolong stressed syllables thus contributing to an overall slightly slowed speech rate. The setting of 50ms delay has been determined to be the “minimum delay necessary for maximum fluency enhancement” (Kalinowski, Stuart, Sark and Armson, 1996,

p. 265). Thus, a short 50ms delay has become a common manufacture recommended calibration amongst DAF speech aids.

Frequency altered feedback presents another, more recently evolved, form of AAF. While experiencing the influence of FAF, a speaker will hear his own voice in either a higher or lower pitch. The impact of this type of aural modification on PWS was first documented by Howell, El-Yaniv, & Powell (1987). This study found significant improvements in the speech fluency of adult stutterers while exposed to FAF. It was then concluded that FAF is more beneficial in enhancing the fluency of PWS as compared to DAF. However, a comparative study contrasting the effects of DAF and FAF failed to support this finding (Kalinowski, Armson, Roland-Mieszkowski, Stuart, & Gracco, 1993). More inconclusive data on the effect of FAF was published in consecutive studies. While exploring the effect of FAF on scripted speech, Stuart, Frazier, Kalinowski & Vos (2008) found a reduction in stuttering duration of up to 50% while Ingham, Moglia, Frank & Ingham (1997) concluded that improvements in fluency during scripted and non-scripted speech were highly variable within their examined subject group. In further studies on FAF, Natke (2000) reported no significant changes in speech fluency of 12 PWS while reading aloud.

Many of the early investigations on the effects of AAF created the modifications in auditory feedback using intricate systems such as audio mixers, signal processors, microphones and amplifiers in a laboratory setting (cf. Armson & Stuart, 1998; Ingham, Moglia, Frank, Ingham, 1997; Howell, Sackin & Williams, 1999). However, the first account of a portable unit delivering DAF can be found as early as 1979 (Low & Duncan, 1979). However, it took several decades for such devices to become functional enough to be available commercially. As a result, portable devices have been used to deliver DAF and FAF in many of the more recent studies (c.f. Antipova, Purdy, Blakeley, & Williams, 2008; Bray, & James, 2009; Van Borsel, Reunes & Van den Bergh, 2003). With the introduction of commercially available AAF devices, the possibility of transferring the documented fluency-enhancing effects from scripted speech (c.f. Hargrave, Kalinowski, Stuart, Armson & Jones, 1994; Zimmermann, Kalinowski, Stuart, & Rastatter, 1997) into natural speaking situations arouse. As such,

contemporary research on speech samples has expanded to include the effects of AAF on both scripted and spontaneous speech (Lincoln, Packman, Onslow, & Jones, 2010; O'Donnell, Armson, & Kiefte, 2008; Pollard, Ellis, Finan, & Ramig, 2009; ). Since data on non-scripted speech has become available, it appears as though the positive effects of DAF and FAF during oral reading outperform the reported fluency enhancements documented while speaking spontaneously. Therefore, some researchers have voiced doubt that the positive effects reported during scripted speech can be generalized to natural speech (Foundas & Conture, 2009; Ramig, Ellis, & Pollard, 2010). A trend drawn from recently available data is that the responsiveness to AAF appears to vary widely from client to client (Lincoln et al., 2010; Pollard et al., 2009;). Whether or not a person who stutters will benefit from an AAF device in any given speaking situation is currently not predictable. This may also be due to the fact that little is known about the specific impact of AAF on the clinical features of stuttering. Many studies have looked at alterations in one clinical category, mainly frequency of stuttered syllables (%SS), to define whether or not an individual had benefited from exposure to AAF. For an increased understanding of AAF's fluency enhancing potential, highly individualized aspects of stuttering, such as specific core behaviors and stuttering severity should be investigated. Lincoln et al. (2010) recognize the role that clinical attributes may play in predicting the benefit of AAF and called for further investigation into the "characteristics that are predictive of responsiveness".

### **4.2. Hypotheses on the effects of altered auditory feedback (AAF)**

The treatment approaches introduced in Chapter 3 utilize speech techniques in order to alter moments of stuttering (stuttering modification) or expand fluent speech (fluency shaping). There are numerous reasons why the use of these techniques is thought to be successful in reducing stuttering. Stuttering modification techniques, for instance, offer a new reaction to the system by voluntarily implementing a specified reaction to end or ease out of a moment of stuttering rather than building up additional tension (fight reaction) or experiencing an avoidance behavior (flight reaction). Fluency

shaping on the other hand is believed to systematically establish a new speech pattern, which is supposed to counteract the built up of muscular tension typically experienced during core behaviors. If applied steadily research has shown that formerly uninvolved neuromuscular pathways are activated in the production of speech, thus normalizing a proven cerebral imbalance for some (Giraud, Neumann, Bachoud-Levi, Wolf von Gudenberg, Euler, Lanfermann, & Preibisch 2008). Even though the knowledge on the effectiveness of speech techniques is limited, the answer to the question why AAF can cause a fluency-enhancement in PWS is even more indistinct.

### **4.2.1. Influences on a deficient auditory processing system**

An early explanation for the fluency-enhancing effects of delayed auditory feedback (DAF) on PWS involves the idea that the auditory processing system of those who stutter may be impaired. DAF consequently was believed to balance auditory processing abnormalities in various ways. Stromsta (1958, 1972) conducted several experiments in which he tried to prove his theory of a disordered auditory system in those who stutter. He claimed that there is a discrepancy in arrival times of air and bone conducted sounds - a so-called *interaural phase disparity* (Stromsta, 1972). For PWS he found that the differences in arrival time between the bone and air conducted sound signal were comparable to those time delays experienced when exposed to DAF. Fluent speakers on the other hand did not show such large time lapses in sound signal transmission. His results suggested that exposure to DAF in non-stutterers causes similar time lapses as naturally experienced by PWS, thus resulting in stutter-like dysfluencies. This was an attempt to explain the so-called *Lee-effect* (Lee, 1950), which first documented the effects of DAF on typically fluent speaker. Stromsta (1972) further implied that the fluency of stutterers improves under DAF because an additional disruption in auditory perception causes an individual to completely ignore auditory speech feedback. Van Riper (1982), a research affiliate of Stromsta, later offered an addition to this line of thought by stating that DAF helps PWS to ignore the disrupting auditory signals and instead focus on proprioceptive and tactile feedback to monitor speech. This increased attention to the execution

of precise oral motor movements when speaking is what causes improved fluency in PWS when exposed to DAF. Stromsta's theory of interaural phase disparity, a flawed auditory processing system, presents a convincing argument in the explanation of the effectiveness of DAF for those who stutter. However, a replication of Stromsta's 1972 experiment failed to find a time lapse in signal transmission between stutterers and non-stutterers (Gregory & Mangan, 1982). Independent of the idea of a defective auditory processing system, the consequence of speaking with greater precision while exposed to DAF remains a captivating explanation and may partially contribute to the observable gains in speech fluency.

### **4.2.2. Neurophysiological differences**

Recent advances in neuro-imaging have presented some intriguing evidence that the neuroanatomy of those who stutter and the associated effects of AAF can be identified through neurological differences (i.e. cerebral dominance). In this context, AAF is believed to normalize or offer an alternative to the flawed neurological activity resulting in dysfluent speech production. Per Alm proposed such a hypothesis, focusing on neurological origins in his doctorate dissertation (2005). Alm considers stuttering a speech motor disorder characterized by abnormalities in the medial premotor cortex. Based on the dual premotor system hypothesis (Goldberg, 1985; Passingham, 1987), he explains that there are two systems for speech motor control: the medial system (basal ganglia & supplementary motor cortex [SMA]) and the lateral system (lateral premotor cortex & cerebellum). The medial system is believed to be dominant for implicit speech motor production while the lateral system is responsible for declarative speech motor output (i.e. speaking a language that requires the use of unfamiliar speech sounds or intentionally speaking in a particular accent) (Alm, 2006). He argues that PSW suffer from interruptions in the timing of signals that initiate motor movements sent by the basal ganglia, thus causing insufficient initiation of speech segments. In other words, the medial system is believed to be disrupted in those who stutter, while the lateral system is generally unimpaired. His hypothesis goes on to explain that speech can be produced fluently if the

flawed signal activation of the medial system is bypassed. One of the several means that allows the shift to the intact lateral system is the use of DAF and FAF. Alm suggests that these forms of AAF de-automatize speech motor control, thus activating the lateral system, responsible for deliberate speech sound production (Alm, 2005, p. 63). Alm argues that this intentional shift from implicit speech output to deliberately influencing the way one's speech sounds, can be achieved by any conscious way of speaking (i.e. use of speech techniques, use of modified feedback, pitch changes). Regardless of which method is chosen, the improvements in fluency are always linked to deliberate speech production causing a relocation of speech control to the intact lateral system. Recent neuro-imaging results support the view of a basal ganglia deficit in PWS. It was further shown that the continuous use of intentional speech patterns, in this case by implementing fluency shaping techniques, restructured deficient basal ganglia functioning (Giraud et al., 2008).

Another recent neuroanatomical hypothesis as to how AAF achieves its fluency enhancing effects was offered by Foundas, Bollich, Corey, Hurley, & Heilman (2001, 2004). This group found anatomical differences pertaining to size and hemispheric asymmetry of the planum temporale (Foundas et al., 2001). The planum temporale is a structure located in the posterior auditory temporal cortex, including vast parts of Wernicke's areal in the left hemisphere (Marshall, 2000). Referred to as auditory association cortex by some, (Griffiths & Warren, 2002) it is generally believed to be responsible for the processing of spoken language (Marshall, 2000). In line with other findings it suggests a right hemisphere dominance for language related tasks in some individuals who stutter (see cerebral dominance, Chapter 3). Foundas et al. (2004) found that those subjects showing high-frequent dysfluencies showed a right-ward asymmetry of the planum temporale. A fluent control group and those stuttering subjects who only showed minor symptoms during baseline when presented with a typical left-ward symmetry of the planum temporale. While exposed to DAF, only those subjects with the atypical right-ward planum temporale symmetry responded positively by showing a significant decrease in dysfluency. The non-stuttering controls or neuroanatomically typical stutterers, either showed no reaction to DAF or became more

dysfluent. Foundas et al. (2004) viewed the observed rightward asymmetry as an auditory perceptual deficit and concluded that a modification of the incoming auditory speech signal (through DAF) may correct this deficiency (Foundas et al., 2004). In contrast to the results of Giraud et al. (2003) it is not clear whether or not continuous exposure to DAF would normalize the deficient symmetry of the planum temporale. These results provide an initial neurophysiological indicator as to who may be most likely to benefit from the use of DAF.

Studies on exposure to DAF (Hasihimoto & Sakai, 2003; Takaso, Eisner, Wise, & Scott, 2010) and FAF (Toyomura, Koyama, Miyamaoto, Terao, Omori, Murohashi, & Kuriki, 2007), involving normally fluent speakers generally show increased activation in the posterior auditory fields (including planum temporale/Wernicke's area). In the future, it will be interesting to see results on replications of AAF neuro-imaging studies including subjects who stutter. With the results of Foundas et al. (2001, 2004) in mind, it is possible that exposure to AAF also causes increased activation of the posterior auditory fields in those who stutter. Such additional neural activity may be what is needed to balance an anatomically flawed auditory perceptual system.

### **4.2.3. Hypotheses on changes in speech production**

There are a number of hypotheses arguing that the improvements in speech fluency are not due to the changes in hearing one's speech rather they are caused by associated variations in how speech is produced. A popular belief was that particularly DAF slows a person's speech rate, an effect which has long been known to reduce stuttering (Goldiamond, 1965; Ryan & van Kirk, 1974; Shames & Florence, 1980; Starkweather, 1987; Stager & Ludlow, 1993). However, more recent studies found that speech fluency improves even when shorter delays of 50ms are used. The use of such short delays does not slow a person's speech rate considerably but nonetheless often results in increased speech fluency (MacLeod, Kalinowski, Stuart, & Armson 1995; Sparks et al., 2002).

Another very closely related thought on why AAF increases speech fluency in PWS was provided by Wingate (Wingate, 1969). He mentioned that

stuttering could be reduced under DAF because the speaker tends to prolong vowels, thus inducing a controlled and deliberately slow way of speaking. This assumption was confirmed by a small clinical trial, proving that vowels were indeed produced in a slightly stretched manner when exposed to a 50 ms delay (Ingham & Montgomery, 1983).

Finally an omnipresent explanation for why AAF in general may be helpful in reducing stuttering is the fact that it simply provides a new, unaccustomed component to speech production. This argument is cited by many publications. Some claim that the distraction of a new way of producing speech (e.g. speaking louder or slower) is what causes the fluency enhancement (Goldiamond, 1965; Wingate, 1969). Others state that the distraction of the new auditory signal itself (much like speaking in a loud environment with background noise) is what creates a more fluent speech output (Bloodstein & Bernstein Ratner, 2008).

### **4.3. Influence of altered auditory feedback (AAF) on the speech of people who stutter (PWS)**

Some forms of AAF, such as masking (Cherry & Sayers, 1956; Kern, 1931; Maraist & Hutton, 1957) have been used for numerous decades as treatment components in stuttering interventions. It was not until 1965 (Goldiamond) that a form of auditory signal modification (e.g. DAF, FAF), rather than a signal distortion (masking), was utilized within the stuttering population. Since then, the influence of such auditory modifications on the speech of those who stutter has been studied in several environments and contexts. Section 4.3. of this chapter provides an up-to-date review of the research findings pertaining to the effects of AAF on those who stutter. The obtainable\* research results have been split according to the speech conditions investigated within each study.

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\* The location and selection of original research cited within this paper was primarily conducted through PubMed database searches using topic specific key words. Additionally, specialized, peer-reviewed Journals such as *The Journal of Fluency Disorders*, *Journal of Speech, Language and Hearing Research* or the *Journal of Communication Disorders* were considered individually in each search. University library webOPAC searches were also conducted in order to locate books and other publications containing suitable information.

#### **4.3.1. Scripted speech**

In the early investigations into the effects of DAF, reading in a clinical environment was the preferred speech sample (Dalrymple-Alford, 1973; Gibney, 1973; Lotzmann, 1961; Lechner, 1979; McCormick, B. 1975). The reasons why reading has been favored may include the fact that when using a reading passage, spoken syllables can be controlled for more easily, thus creating recordings that have the same lengths across all subjects. Additionally, secondary behaviors such as word avoidances can be detected since every subject is provided with pre-determined wording. Such methodological factors have often lead to reading samples as the preferred mode because of its simplicity, thus outweighing the need for data collection that is applicable to real-life situations (such as spontaneous conversations).

Most of these controlled studies were aimed at investigating the general effect of DAF within the stuttering population. In other words the goal was to determine whether or not a reduction in stuttering could be detected and clearly linked to DAF. This initial goal was achieved by many studies, as most investigations found improvements in speech fluency as a result of DAF (cf. Chase, Sutton, & Rapin, 1961, Kalinowski, 1993; Macleod, Kalinowski, Stuart, & Armson, 1995; Kalinowski, Armson, Roland-Mieszkowski, Stuart, & Gracco, 1993; Kalinowski, Stuart, Sard, & Armson, 1996; Kalinowski, Stuart, Wamsley, & Rastatter, 1999).

More diverse findings have emerged over the years. Comparative studies of the different forms of AAF were published suggesting that DAF and FAF are superior over masking in reducing stuttering frequency (Kalinowski, 1993). However, when comparing DAF to FAF, no unison conclusion has been reached as to which of the two is more promising in reducing stuttering (Ingham, Moglia, Frank, Ingham, & Cordes, 1997; Stuart, Frazier, Kalinowski, & Voss, 2008). It was further found that true coral speech (two individuals speaking aloud at the same time) produces greater fluency enhancement than the artificially produced coral effect by means of combining DAF with FAF (Saltuklaroglu, Kalinowksi, Robbins, Crawcour, & Bowers, 2009). Research has also focused on determining the optimal settings for AAF when reading.

One study suggested that a delay time of 50 ms (DAF) “is the shortest delay producing the maximum reduction in stuttering” (Kalinowski, Stuart, Sark, & Armson, 1996). When employing FAF within the stuttering population it has been shown that downward frequency shifts rather than upward shifts are preferred in reducing stuttering (Natke, Grosser, & Kalveram, 2001). Other published articles have established that the effect of AAF is independent of audience size when reading aloud (Armson, Foote, Witt, Kalinowski, & Stuart, 1997). Another publication concluded that AAF, when applied binaurally, is more effective in reducing stuttering than AAF presented to one ear only (Stuart, Kalinowski, & Rastatter, 1997).

### **4.3.2. Spontaneous speech**

Investigating the effects of DAF and FAF during both monolog and dialog speech is of great interest because portable AAF devices are most likely used during spontaneous speech. While the results gathered from reading provide initial information on the potential of AAF, it is rather unlikely that the users of such devices only utilize their portable units within such limited contexts. In fact, AAF devices are advertised to alleviate stuttering particularly during situations of daily life such as presentations (monologs) and conversations (dialogs). Because of this intended use, the need arose for research on fluency enhancements during spontaneous speech.

Unfortunately, there are only a few studies to be found that collected spontaneous speech samples when studying AAF. In a small case study including four participants, the effects of FAF on spontaneous speech was first assessed in 1997 (Ingham, Moglia, Frank, Ingham, & Cordes, 1997). Data for this study was collected in a laboratory and the exact nature of the spontaneous speech task was not specified. Results suggest widely varied results within their four subjects, ranging from measurably decreased stuttering to increased stuttering, and no change in speech fluency. In regards to DAF only, it was found that stutter-like-dysfluencies such as articulation errors or interjections were more likely to occur during conversation, particularly in male subjects (Corey & Cuddapah, 2008). Only within the last couple of years have results been augmented by studies using commercially

available devices. One study found that monolog speech production improved significantly; both immediately after first wearing the device and during a four-month follow up (Stuart, Kalinowski, Saltuklaroglu, & Guntupalli, 2006). In this study participants were required to wear the device for at least five hours daily in their natural environments between the initial and follow-up data collection. Additionally, the speech naturalness of the participants was rated to be more natural when wearing a device as compared to a no-device baseline measure. Interestingly, another study showed, that speech naturalness was also rated higher while using AAF as compared to the spontaneous speech of speakers using fluency shaping techniques (Stuart & Kalinowski, 2004). Another recent study was aimed at finding an ideal setting at which a device should be programmed in order to achieve the maximum fluency enhancement during conversation. With a participant group of eleven PWS with varying severity, no specific results could be obtained and only a general conclusion that all tested settings proved beneficial in reducing stuttering (Lincoln, Packman, Onslow, & Jones, 2010). Long-term results are valuable because they provide information of the longevity of the fluency-enhancing effect, a factor questioned by some. Recently, evidence on the longevity of DAF's fluency-enhancing effect was presented (van Borsel, Reunes & van den Bergh, 2003). In this investigation, the authors showed that during a three-month period of consecutive use of DAF, the percentage of stuttered words had dropped to a significantly lower level, even when no DAF device was used. This gives a first indication that a carry-over effect of the fluency-enhancement experienced during DAF may be a possibility. Other studies investigating the long-term effect of AAF in situations of daily living revealed incoherent results. Generally, scientific findings to date suggest that there is greater immediate improvement, which for most users diminishes somewhat with extended exposure to a device (O'Donnell, Armson, & Kiefte, 2008; Stuart, Kalinowski, Saltuklaroglu, & Guntupalli, 2006; Pollard, Ellis, Finan, & Ramig, 2009). Additionally, it has been found that speech fluency is at its peak during oral reading, while the most stuttering persists during formulated speech (Pollard et al., 2009; Stuart et al., 2006). Table 11 provides a summary of peer-reviewed studies accumulating an evidence-base for AAF speech aids.

### 4.3.3. Subjective impressions of device usage

Two of the above mentioned studies that investigated the long-term use of AAF devices also looked at the user's subjective impression of the experience (O'Donnell et al., 2008; Pollard et al., 2009). The earlier study (O'Donnell et al., 2008) showed that five out of seven participants found the device "easy to use, successful at reducing their stuttering and non-interfering with their ability to speak". The two remaining subjects found the device "not to be beneficial" and the AAF effects to be "difficult to tolerate" (O'Donnell et al., 2008, p. 111). Pollard et al. (2009) noticed a disconnect between subjective impressions and measurable changes in stuttering frequency. In some cases, clients perceived the device as useful despite a lack of measurable improvement in core behaviors. Lincoln & Walker (2007) conducted a survey including 14 AAF device users. Subjects used either a binaural portable device by the manufacturer Casa Futura or a wireless aid produced by Janus development. The use patterns and perceived effectiveness were generally equal across device users. However, there appeared to be a difference in satisfaction levels, particularly when it comes to the level of self-consciousness when wearing a device. Subjects reported greater levels of satisfaction the smaller and less visible the implemented device was.

Table 11: Summary of altered auditory feedback (AAF) studies utilizing portable speech aids

Immediate effects						
Study	Evidence level*	N	Speech Sample	Results	Type of AAF	Device used
Natke, 2000	IIb	12	• Reading	<ul style="list-style-type: none"> <li>• Fluency improved under DAF only</li> <li>• No impact on speech fluency during FAF</li> </ul>	<ul style="list-style-type: none"> <li>• DAF</li> <li>• FAF</li> </ul>	DFS 404, Casa Futura Technologies, Boulder, USA
Natke, Grosser, & Kalveram, 2001	IIa	20	• Monolog	<ul style="list-style-type: none"> <li>• Significant fluency enhancement was reached using a downward frequency shift in PWS</li> <li>• Fundamental frequency changed</li> </ul>	<ul style="list-style-type: none"> <li>• FAF</li> </ul>	DFS 404, Casa Futura Technologies, Boulder, USA

				during FAF only changed within the control group		
van Borsel, Reunes, & van den Bergh, 2003	III	9	<ul style="list-style-type: none"> <li>Automatic speech</li> <li>reading</li> <li>repeating words &amp; sentences</li> <li>monolog</li> <li>conversation</li> </ul>	<ul style="list-style-type: none"> <li>Percentage of stuttered words dropped significantly using DAF across all speech samples</li> <li>After a three-month period of extended exposure to DAF dysfluent speech was slightly higher during post-test but still reduced significantly as compared to pre-test values</li> </ul>	<ul style="list-style-type: none"> <li>DAF</li> </ul>	School DAF, Casa Futura Technologies, Boulder, USA
Antipova, Purdy, Blakeley, & Williams, 2008	IIb	8	<ul style="list-style-type: none"> <li>Reading</li> <li>Monolog</li> </ul>	<ul style="list-style-type: none"> <li>Stuttering frequency was reduced with any AAF setting tested</li> <li>75 ms delay on its own &amp; in combination with a ½ octave downward shift were found to be most effective</li> </ul>	<ul style="list-style-type: none"> <li>DAF</li> <li>FAF</li> <li>DAF &amp; FAF</li> </ul>	Pocket Speech Lab, Casa Futura Technologies, Boulder, USA
Bray & James, 2009	III	5	<ul style="list-style-type: none"> <li>Telephone conversations</li> </ul>	<ul style="list-style-type: none"> <li>Both frequency of stuttering and negative attitudes towards phone conversations decreased while using a device – no statistical significance was reported</li> </ul>	<ul style="list-style-type: none"> <li>DAF &amp; FAF</li> </ul>	Telephone assistive device (TAD, VA609), VoiceAmp, Cape Town, South Africa
Lincoln, Packman, Onslow, & Jones, 2010	IIb	11	<ul style="list-style-type: none"> <li>Reading</li> <li>Dialog</li> </ul>	<ul style="list-style-type: none"> <li>All combinations of DAF &amp; FAF reduced stuttering significantly during conversation</li> <li>There was no statistically significant difference between the individual AAF types or settings – indicating that the most effective AAF type or setting could not be determined</li> </ul>	<ul style="list-style-type: none"> <li>DAF</li> <li>MAF (mask-ing)</li> <li>DAF &amp; FAF</li> </ul>	Pocket Speech Lab, Casa Futura Technologies, Boulder, USA

Longitudinal trials						
Study	Evidence level	N	Speech sample	Results	Type of AAF	Device used
Stuart, Kalinowski, Rastatter, Saltuklaroglu, & Dayalu, 2003	III	5	<ul style="list-style-type: none"> <li>• Reading</li> <li>• Monolog</li> </ul>	<ul style="list-style-type: none"> <li>• Stuttering was reduced significantly during both reading and monolog</li> <li>• These fluency enhancements were maintained for 4-months.</li> <li>• Speech was rated more natural while wearing the device</li> </ul>	<ul style="list-style-type: none"> <li>• FAF &amp; DAF</li> </ul>	Speech Easy, In the canal (ITC) device, Janus Development Inc., Greenville, USA
Stuart, Kalinowski, Saltuklaroglu, & Guntupalli, 2006	IIb	9	<ul style="list-style-type: none"> <li>• Reading</li> <li>• Monolog</li> </ul>	<ul style="list-style-type: none"> <li>• Stuttering frequency was reduced significantly right after initial use and 12-months after</li> <li>• Client perceptions of secondary behaviors were reduced significantly during a 12-month follow-up</li> <li>• During follow-up data collection speech was rated more natural by naïve listeners</li> </ul>	<ul style="list-style-type: none"> <li>• DAF &amp; FAF</li> </ul>	Speech Easy, In the canal (ITC) & completely in the canal (CTC) device, Janus Development Inc., Greenville, USA
O'Donnell, Armson, & Kiefe, 2008	IIb	7	<ul style="list-style-type: none"> <li>• Reading</li> <li>• Monolog</li> <li>• Dialog</li> <li>• Phone conversations</li> </ul>	<ul style="list-style-type: none"> <li>• All participants experience reductions in stuttering immediately after the device was fitted (reading, monolog, dialog)</li> <li>• In situations of daily living (phone conversations) and during the second laboratory assessment (12 – 16 weeks post fitting) the device's effects varied widely across participants</li> </ul>	<ul style="list-style-type: none"> <li>• DAF &amp; FAF</li> </ul>	Speech Easy, In the canal (ITC) basic & advanced device, Janus Development Inc., Greenville, USA
Pollard, Ellis, Finan, & Ramig, 2009	IIb	11	<ul style="list-style-type: none"> <li>• Reading</li> <li>• Conversation</li> </ul>	<ul style="list-style-type: none"> <li>• Group effect showed a statistically significant</li> </ul>	<ul style="list-style-type: none"> <li>• DAF &amp; FAF</li> </ul>	Speech Easy, In the canal (ITC) device,

<ul style="list-style-type: none"> <li>• Asking a stranger a question</li> </ul>	<p>reduction of stuttering immediately, but not after prolonged use over a 4-month period</p> <ul style="list-style-type: none"> <li>• Stuttering reduction was generally greater during reading as compared to formulated speech</li> </ul>	<p>Janus Development Inc., Greenville, USA</p>
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\* based on the evidence classification system by ASHA, 2011 (cf. Table 9)

#### **4.4. Portable altered auditory feedback (AAF) devices**

To the interested consumer, AAF has become available in many ways and forms. In the treatment of stuttering, clinicians occasionally use AAF as a tool to establish the use of fluency-enhancing techniques in the clinical setting (Curlee, Perkins, 1969; Goldiamond, 1965; van Riper, 1973; Ryan & Ryan, 1995). In the clinical setting, AAF is mostly delivered through computer programs or implemented by using bulky equipment (e.g. ZAK Medizin Technik, Speech Delayer SV2-10105). Alternatively, for AAF to be used during natural speech, it is available as downloadable software via a personal computer (e.g. Arens, Speech Monitor). With the use of a microphone, the AAF effect can be applied during limited verbal interactions such as phone calls. Recently with the expansion of smart phone technology, it is also possible to download an application onto a cellular phone, which offers both DAF and FAF to be used in a cost efficient, portable way (e.g. DAF Assistant, Artefact LLC, 2011). However, little is known about the quality of this AAF delivery option. With the exception of the aforementioned smart phone application, the limiting usability factor is having physical access to the AAF system.

As technology advanced over time, affordable and portable speech aids emerged on the market. In a comprehensive review of AAF and the treatment of stuttering, Lincoln et al. (2006) summarized a list of commercially available devices and, at the time, found a total of seven manufacturers. Most portable devices have a standard set of audio manipulation capabilities. Among those options are only DAF (delay in milliseconds), only FAF (frequency shifting in Hertz or octave scale pitch-shifting), simultaneous DAF

and FAF (choral effect) and/or masking (white noise or gated pink noise). While functionality is often similar, products differ greatly in their size, speech signal delivery, and settings control. As a whole, the portable devices can be generalized into two groups; the larger modular format and the smaller self-contained format.

The modular type devices are comprised of a primary control hub that connects to audio input and output accessories. This hard-case hub unit, approximately the size of a deck of cards, includes the hardware needed to adjust the volume and AAF options (e.g. manufacturer: Voice Amp, device: VA 601i; manufacturer: Casa Futura Technologies®, device: SmallTalk). Depending on the user's preference, input/output accessories include binaural wired headsets, monaural wireless earpieces and stereo microphones. The headset models (e.g. Sennheiser, PC 131) offer a combined microphone and headphone construction that connects to the AAF device using an audio cable. The wireless options may combine inductive loop microphones (e.g. Artone, Neckloop) with a monaural earpiece (e.g. Starkey, ITE).

The self-contained type combines audio input, audio output and the AAF hardware into one small device that can be worn in or behind the ear (manufacturer: Janus Development, device: SpeechEasy™). Because of the product's size, the various calibration options must be programmed into the unit and cannot be actively controlled by the user.

As different as the AAF delivery options, as diverse are the ways of obtaining a device. One manufacturer trains certified speech pathologists to fit and distribute their devices based on a uniform evaluation protocol (Janus Development). Some sellers have dual distribution systems where a customer can either contact an authorized clinician or purchase from the manufacturer directly (e.g. Voice Amp). However, most device manufacturers rely on the client to contact and purchase a device directly from them (e.g. Casa Futura, KayPentax). With the aids that are purchased after a personal consultation with an appointed distributor, a specific setting or settings may be individualized and programmed into the device. If the aid is purchased online, some devices offer pre-programmed standard options, which are recommended for first time users or for use in noisy environments. After familiarizing oneself with the operation of the device, the customer may

individualize settings by either choosing from a number of preset options (manufacturer: Casa Futura; device: Small Talk) or calibrating the settings electronically by purchasing an additional software component (manufacturer: Voice Amp; device: VA 601i). The devices used for this study are delivered with recommended pre-programmed options for first time users within different environments. In order to investigate the immediate effect PWS would encounter while using an AAF device, these suggested low invasive settings for quiet environments were used throughout this investigation.

### **4.5. Need for the present studies**

Table 11 summarizes all obtainable studies that have used a commercially available AAF speech aid to-date. Despite many interesting findings that were accumulated through these studies, there are also several unaddressed flaws that come with each investigation. The first concern when looking at the available literature is that many studies have been conducted by authors who are biased because they are either manufacturers or are financially involved in the production of the employed speech aid (e.g. Stuart, Kalinowski, Rastatter, Saltuklaroglu, & Dayalu, 2004; Stuart, Kalinowski, Saltuklaroglu, & Guntupalli, 2006). In other words, there is a lack of objective studies, conducted by independent investigators and uninvolved institutions.

Another threat to the validity of some of the referenced studies is the way the subject sample was obtained. Some investigations have pre-selected their subjects based on the response to AAF. One study was based on an inclusion criterion involving a pre-determined minimum fluency enhancement that had to be achieved when using a device before addition to the study was granted (O'Donnell et al., 2008). Other studies required a certain severity or frequency of stuttering in order to be able to partake in the investigation (Kalinowski, Stuart, Sark, & Armson, 1996; Saltuklaroglu, Kalinowski, Robbins, Crawcour, & Bowers, 2009; Stuart, Kalinowski, Rastatter, Saltuklaroglu, & Dayalu, 2004; Stuart, Kalinowski, Saltuklaroglu & Guntupalli, 2006). Such tight inclusion criteria appear to limit the validity of the resultant findings because the outcome cannot be applied to the entire stuttering population but only to a very specific sub-group. While for statistical reasons it

is logical why a minimum quantity of stuttering is desirable, such criteria do not take into consideration that AAF speech aids are manufactured and advertised for the stuttering population as a whole. A diverse group, is one that includes not only the severely dysfluent but also individuals with mild stuttering or limited frequency of dysfluencies due to extensive secondary behaviors. Whether or not these individuals may benefit from the use of a device will not be answered if the subject group is limited to those with specific symptoms.

In terms of data reporting, another problematic trend is apparent. As established in Chapter 1, it is difficult to find a consensus on how to report such complex measures as stuttering frequency. Regardless of which measurement of frequency is used (see Table 2), some studies report ambiguous figures when determining whether or not a device was successful in reducing stuttering. More specifically, some studies choose to report a percentage of change when comparing pre and post-treatment values. However, the original values displaying the amount of dysfluency or frequency of stuttering are not reported (cf. Antipova, Purdy, Blakeley, & Williams, 2008; Saltuklaroglu, Kalinowski, Crawcour, & Bowers, 2009). Rather, a broad figure reflecting the percentage of improvement in speech fluency is reported. Such figures can be quite confusing as a 50% reduction in stuttering frequency could reflect a rather large decline of stuttering (from 80 %SS down to 40 %SS) or a negligible improvement of speech fluency (from 4 %SS down to 2 %SS). In other cases improvements are reported as general trends by reporting the descriptive statistics only without qualifying the resulting difference by calculating the statistical significance (cf. Bray & James, 2009).

A general issue with clinical trials in stuttering research is the lack of large subject groups. When reviewing the available immediate effect studies it becomes apparent that a sample size of twelve participants is the largest subject group that can be found (Natke, 2000).

The studies presented in this paper have been designed to address some of these threats to validity, which results in a research design that adds to the current body of knowledge regarding AAF. The results of the immediate effect study are supposed to present evidence on a IIa level (ASHA, 2011). Level IIa in this system stands for '*well designed controlled study without*

*randomization*'. Even though, there was no control group present, who consisted of an independent subject group not exposed to AAF, the examined subject group itself underwent a control condition (Placebo Condition). The results of the longitudinal study presented in part III of this paper provide evidence on a IIb level, which stands for a '*well-designed quasi-experimental study*'. This study should be considered quasi-experimental because it is lacking both a control group and the random assignment of subjects. The strengths of the long-term trial however, lay in the various levels of data (both quantitative and qualitative) accumulated throughout numerous data collection points, pre-, mid- and post-test. Additionally, the original research presented in parts II and III of this text add to the existing level II research designs in the following ways:

- Reporting of unbiased results obtained by an objective primary investigator.
- Accumulation of a rather large subject sample ( $N = 30$ ) for a clinical trial with the presented focus.
- Inclusion criteria were based on the presence of developmental stuttering, without specific reference to the amount of overt stuttering experienced. This resulted in a subject group that was interested in experiencing the use of a device, thus reflecting the heterogeneous group of PWS likely to reflect the actual AAF device-user group.
- Precise reporting of all descriptive statistics with reproducible calculations of effects and improvements.
- A Placebo condition was included in order to differentiate the strengths of the AAF effect.
- Various speech samples (scripted & spontaneous speech) and device types were compared directly in the same study utilizing the same methodology allowing direct comparison of the effect across different tasks.
- Both studies utilized diversified quantitative and qualitative data collection including subjective participant impressions and objective measures of stuttering severity.

- The long-term study included data collection in the laboratory setting as well as in situations of daily living, with a focus on obtaining detailed qualitative accounts of the device use.

With these methodological additions, the studies presented within the subsequent chapters aim to add to the current body of knowledge regarding the much discussed value of AAF as a tool in the remediation of stuttering.

## **PART II: IMMEDIATE EFFECT STUDY\***

### **Chapter 5: Materials and methods**

#### **5.1. Participants**

A group of 30 PWS (7 females and 23 males) participated in this study. All individuals were at least 18 years of age to be considered for participation. The ages of subjects ranged from 18 to 68 years ( $M = 36.5$ ;  $SD = 15.2$ ). Participants were all diagnosed with the fluency disorder stuttering with no history of other speech, language or neurological disorders. All subjects had received some form of speech and language intervention in the past, but none have had any clinical experience with AAF. Participants also had to pass a basic hearing screening (conventional pure tone thresholds at 20 dB across 8 frequencies: 0.25 KHz – 8 KHz). The subjects were recruited through web postings and letters sent to stuttering support groups throughout Germany. The intention was to address those PWS who were interested in exploring the use of an AAF device, thus representing the diverse group of potential customers.

#### **5.2. Apparatus**

All recordings were collected at the speech and language center of the University of Education in Heidelberg, Germany in the presence of the primary investigator and on occasion a trained research assistant. Participants sat at a table facing the main researcher with the AAF devices placed in front of them, yet hidden behind a wooden barrier. The subjects were not supposed to see the devices in order to avoid bias based on the visual appearance of the speech aids. The initial hearing screening was conducted in the same room, using a mobile, clinical, binaural Audiometer (Schwarzhaupt Medizintechnik GmbH, Model: HRT-80). Each speech sample was recorded in three different ways – two audio recordings using the recording program Audacity 1.3 Beta

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\* The materials, methods, results and discussion of the immediate effect study were published in a shortened version from the one presented herein in the Journal of Fluency Disorders: Unger, J.P., Glück, C.W., & Cholewa, J. (2012). The immediate effects of AAF devices on the characteristics of stuttering: a clinical analysis. *JFD*. 37(2), 122-134.

run on a Macbook Air. Additionally, all speech samples were recorded audio-visually using a camcorder (Canon, FS100) with a digital wireless microphone (Sima, SDW-150).

For the experimental conditions, two commercially available AAF devices were used. Device A was the VA 601i Fluency Enhancer<sup>\*</sup> (VoiceAmp, Cape Town, South Africa) and Device B was the SmallTalk<sup>\*\*</sup> (Casa Futura Technologies, Boulder, CO, USA). Even though both devices can be equipped with a number of different headphone or earpiece options, throughout this study the devices were used with the standard set of headphones delivered by the manufacturer upon basic purchase of each aid. Device A was used with a monaural ear-bud (Nokia, HDC 5) while Device B was used with a binaural headset (Sennheiser, PC 131). Figure 4 shows pictures of both devices with the association headphones used. For the purposes of this study, both the FAF and DAF functions of each device were employed. The devices delivered these AAF settings simultaneously at the recommended settings for initial utilization or use in quiet environments as specified by the manufacturer. For Device A the pre-programmed green setting for quiet environments was chosen. The DAF setting consists of a 50 ms delay and an upward frequency-shift to 250 Hz. Device B was set to a delay time of 50 ms and a low-invasive downward frequency-shift of -0.4 octaves, as recommended for first time users. Precision of these settings was tested prior to each use. The participants controlled the sound pressure level for each device individually. In a brief trial period, prior to the recording of the speech samples within each with device condition, participants were asked to adjust the volume to a comfortable setting. For the administered Placebo setting participants were asked to wear a set of headphones (Nokia, HDC 5), which were connected to Device A. A Placebo setting was programmed, during which the AAF functions of the device were disabled.

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\* abbreviated Device A

\*\* abbreviated Device B

Figure 4: Images of Device A and Device B as used during the immediate effect study

**Device A**

**Device Name:** VA601i Fluency Enhancer  
**Manufacturer:** VoiceAmp, South Africa



**Device B**

**Device Name:** SmallTalk  
**Manufacturer:** CasaFutura Technologies, USA



**Monaural headset used  
with Device A**



**Binaural headset used  
with Device B**



The collected audio samples consisted of reading passages, monologs and dialogs. The reading passages were derived from a ninth grade German textbook, as this correlates with the average reading level of a German adult. The reading samples consisted of the works of Hermann Hesse (Beneath the wheel, 1906), Ernest Hemingway (For whom the bell tolls, 1941), Berthold Brecht (The Augsburg chalk circle, 1940) and Anne Frank (The diary of Anne Frank, 1947), which were printed on white A4 format paper with black 13.5-font Arial typeface. In order to accumulate the monolog recordings subjects were given index cards (3" x 5") stating topics pertaining to every-day life, printed in 16-font Arial typeface. Topics included a variety of areas such as

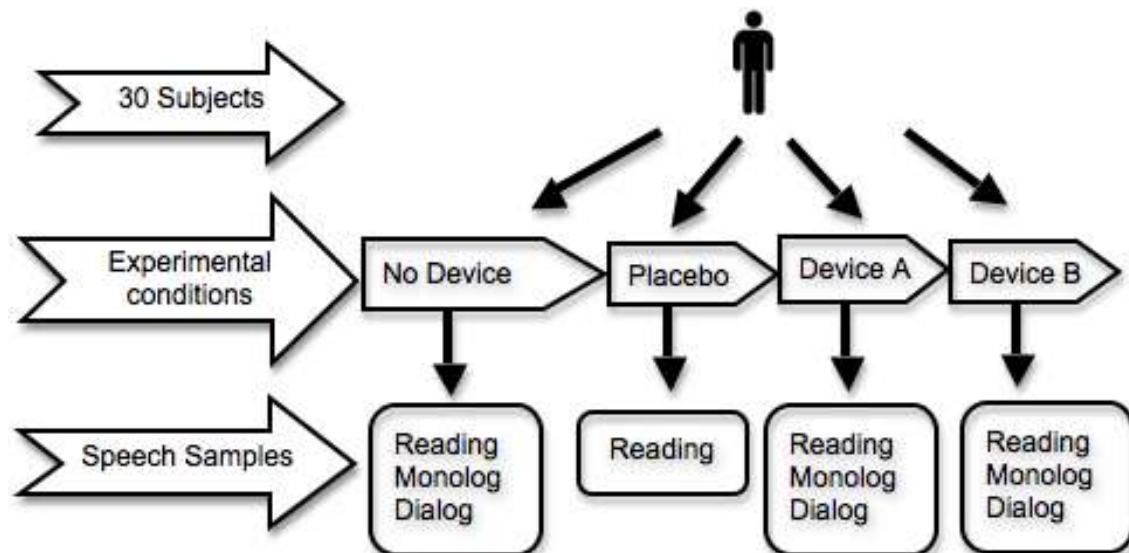
“Hobbies”, “My occupation”, “My family”, “My favorite movie” or “Vacation”. On the backside of each index card general thought provoking questions were printed to support the development of a five minute monolog (e.g. for the general topic “Vacation” questions included “What is your favorite travel destination?”, “Who do you usually travel with?”, “Where would you like to travel to and why?”, “How do you usually spent your vacation?” etc.). After looking at any given topic the speakers were provided the opportunity to either gather their thoughts on each subject or reject the matter in which case they were asked to draw another topic card. The recording of each five-minute monolog was started upon the speaker’s signal. A digital clock was set to indicate the end of each five-minute speaking period by a sound signal. Dialog cards were provided in the same format. Topics included possibly controversial issues on current events in the areas of politics, pop culture, education and history. Participants were asked to read each topic aloud and state their opinion upon which a conversation with the primary investigator or research assistant evolved. A sound signal terminated the ten-minute recording period. For purposes of subsequent analysis of the dialog samples, only the speaking time of the participant was considered.

### **5.3. Procedure**

A total of ten speech samples across four different experimental conditions (No Device, Placebo, Device A, Device B) were collected, resulting in a total of 65 minutes of actual speech time per participant. Using the materials described in Section 5.2., each subject was asked to read a passage for five minutes, hold a monolog for five minutes and engage in a conversation for ten minutes. This procedure was repeated two times for each AAF device used. The reading sample was further replicated a fourth time in order to collect the Placebo sample. Participants were faced with a new topic for each monolog and dialog and a different reading passage for each experimental condition. While the order of the experimental conditions remained constant (1. No Device, 2. Placebo, 3. Device A, 4. Device B), the order of the collected speech samples was randomized within each condition

to control for adaptation effects. Figure 5 provides an at-one-glance summary of the data collection process for each subject.

Figure 5: Summary of data collection process during the immediate effect study



#### 5.4. Research questions

Attempting to diversify recent findings on the effect of AAF on the speech of PWS the current study examines the immediate effect of DAF and FAF. The latter two as well as other forms of AAF have become widely available in the form of prosthetic speech aids. The fluency-enhancing effect of such devices for some PWS has been established by many of the aforementioned studies. However, it remains difficult to predict who will most likely benefit from the use of such an aid. The study at hand is trying to contribute to answering this question by differentiating the observable changes in fluency, systematically. Namely, notable decreases in stuttering were examined more closely by investigating changes among common clinical categories, which can be derived for every PWS. Therefore, the main objective of this investigation is the evaluation of the devices' effects on the following dependent variables during both scripted and spontaneous speech:

1. Stuttering frequency (%SS) and duration.
2. Speech and articulatory rate (syllables per minute).

3. Frequency of three groups of core behaviors (repetitions, prolongations, blocks).

Furthermore, the degree of fluency-enhancement was investigated, within:

4. Scripted (reading) and spontaneous speech (monolog and dialog) samples.
5. Stuttering severity ratings.

First the decrease in dysfluencies within the three different speech samples was evaluated for the entire participant group. The goal was to distinguish whether or not fluency-enhancements differed across speech tasks. In another step it was examined whether the use of a device would impact the stuttering severity rating based on the SSI-4 (Stuttering Severity Instrument – 4<sup>th</sup> Edition, Riley, 2009). Additionally, it was distinguished whether a fluency-enhancement is dependent on the severity of stuttering experienced by a participant.

6. Additionally, this study investigated the impact on the dependent variables during a Placebo setting.

During the Placebo setting participants were under the impression of being exposed to DAF and FAF when they simply wore a device that did not display a shift in frequency or a delay.

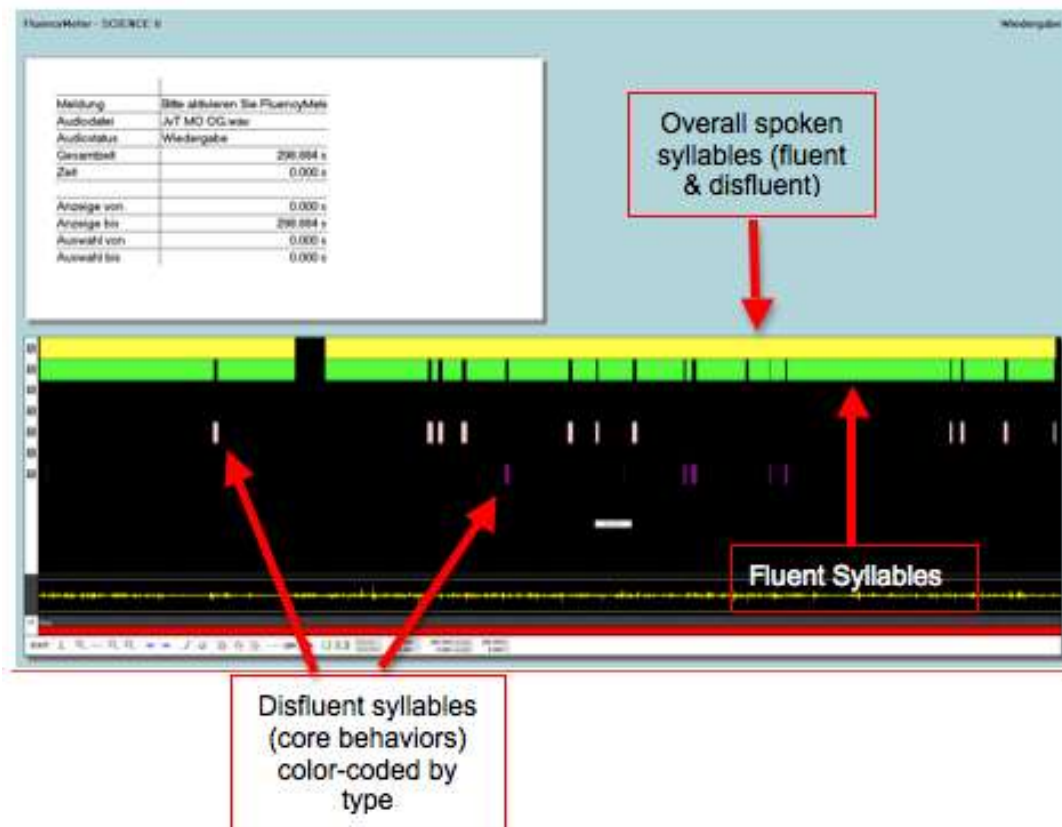
7. A final aspiration was to interpret the subjective impressions of the client group in terms of the experienced device use.

### **5.5. Assessment of speech parameters**

In order to evaluate the collected speech samples each recording was converted into wave file format (.wav) and imported into the software program Fluency Meter Science Edition (Glück, 2003) for molecular analyses. This program was used to establish the speech rate for each sample, and to determine a total syllable count as well as mean duration of each fluent and dysfluent syllable. Moments of stuttering were also examined by type. For this purpose dysfluencies were categorized into 3 different core behavior categories: repetitions (sum of sound and syllable repetitions), prolongations and blocks (sum of silent and audible blocks). Figure 6 shows the working screen of this program, with the total speech time marked in yellow, all fluent

syllables marked in green and dysfluent syllables marked in color, depending on the specific type of core behavior. Fluency Meter Science included every assessed syllable into the frequency count, only those moments of stuttering, which were longer than .45 seconds were considered in the calculation of the total duration of all dysfluencies. This criterion was chosen in order to exclude normal, non-stutter-like dysfluencies from the analysis of core behaviors. Trained research assistants, who were blind to the experimental conditions they analyzed, as well as the primary investigator examined each speech sample. Overall Fluency Meter Science was used to analyze a total of 32.5 hours of speech recordings containing roughly 207 000 syllables. For analysis the program played every speech sample back with the option to pause and replay each segment repeatedly. The raters operated the program (run on several Windows operated laptop computers) manually by indicating the occurrence of fluent and dysfluent syllables through either mouse clicks or the push of designated keyboard buttons. In a second cycle of evaluation each syllable marked as dysfluent was then identified as a particular core behavior by pushing one of five keyboard buttons, which represented the five assessed core behaviors. Raters also administered the length of each dysfluent syllable by keeping the particular key pressed for the entire duration of a detected moment of stuttering. In order to distinguish moments of stuttering from normal dysfluencies, repetitions were only considered if more than two repetition units were present (Guitar, 1998, p. 127; Yairi & Lewis, 1984). In order to determine the inter-rater reliability for each speech sample analysis, the intra-class correlation (Shrout & Fleiss, 1979) for two or more raters was calculated. Results revealed a high agreement among raters (ICC = .998).

Figure 6: Fluency Meter Science working screen



## 5.6. Statistical design

Due to the nature of the underlying research questions it was necessary to employ a number of statistical tests. In general, all subjects partook in every experimental condition (No Device, Placebo, Device A, Device B). Therefore, the research design can be considered a repeated measures design (cf. Price, 2000; Field, 2009, p. 458). For the majority of the investigated dependent variables (stuttering frequency, duration of moments of stuttering, speech and articulatory rate, stuttering type) repeated measures ANOVAs were calculated using SPSS 18.0 (2010). For all repeated measures calculations, the basic assumption is that the outcome of the different treatment conditions is dependent because each condition is tested on the same person. The variance of the discrepancy between treatment levels is therefore considered to be equal (sphericity assumption). The program SPSS uses a test entitled *Mauchley's test* (Mauchley, 1940), which examines whether or not the variation of results between conditions are equal (Field,

2009). The assumption of sphericity is violated (the variations between experimental conditions results are not equal) if the Mauchley's test statistic is significant ( $p < .05$ ). It is still possible to calculate a repeated measure ANOVA even with data that violates the assumption of sphericity. This is done by utilizing corrections of the overall number of varying values (degrees of freedom,  $df$ ). For this investigation two corrections were used in order to adjust the degrees of freedom, thus decreasing the probability of a Type II error. Depending on the estimate of sphericity ( $\epsilon$ ) provided by SPSS 18 either the Greenhouse-Geisser (Greenhouse & Geisser, 1959) or the Huynh-Feldt correction (Huynh & Feldt, 1976) was applied. According to Girden (1992) the Huynh-Feldt correction should be used when the estimated sphericity value is greater than 0.75 ( $\epsilon > .75$ ). In cases that have an estimated sphericity value of less than 0.75 ( $\epsilon < .75$ ) the Greenhouse-Geisser correction should be applied.

When post-hoc tests were used, Type I error rate was controlled using the Bonferroni method. Changes in dependent variables within different stuttering severity ratings were investigated in Section 6.5. In this section the Wilcoxon signed-rank test was performed to determine the effect on the SSI-4 severity ratings. For the device effects within the two sample severity groups, separate MANOVAs with consecutive univariate ANOVAs for each analyzed speech sample were computed. Section 6.7. summarizes the subjective impressions of the participant group in regards to the device usage. For the three different variables considered the Pearson chi-square test, a paired samples t-test as well as the Wilcoxon signed rank test were performed.

## **Chapter 6: Results – immediate effects**

### **6.1. Effects on stuttering frequency and duration**

In order to determine the overall effect each device had on the fluency of the participant group, changes in frequency and mean duration of the total dysfluencies were determined. Mean duration of all stuttering events were calculated using the software program Fluency Meter Science Edition (Glück, 2003) by dividing the total time of the assessed dysfluencies by the total number of dysfluencies. Resulting in an average duration of dysfluencies measured in seconds. The aforementioned software program also calculated the frequency of all dysfluencies by providing a total number and percentage of stuttered syllables for each speech sample.

Repeated Measures ANOVAs were calculated for all collected speech samples (reading, monolog, dialog), within the baseline and with device conditions. The frequency of moments of stuttering, measured in percent stuttered syllables (%SS) and the mean duration of the observed dysfluencies served as dependent variables. Table 12 provides a summary of all collected syllables within each speech sample recording.

#### **6.1.1. Frequency**

The results show that there was a significant group effect in the occurrence of stuttered syllables between the baseline and with device conditions  $F(1.76, 51.08) = 4.89, p = .014, \eta^2 = .145$ . It was evident, that when comparing the baseline to the with device conditions, stuttering was reduced significantly while using both Device A ( $p = .000$ ) and Device B ( $p = .000$ ).

#### **6.1.2. Duration.**

There was no significant difference in the average length of moments of stuttering  $F(2, 58) = .27, p = .762, \eta^2 = .009$  when speaking while using a device. These results suggest that even though moments of stuttering appeared less often during the with device conditions, the average lengths of the still occurring dysfluencies remained essentially unaltered.

Table 12: Means (*M*) and standard deviations (*SD*) of syllables across experimental conditions

	Experimental Conditions					
	No Device		Device A		Device B	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total number of syllables	3008.33	911.66	2919.17	721.16	2965.66	785.99
Number of fluent syllables	2866.77	939.69	2825.47	735.24	2872.23	935.77
Number of dysfluent syllables	141.56	101.63	93.70	88.93	93.44	96.54
Percent stuttered syllables	5.79	4.72	3.75	3.95	3.45	3.30

## **6.2. Influence on speech and articulatory rate**

For the purposes of this study, speech rate was measured in syllables per minute. The term speech rate refers to the pace at which a person produces spoken syllables. Both fluent and dysfluent syllables are considered when computing speech rate. The mean results for speech rate within each experimental condition were compared in order to detect changes in the pace of overall speech production. Additionally, changes in articulatory rate were investigated. Contrary to speech rate, articulatory rate measures the speed at which fluent speech is produced. Therefore, dysfluent syllables were not considered in the computation of articulatory rate, which is also measured in syllables per minute.

### **6.2.1. Speech rate**

Results revealed that there was no significant group effect in speech rate  $F(2.08, 60.18) = 1.18, p = .323, \eta^2 = .038$ . This result indicates that the evaluated subject group did not experience a notably slower speech rate while exposed to AAF.

### **6.2.2. Articulatory rate**

Results revealed that there was no significant group effect in articulatory rate  $F(2.09, 60.54) = 1.98, p = .145, \eta^2 = .064$ . Based on this result, it is evident that there were no statistically significant changes in articulatory rate when comparing the baseline to the with device experimental conditions. This indicates, that fluent speech output was also produced at an unaltered speed, whether or not a device was used.

### **6.3. Impact on stuttering type**

In order to determine the effect of each with device condition on the frequency of different core behaviors, three types of dysfluencies were considered during the speech sample analysis; repetitions (consisting of sound and syllable repetitions), prolongations, and blocks (comprised of silent and audible blocks). For statistical calculations, the occurrence of these three symptom groups, measured in percent stuttered syllables, operated as dependent variables.

#### **6.3.1. Total Repetitions**

Findings suggest that there was no significant group effect in the frequency of total repetitions among the two with device conditions  $F(1.52, 44.11) = .861, p = .402, \eta^2 = .029$ , indicating that the use of a device did not impact the occurrence of repetitions.

#### **6.3.2. Prolongations**

There was also no significant group effect in the occurrence of prolongations throughout the baseline, Device A and Device B conditions  $F(1.75, 50.62) = .645, p = .508, \eta^2 = .022$ .

#### **6.3.3. Total Blocks**

Findings suggest that there was a significant group effect in the occurrence of total blocks among the two with device conditions  $F(1.73, 50.06) = 9.35, p = .001, \eta^2 = .244$ . Results showed, that blocks were reduced

significantly during both with device conditions (Device A:  $p = .017$ ; Device B:  $p = .049$ ).

Based on these results, the AAF devices appeared to decrease the occurrence of blocks during the administered speech samples. However, the stuttering symptoms of prolongations and repetitions were not affected by the use of a device.

#### **6.4. Effects on speech samples**

Another repeated measures ANOVA was calculated to differentiate the effect of the device use on the three administered speech samples (reading, monolog, dialog). The goal was to distinguish whether there was a reduction in stuttering across all speech samples or whether a decline in dysfluencies was limited to specific speech tasks alone. Frequency of moments of stuttering, measured in percent stuttered syllables (%SS), served as dependent variable.

##### **6.4.1. Reading**

The findings suggest that there was a significant group effect in the frequency of stuttering during the reading task  $F(1.86, 54.17) = 7.29$ ,  $p = .002$ ,  $\eta^2 = .201$ . The subject group experienced a significant reduction in stuttering while using both devices during the scripted speech task (Device A:  $p = .002$ ; Device B:  $p = .007$ ).

##### **6.4.2. Monolog**

There was also a significant decrease in dysfluencies during the spontaneous speech task of holding a monolog  $F(2, 58) = 9.64$ ,  $p = .000$ ,  $\eta^2 = .249$ . This decline in stuttering was evident during both device conditions (Device A:  $p = .009$ ; Device B:  $p = .001$ ).

##### **6.4.3. Dialog**

The evaluated subject group further appeared to benefit from the device use during the conversational speech task  $F(2, 58) = 7.63$ ,  $p = .001$ ,

$\eta^2 = .208$ . Stuttering was reduced significantly when using both devices (Device A:  $p = .048$ ; Device B:  $p = .005$ ).

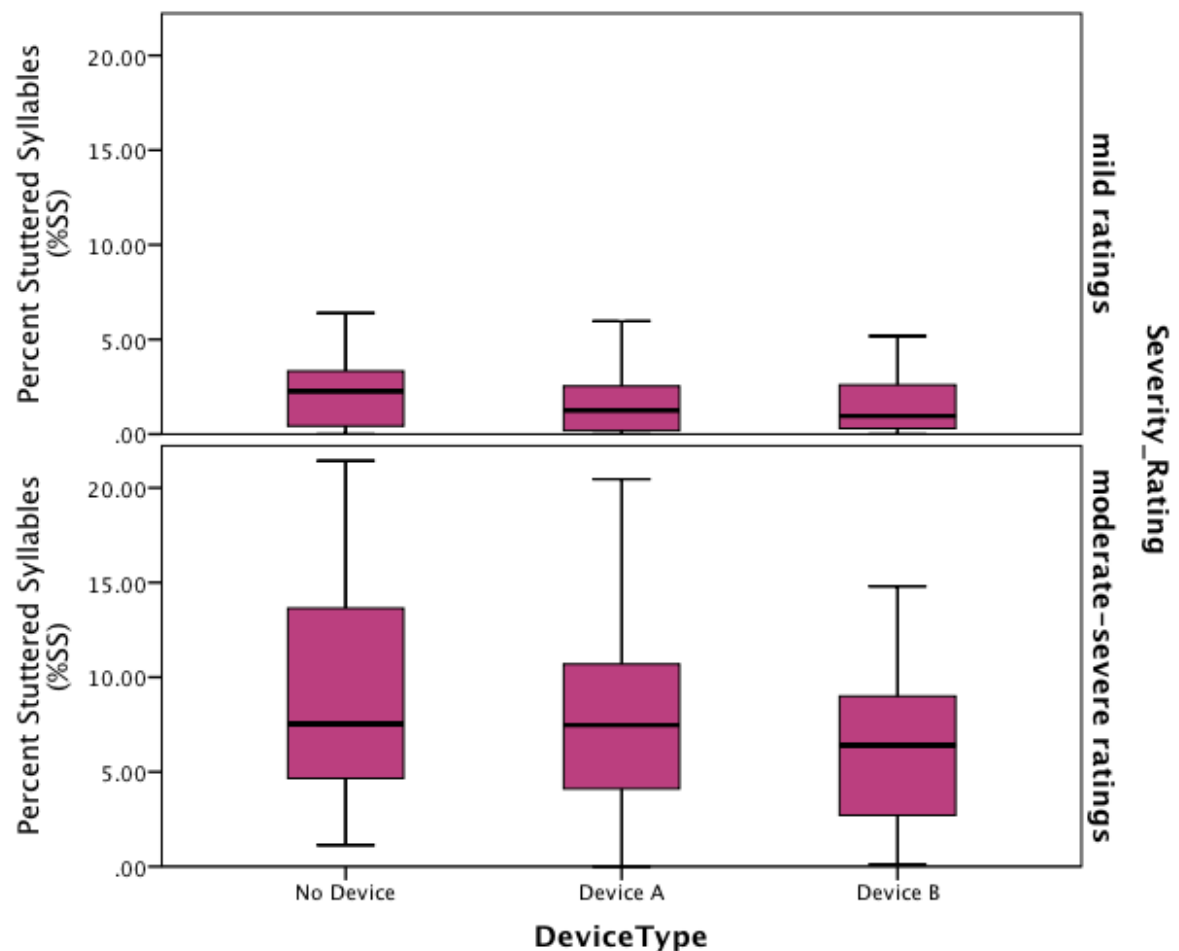
The use of a device significantly lowered dysfluencies during all administered speech samples. However, reductions in %SS varied between speech tasks; reading:  $M = 2.33$ ,  $SD = 3.75$ ; monolog:  $M = 2.26$ ,  $SD = 3.32$ ; dialog:  $M = 1.49$ ,  $SD = 2.71$ . While subjects appeared to benefit from the use of a device during scripted and spontaneous speech, the mean reduction in dysfluencies did not result in stutter-free speech within any sample. Descriptive statistics show, that stuttering remained most evident during the spontaneous speech tasks (monolog:  $M = 3.97$ ,  $SD = 4.10$ ; dialog:  $M = 4.32$ ,  $SD = 4.25$ ), indicating that an AAF device had a dominant impact on stuttering during scripted speech tasks (reading:  $M = 2.99$ ,  $SD = 4.82$ ).

### **6.5. Fluency-enhancement across severity ratings**

The Stuttering Severity Instrument – 4 (SSI-4, Riley, 2009) was used to calculate stuttering severity. This norm-referenced tool defines the severity of stuttering based on five categories (1 = very mild stuttering, 2 = mild stuttering, 3 = moderate stuttering, 4 = severe stuttering, and 5 = very severe stuttering). A severity rating was calculated for each participant based on the speech samples collected during the No Device, Device A, and Device B conditions (based on a reading, monolog and dialog sample). The Placebo condition, which was only administered during one reading sample, did not provide a suitable sample basis to calculate a severity rating based on the SSI-4. The Wilcoxon signed-rank test was performed to determine whether there was a mean difference in stuttering severity across subjects in each experimental condition. Results revealed that there was a significant group effect in the SSI-4 severity ratings when comparing the No Device to the Device A rating  $z = 3.75$ ,  $p = .000$ ,  $r = -0.48$  and the baseline to Device B severity rating  $z = 3.63$ ,  $p = .000$ ,  $r = -0.47$ . More specifically, the Wilcoxon test revealed that for Device A 17 subjects showed a decline in their stuttering severity rating while the use of this device did not result in a lowered SSI-4 score for 13 participants. Throughout the Device B experimental condition, the SSI-4 rating decreased for 16 subjects and remained unaltered for 14.

In order to investigate the impact a device can have on individuals of different stuttering severities more closely, I examined the SSI-4 severity ratings of the 30 PWS who partook in this investigation more closely. Fourteen participants fell into the mild severity categories of “very mild” and “mild”. Sixteen subjects received advanced baseline ratings of advanced severities including “moderate”, “severe” and “very severe”. I split our participant group into these two SSI-4 based severity groups and performed MANOVAs for each group within each speech sample. The intention was to determine whether or not one of the severity groups would benefit from the use of a device more distinctly. Figure 7 presents an overview of the percentage of dysfluent syllables produced within each severity group.

Figure 7: Mean percent stuttered syllables (%SS) for three experimental conditions and all speech samples within two stuttering severity groups



### 6.5.1 Reading

There was a non-significant effect on the occurrence of dysfluencies within the mild  $F(2,12) = 2.98, p = .089, \eta^2 = .332$  severity group while using a device. For the mild group, the SS% did not change to a statistically significant degree during the use of Device A  $F(1, 13) = 3.57, p = .081, \eta^2 = .261$  or Device B  $F(1, 13) = 2.69, p = .125, \eta^2 = .171$ . However, for the group of clients with moderate to severe SSI-4 ratings, the use of a device resulted in a statistically significant change in %SS while reading  $F(2, 14) = 3.75, p = .049, \eta^2 = .349$ . The occurrence of stuttered syllables was reduced significantly while using both Device A  $F(1, 15) = 7.60, p = .015, \eta^2 = .336$  and Device B  $F(1, 15) = 7.59, p = .015, \eta^2 = .336$ .

### **6.5.2. Monolog**

There was a significant group effect among both the mild  $F(2, 12) = 7.79, p = .007, \eta^2 = .565$ , and moderate-severe  $F(2, 14) = 15.49, p = .000, \eta^2 = .689$ , SSI-4 severity groups, indicating that the use of a device impacted the frequency of stuttering experienced. The mild severity group showed statistically significant differences in %SS when using Device A  $F(1, 13) = 58.26, p = .001, \eta^2 = .554$  and Device B  $F(1, 13) = 51.98, p = .018, \eta^2 = .359$ . The moderate-severe group showed similar improvements during the use of Device A  $F(1, 15) = 21.81, p = .000, \eta^2 = .592$  and Device B  $F(1, 15) = 30.13, p = .000, \eta^2 = .668$ .

### **6.5.3. Dialog**

There was further a significant group effect in terms of the %SS experienced during conversational speech. Both the mild  $F(2, 12) = 8.49, p = .005, \eta^2 = .586$  and moderate-severe SSI-4 categories  $F(2, 14) = 14.04, p = .000, \eta^2 = .667$  significantly benefited from the use of a device. Within the mild severity group, the frequency of stuttered syllables was decreased significantly while using both Device A  $F(1, 13) = 18.37, p = .001, \eta^2 = .586$  and Device B  $F(1, 13) = 15.84, p = .002, \eta^2 = .549$  conditions. Similarly, the group who fell within the moderate-severe ratings also experienced a significant reduction in the occurrence of stuttered syllables during the use of both Device A  $F(1, 15) = 27.24, p = .000, \eta^2 = .645$  and Device B  $F(1, 15) = 28.95, p = .000, \eta^2 = .659$ .

In summary, both severity groups (mild and moderate-severe) showed reductions in the amount of symptoms experienced during the spontaneous speech tasks. Table 13 displays a summary of the percentage of stuttered syllables (%SS) within two stuttering severity groups. These results show that only those subjects with more advanced severity ratings (moderate-severe) benefited from the use of an AAF speech aid to a statistically significant degree during the scripted speech task.

Table 13: Means (*M*) and standard deviations (*SD*) of percentage stuttered syllables (%SS) across all experimental conditions and speech samples split by stuttering severity rating

SSI-4 severity rating	Reading				Monolog				Dialog			
	mild ratings*		moderate –severe ratings**		mild ratings*		moderate –severe ratings**		mild ratings*		moderate –severe ratings**	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No Device	1.52	2.33	8.65	6.46	2.77	2.39	9.25	4.82	2.28	1.37	8.90	5.10
Placebo	1.20	1.38	6.39	6.54								
Device A	.79	1.57	4.03	5.85	2.04	1.90	6.12	5.34	1.98	1.73	6.74	5.16
Device B	1.24	2.84	3.57	5.18	1.93	2.67	5.31	3.87	2.09	1.96	5.91	4.39

\* includes SSI-4 severity ratings “very mild” and “mild”

\*\* includes SSI-4 severity ratings “moderate”, “severe” and “very severe”

## 6.6. Changes in speech fluency during the Placebo setting

The Placebo setting, during which a device without active AAF settings was used, was administered for the scripted speech sample. The goal was to determine if changes in speech fluency could be achieved while the participants were under the impression of being exposed to AAF.

### 6.6.1. Stuttering Frequency

There was a significant group effect in the amount of stuttered syllables exhibited during the Placebo setting  $F(1, 29) = 5.34, p = .028, \eta^2 = .155$ . This result indicates that stuttering occurred less often while reading within the Placebo condition. When further comparing the Placebo reading condition with the reading samples collected during the active device settings, a non-significant effect is visible. Such a non-significant change is evident, when comparing the Placebo to the Device A reading sample,  $F(1, 29) = 3.19, p = .084, \eta^2 = .099$  and the Placebo to the Device B reading sample  $F(1, 29) = 2.77, p = 1.07, \eta^2 = .087$ . For the reading samples this means that there was

no mathematically meaningful additional benefit of the active device conditions in comparison to the Placebo condition. When taking descriptive statistics into account, the additional fluency enhancement during the active device conditions is roughly another one percent decrease in the percentage of stuttered syllables (difference between Placebo and Device A condition:  $M = 1.39$ ,  $SD = 5.06$ ; difference between Placebo and Device B condition:  $M = 1.48$ ,  $SD = 4.91$ ). For the naturally rarely encountered communicative context of reading aloud this result shows, that the subject group experienced a fluency enhancement whether or not the device features were activated.

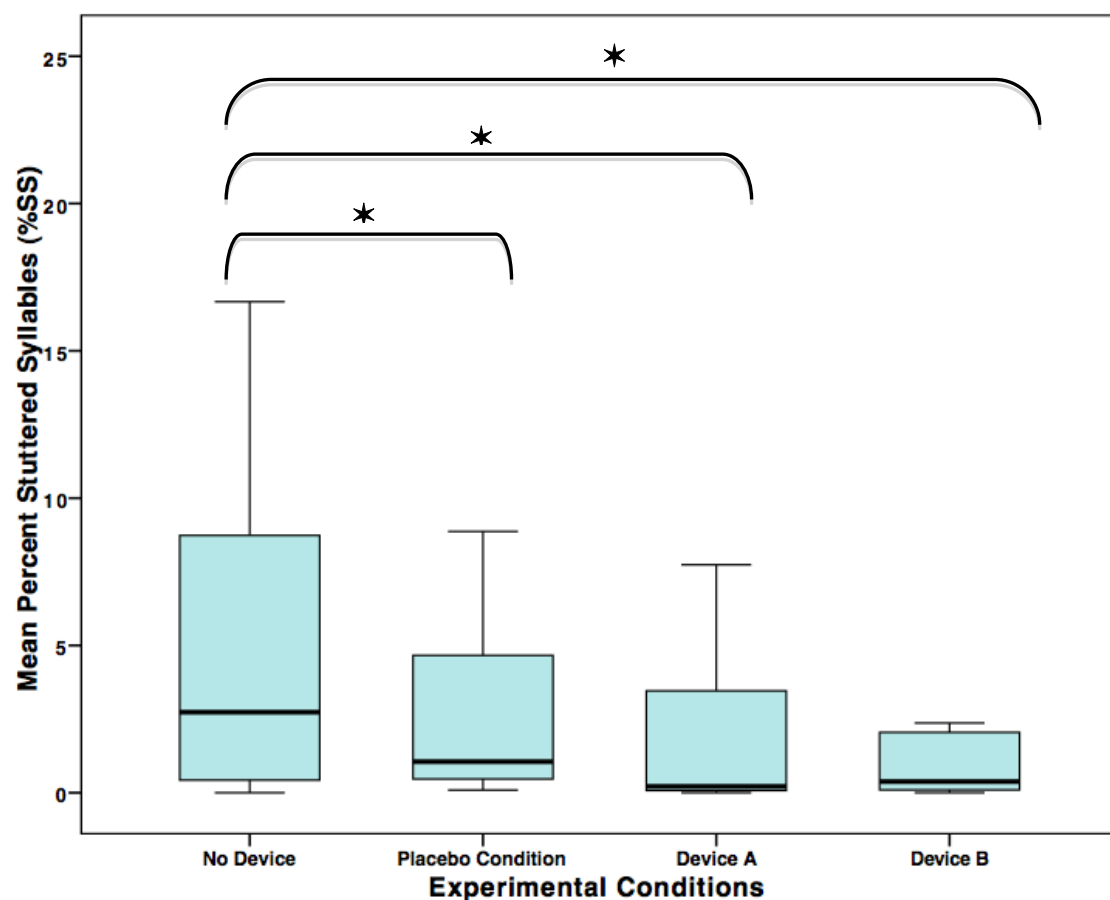
#### **6.6.2. Influence on the percentage stuttered syllables (%SS) within low and high SSI-4 severity ratings**

In order to see whether the different severity ratings responded to the Placebo setting, the participant group was split into two severities; those with low ratings (SSI-4 severity ratings of “very mild” and “mild”) and those participants with high severity ratings (SSI-4 severity ratings of “moderate”, “severe” and “very severe”) were differentiated. The SS% during the Placebo setting and the %SS during the reading passage without a device were compared. The low severity group showed a non-significant reduction in the occurrence of stuttered syllables while exposed to the Placebo setting  $F(1, 13) = .245$ ,  $p = .629$ ,  $\eta^2 = .018$ . However, those participants within the higher severity ratings presented with a statistically significant decrease in %SS while exposed to the placebo setting  $F(1, 15) = 6.30$ ,  $p = .024$ ,  $\eta^2 = .296$ .

Results show that there was a statistically significant decrease in the frequency of stuttered syllables (%SS) across the entire participant group (No Device:  $M = 5.32$ ,  $SD = 6.09$ ; Placebo setting:  $M = 3.97$ ,  $SD = 5.47$ ). When splitting the subjects into two severity groups (low SSI-4 severity ratings: “very mild” and “mild”; high SSI-4 severity ratings: “moderate”, “severe” and “very severe”) the statistically significant reductions in %SS were confirmed for moderate-severe group. The mild severity group however, was not responsive to the Inactive Condition. This could indicate that the responsiveness to an Inactive Condition depends on a person’s stuttering severity. However, with the current sample group the more likely explanation is that those subjects in

the mild severity group experienced minimal stuttering during the No Device when reading ( $M = 1.52$ ,  $SD = 2.33$ ). Based on this low figure it may simply be impossible to achieve a reduction in stuttering that accounts for a statistically significant change. Figure 8 shows the mean percentage of stuttered syllables produced during the reading samples within four experimental conditions.

Figure 8: Percent stuttered syllables (%SS) throughout the Baseline, Placebo and With Device experimental conditions during the reading samples for all subjects ( $N = 30$ )



Statistically significant effects are marked with a star (\*). When comparing the four experimental conditions, the differences in %SS reached a statistically significant level ( $p < .05$ ) within the following variables: No Device – Placebo; No Device – Device A; No Device – Device B.

### **6.7. Subjective impressions of the device usage**

After all speech samples had been recorded, each participant was asked to complete a brief questionnaire summarizing their personal experience of the usage of both devices. The subsequent section summarizes the findings in regards to three questions: did the participants feel the use of a device improved their speech fluency, how comfortable was the use of each device, and would the participants choose to use an AAF device as a speech aid in daily live?

#### **6.7.1. Subjective improvement**

Participants were asked to check mark a simple yes/no question stating whether or not they thought the use of a device had improved their fluency. For each device, 16 clients reported that they had experienced an enhancement in fluency while 14 participants stated that they had not observed an increase in fluency. Based on the results of the Pearson chi-square test, there was a non-significant association between the type of device used and whether or not clients perceived a fluency enhancement  $\chi^2(1) = 0, p = 1.00$ .

#### **6.7.2. Wearing comfort**

Subjects were further asked to rate how comfortable they perceived the device specific features (such as type of headphones used, sound quality, adjustment options) to be on a four point rating scale (1= excellent, 2 = good, 3 = mediocre, 4 = bad). A paired samples t-test indicated that there was a significant relationship between the type of device used and the comfort rating expressed by the subject group  $t(29) = -9.52, p = .000$ . Based on these results, the current subject group generally perceived device specific features as more comfortable in Device A ( $M = 2.17, SD = .79$ ) as compared to Device B ( $M = 3.13, SD = 1.01$ ).

#### **6.7.3. Usage in daily life**

Based on the trial use of both devices experienced during this investigation, subjects were asked whether or not they would choose to use

one of the AAF device as a therapeutic aid in situations of daily living. Three answer options (1 = yes, 2 = maybe, no = 3) were provided. The Wilcoxon signed-rank test indicated, that participants generally had a more positive outlook on the possible use of Device A ( $Mdn = 2$ ) in speaking situations of daily live as compared to Device B ( $Mdn = 3$ )  $z = 3.16$ ,  $p = 0.02$ ,  $r = -.041$ .

## **Chapter 7: Discussion – immediate effects**

### **7.1. Summary of findings and conclusion**

Numerous studies have documented an increase in speech fluency during scripted speech while exposed to various forms of AAF (e.g. Macleod et al., 1995; Zimmermann et al., 1997; Armson et al., 1997; Armson & Stuart, 1998; Van Borsel et al., 2003). More diverse findings exist regarding the influence of AAF on spontaneous speech (Antipova et al., 2008; O'Donnell et al., 2008; Pollard et al. 2009; Lincoln et al., 2010). The present study attempted to add to the current body of knowledge regarding the immediate effect of AAF on the speech of PWS. The results were achieved by evaluating the impact of two commercially available AAF aids on clinical features of stuttering during both scripted and spontaneous speech.

In agreement with the results of many aforementioned studies, a significant reduction in the occurrence of dysfluencies during scripted speech was found. Even though descriptive statistics show discrepancies in the individual degree of improvement, I found a significant group effect in the reduction of %SS during the spontaneous speech tasks. Despite this positive finding, a closer examination of the average duration of remaining moments of stuttering showed no decreases in length. This result is inconsistent with other findings (Martin & Haroldson, 1979; Stuart, et al., 2008), which established statistically significant differences in the duration of dysfluencies while subjects were exposed to one form of AAF. In terms of the specific impact on the core behaviors of stuttering, this study looked at reductions in the occurrence of three symptom groups; repetitions, prolongations, and blocks. A study by Stuart et al. (2008) did not discover any specific reductions in the proportion of three evaluated core behaviors (sound prolongations, sound repetitions, and inaudible blocks) during an oral reading task while exposed to FAF. The results of the current study revealed a significant reduction in blocks during both scripted and spontaneous speech while using a device. The differing results on duration and stuttering type may imply that the effects of exposure to only one form of AAF during an oral reading task are different

from the fluency-enhancing effects that can be achieved while using a portable AAF device that employs the choral effect during diversified speaking situations.

An important result of this study lies within the evaluation of a Placebo condition on the frequency of stuttering. A significant reduction in the frequency of dysfluencies was evident within the moderate-severely rated participant group while reading when exposed to a Placebo setting. This finding supports the view of Bloodstein & Bernstein Ratner (2008) who suggested that the effects of AAF may be achieved through a so called “novelty effect”. They concluded, “that any change in stutterers’ accustomed way of hearing themselves speak is likely to alleviate their speech difficulty.” (p. 301). Hearing one’s own voice while wearing headphones, even without a displayed delay or shift in frequency, is unfamiliar. Such an “unaccustomed” perception of the speech signal may account for the significant reductions in %SS experienced by the participant group.

This study also investigated the effect of minimally invasive AAF settings on the severity ratings of the SSI-4 (Riley, 2009). Results show that the improvements in fluency, namely the reduction in stuttering frequency, were substantial enough to lower the stuttering severity ratings for 16 of the 30 participants. However, the fact that the severity ratings of 14 subjects did not change implies that the degree of one’s stuttering might be linked to the extent of fluency enhancement experienced while using an AAF aid. To further evaluate this assumption, the participant group was split into a mild (including the SSI-4 based severity ratings of “very mild” and “mild”) and moderate-advanced group (including the SSI-4 ratings of “moderate”, “severe” and “very severe”). Within these two groups the reduction in %SS were calculated during the administered speech samples (reading, monolog, dialog). Results showed that the mild severity group experienced statistically significant reductions in stuttering but only during the spontaneous speech tasks. Those clients within the moderate-severe categories presented with significant decreases in stuttering during all recorded speech samples. Table 14 provides a summary of all statistically significant effects for both severity groups. On the one hand, this result implies that the use of an AAF device may be most useful for those individuals with a more advanced form of

stuttering, since it alleviates stuttering to a significant degree in all speaking situations. On the other hand it could be argued, that the lack of improvement during the reading task for those in the mild categories may be explained by a “floor effect”. Meaning that the %SS during this speech task was low to begin with ( $M = 1.44$ ,  $SD = 1.48$ ), leaving little room for further improvement. Antipova et al. (2008) have also pointed out the possibility of a “floor effect” when analyzing reductions in stuttering within the mild severity ratings of the SSI (p. 286). However, one chooses to explain the differences in the observed fluency enhancements, this data set shows consistent results for the use of a device during spontaneous speech, which is the most commonly encountered form of speech in daily life.

With these documented quantitative reductions of stuttering in mind, it becomes important to evaluate the quality of these changes by considering the benefit of these alterations from the perspective of PWS. The assessment of the subjective participant impressions during the device usage revealed some interesting trends. Regardless of which speech aid was used, only 16 of the 30 participants reported that they felt their speech had improved while using a device. These 16 subjects consisted of eight PWS who fell within the mild severity ratings and eight individuals who were categorized as moderate-severe stutterers. This observation implies, that the individual decision whether or not a device is successful in easing stuttering is independent of the severity of one’s stuttering. These results are in line with evidence presented by other studies (Pollard et al., 2009; Molt, 2006) that reported discrepancies between improvements in quantitative measures of stuttering and the extent to which device users experienced improvement. This is an important consideration since it is ultimately not only evidence-based fluency enhancements that determine the success of a treatment but the client’s contentedness.

Table 14: *p*-values for all statistically significant effects across all speech samples and experimental conditions (alpha level:  $p < .05$ )

	Placebo Device A				Device B		
	RD*	RD*	MO**	DI***	RD*	MO**	DI***
Stuttering Frequency (% SS)							
Entire subject group	.028	.002	.009	.048	.007	.001	.005
Mild severity ratings (SSI-4, Riley, 2009)	<i>NS</i>	<i>NS</i>	.001	.001	<i>NS</i>	.018	.002
Moderate-advanced severity ratings (SSI-4, Riley, 2009)	.024	.015	.000	.000	.015	.000	.000
All speech samples & all subjects							
Blocks		.017			.049		
SSI-4 severity rating		.000			.000		

\* = reading

\*\* = monolog

\*\*\* = dialog

## 7.2. Limitations and future research directions

One limitation of this study may be the use of pre-set AAF settings. Another recent investigation by Lincoln et al. (2010) noted “using the same setting for all participants during conversation is likely to underestimate the effects of AAF, given that individuals respond differently to different settings” (p. 1130). Even though the goal of the current study was to find group effects for the analyzed features, I also noticed an individual response pattern to the chosen AAF settings. While it is likely that specified settings could increase the fluency-enhancement experienced, it remains difficult to obtain such individualized settings. One obstacle is the circumstance that there is no generalized procedure of how to find such an ideal, individualized AAF setting. The authors of the aforementioned study suggested that the

exploration of such settings could best be achieved through “carefully designed case studies” (p. 1130) rather than group research. However, one would have to carefully consider how to investigate the most effective individual setting. Both quantitative measures, such as reductions in percent stuttered syllables, as well as qualitative factors, such as client perception of the experienced aural modification, should be considered. In light of recent results presented by this and other studies (Molt, 2006; Pollard, et al., 2009; Bray, James, 2009) showing inconsistencies in the subjective impressions and measurable reductions in stuttering in some participants, it may prove rather difficult to obtain general, evidence-based suggestions on the ideal AAF settings. Therefore, it may be most beneficial to focus future research efforts on the conceptualization of a longitudinal setting protocol. Based on the best-practice guidelines for stuttering treatment (ASHA, 1995), such a protocol could provide periodical evaluations of objective measures of clinical categories of stuttering as well as subjective client ratings. Implemented over time and in various speaking situations, it may serve as a form of ongoing assessment that could be used for any device make and model. Such a process may serve as a suitable tool in the search for a setting most likely to achieve the maximum individual fluency-enhancement possible in everyday life.

Another research design limitation is the order of the administered experimental conditions. While the speech tasks varied within the experimental conditions, the conditions themselves had to remain constant (1. No Device, 2. Placebo, 3. Device A, 4. Device B). A randomized occurrence of the active AAF conditions would have been desirable to avoid a possible order effect. However, in an effort to conceal the Placebo setting it was preferable for the subjects to wear the same headphones during both the Placebo and the first active AAF condition. The software component of Device A made it possible to program these inactive AAF settings into the device. For this purpose the DAF and FAF capacity of the device was disabled. Since both the Placebo setting and active Device A settings were displayed through the same headphones, the active AAF settings of Device A always had to follow the Placebo setting. In order to investigate the power of the “novelty effect” as well as the extent of active AAF settings more closely, it may be

worthwhile to conduct a longitudinal clinical trial including a Placebo setting. Such an investigation could help to differentiate the long-term benefits of AAF from those speech improvements caused by sheer originality of the unaccustomed aural feedback.

## **PART III: THREE-MONTH LONGITUDINAL TRIAL**

### **Chapter 8: Materials and methods**

#### **8.1. Participants**

A group of six PWS (one female and five males) partook in this study. The subject group was recruited from the larger group of participants, who had previously partaken in the immediate effect trial presented in Chapters 5-7 of this paper. They therefore met the same inclusion criteria as the larger sample group. Participation in the longitudinal trial was also based on the willingness to utilize an AAF device in situations of daily living, throughout a period of three month. Additionally, clients were expected to appear in person for data collection in the form of speech sample recordings both at the beginning (T1) and end (T4) of the three-month trial period. They also had to be willing to partake in two mid-trial phone conversations (T3 & T4) and complete a weekly questionnaire and user diary. Finally, each participant had to undergo a technical introduction and individualized setting calibration of the AAF device they were provided with, at the beginning of the trail.

#### **8.2. Apparatus**

Each participant was provided with a loaned VA 601i Fluency Enhancer (VoiceAmp, Cape Town, South Africa). This device has the ability to modify the auditory signal utilizing both DAF and FAF. The DAF settings employ milliseconds (ms) as their delay unit while FAF is measured in Hertz (Hz). Each device has three program options, which consist of generic or custom programmed DAF and FAF settings. A fourth program exists, which displays masking noise (MAF) only. Table 15 displays the custom calibrated programs used for each participant during this trial. Each setting was programmed into the device using the *VA601i Calibration Wizard* software during the initial data collection point and device pick-up meeting at the University of Education Heidelberg. Subjects were given one device each as

well as two different headphone options; a monaural, wired ear-bud (Nokia, HDC 5) and a loop neck microphone (Artone, Neckloop) with a wireless earpiece (Starkey, ITE). Subjects therefore had the chance to use either the wired headphone or wear the device in a less visible manner using the wireless ear bud. The latter option resembles an in-the-canal hearing aid and connects to the AAF device via the inductive loop microphone, worn around the subject's neck.

Table 15: Summary of altered auditory feedback (AAF) settings across all data collection points

		AAF setting programs					
Subject	Gender	Program 1		Program 2		Program 3	
		DAF	FAF	DAF	FAF	DAF	FAF
Initial data collection (T1)							
Subject 1	Male	<b>60ms*</b>	<b>100Hz</b>	80ms	40Hz	100ms	200Hz
Subject 2	Male	<b>60ms</b>	<b>100Hz</b>	90ms	200Hz	120ms	350Hz
Subject 3	Male	<b>60ms</b>	<b>100Hz</b>	80ms	200Hz	100ms	350Hz
Subject 4	Female	<b>50ms</b>	<b>250Hz</b>	100ms	350Hz	120Hz	450Hz
Subject 5	Male	<b>60ms</b>	<b>100 Hz</b>	90ms	350Hz	100ms	200Hz
Subject 6	Male	<b>60ms</b>	<b>100Hz</b>	80ms	40Hz	100ms	200Hz
First mid-trial data collection (T2)							
Subject 1	Male	<b>60ms</b>	<b>100Hz</b>	80ms	40Hz	100ms	200Hz
Subject 2	Male	<b>80ms</b>	<b>100Hz</b>	90ms	7Hz	120ms	5Hz
Subject 3	Male	<b>60ms</b>	<b>100Hz</b>	80ms	200Hz	100ms	350Hz
Subject 4	Female	<b>50ms</b>	<b>250Hz</b>	100ms	350Hz	120Hz	450Hz
Subject 5	Male	60ms	100 Hz	<b>90ms</b>	<b>350Hz</b>	100ms	200Hz
Subject 6	Male	60ms	100Hz	<b>80ms</b>	<b>40Hz</b>	100ms	200Hz
Second mid-trial data collection (T3)							
Subject 1	Male	<b>60ms</b>	<b>100Hz</b>	80ms	40Hz	100ms	200Hz
Subject 2	Male	126ms	2Hz	<b>100ms</b>	<b>1500Hz</b>	120ms	5Hz
Subject 3	Male	50ms	247ms	<b>80ms</b>	<b>200Hz</b>	100ms	350Hz
Subject 4	Female	<b>50ms</b>	<b>250Hz</b>	100ms	350Hz	120ms	100Hz
Subject 5	Male	210ms	98Hz	<b>205ms</b>	<b>114Hz</b>	196ms	96Hz
Subject 6	Male	180ms	1500Hz	<b>90ms</b>	<b>530Hz</b>	63ms	228Hz

## Final data collection (T4)

Subject 1	Male	<b>60ms</b>	<b>100Hz</b>	80ms	40Hz	100ms	200Hz
Subject 2	Male	126ms	2Hz	<b>100ms</b>	<b>1500Hz</b>	120ms	5Hz
Subject 3	Male	<b>50ms</b>	<b>247ms</b>	80ms	200Hz	100ms	350Hz
Subject 4	Female	<b>50ms</b>	<b>250Hz</b>	100ms	350Hz	120ms	100Hz
Subject 5	Male	210ms	98Hz	205ms	114Hz	<b>196ms</b>	<b>96Hz</b>
Subject 6	Male	<b>180ms</b>	<b>1500Hz</b>	90ms	530Hz	63ms	228Hz

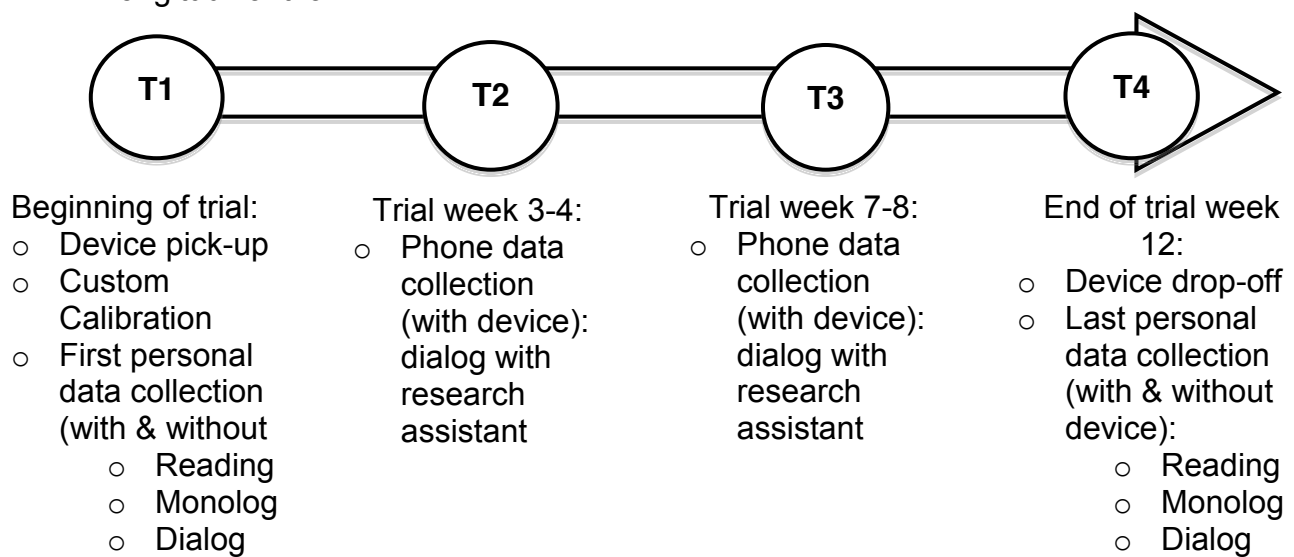
\* bold numbers indicate settings used during each speech sample recording.

### 8.3. Procedure

Each subject who had agreed to partake in the mandatory quantitative and qualitative data collection, scheduled an individualized appointment with the primary investigator at the University of Education Heidelberg. During this meeting, device specific features such as volume control, program readjustment and headphone connection hubs were introduced to each participant. The three programs, which store the generic or individualized pre-set DAF and FAF settings, were also calibrated. For this purpose the primary investigator was trained by the manufacturer to follow calibration protocol and operate the associated software. Settings were stored based on subject preference, with the first program generally containing the least invasive, most natural sounding settings. Following the device calibration, the initial collection of speech samples for quantitative analysis was obtained. For this purpose each subject was asked to read a newspaper article for 5-minutes, hold a monologue about a pre-determined topic for 5-minutes and partake in a 10-minute conversation with the primary investigator about current events. This procedure was conducted once without a device in place, followed by a recording using the AAF device. While subjects were free to select a program of choice for the recording of these speech samples, all of them chose the first program for initial use. During this initial pick-up meeting (T1) subjects were also familiarized with the electronic documents, to be submitted weekly. Each participant was shown how to complete the online questionnaire by check-marking answer options with a mouse click. Additionally, weekly logs in the form of user dairies had to be submitted electronically using pre-formatted

Emails. While the questionnaires collected information on predestined contents such as preferred setting, user environment and quantity, the logs served the purpose of obtaining unobstructed personal experiences regarding the device use. Subjects did not have to use the device at a preset rate or for a minimum duration each week. Rather, the purpose of this investigation was to see how often an AAF device owner uses a device naturally. In order to investigate such use patterns, it was important for subjects to decide freely when and where the use of a device appeared helpful to them. Following the initial quantitative data collection, subjects partook in two mid-trial phone conversations (T2 & T3) with an unfamiliar research assistant. Each phone call was approximately 15-minutes in lengths, including set-up time and a 10-minute dialog considered for data evaluation. The topic of conversation was open, with most dialogs focusing on personal accounts of the device use that week. Calls were pre-scheduled, meaning that the week and approximate time of day during which a subject would receive a call had been discussed previously. This was done in order to ensure that the subject would have the device handy and was able to wear it. Following the three-month period, after subjects had completed trial week 12, they were asked to return the devices in person. During this final meeting (T4) the quantitative data collection was concluded by repeating the recording of speech samples. The same scripted and spontaneous speech samples as during the initial meeting were recorded both without and with a device. Materials used to elicit speech differed in content but followed the same format as those materials used during initial data collection. Figure 9 sums up all quantitative data collection points.

Figure 9: Summary of quantitative data collection points across three-month longitudinal trial



#### **8.4. Research questions**

The results of this longitudinal study are intended to expand current knowledge on both objective and perceived benefits of AAF device use in every-day life. A unique feature of this investigation is the natural rate at which the devices were used throughout the study. In other words, subjects were supposed to use their device whenever they saw fit, rather than at a predetermined rate. This design enables one to collect realistic data on qualitative measurement such as use environments and utilization quantity. The two assessed tiers of data (quantitative and qualitative) are analyzed in detail, in order to provide answers to the following questions:

Quantitative Analysis:

- Does stuttering, as determined by three features of stuttering severity, change to a statistically significant degree, when an AAF device is used consecutively over a three-month period?
  - Contrasted measures of stuttering severity (dependent variables):
    1. Stuttering frequency (measured in percent stuttered syllables/%SS) and duration of moments of stuttering (measured in milliseconds/ms).
    2. Speech and articulatory rate (syllables per minute).
    3. Frequency of three groups of core behaviors (repetitions, prolongations, blocks).

Qualitative Analysis:

- Are there recognizable patterns in terms of AAF device utilization in natural environments?
  - Analysis of device usage in natural environments (dependent variables):
    1. Frequency of device usage.
    2. Usage environments.
    3. Feature usage:
      - a. Setting preference.
      - b. Headphone preference.
  - Analysis of user perception of device usage in natural environments (dependent variables):
    1. Overall user satisfaction.
    2. Prominent concerns during device usage.

### **8.5. Assessment of speech parameters**

For the assessment of the quantitative features of stuttering severity (frequency, duration, speech & articulatory rate, frequency of groups of core behaviors) the software program Fluency Meter Science (Glück, 2003) was utilized. For a detailed description on how this program was used please refer to Section 5.5. Assessment of Speech Parameters of Chapter 5. Fluency Meter Science was employed in the same fashion, with the same criteria in place for data analysis during the immediate effect trial, described in Chapters 5 through 7.

An overall 10 hours of speech recordings, including roughly 38 000 syllables were analyzed both by trained research assistants as well as the primary investigator. The qualitative data on the subjective impression of the device usage was collected using pre-formatted electronic documents. Each subject handed in two documents a week (one questionnaire and one user diary). Answers were coded with a number system and imported into an excel chart, displaying the accumulative answers for the 12 trial weeks for each participant.

### **8.6. Statistical design**

Statistical analysis was conducted using SPSS 19.0 (2011). For the quantitative dependent variables (frequency, duration, speech & articulatory rate, frequency of groups of core behaviors) the Wilcoxon signed-rank test (Wilcoxon, 1945) for non-parametric data was administered. Prior to choosing an appropriate test statistic, the distribution of the data set was tested for normality of distribution using the Kolmogorov-Smirnov test. This test revealed that the data deviated significantly from a normal distribution whenever a device was used, T1:  $D(6) = 0.42$ ,  $p = .001$ ; T4:  $D(6) = 0.31$ ,  $p = .013$ . The Wilcoxon signed-rank test is the recommended non-parametric test statistic for small subject groups when determining the statistical significance of differences in scores derived from the same participants (Field, 2009).

## **Chapter 9: Results - longitudinal effects**

### **9.1. Longitudinal effects of AAF on quantitative features of stuttering severity**

The following paragraphs (9.1.1.- 9.1.5.) exhibit the long-term effects of the portable AAF unit used on the symptoms of stuttering of 6 PWS. The dependent variables examined within the various speech samples collected are displayed in each heading.

#### **9.1.1. Effects on stuttering frequency**

The Wilcoxon signed-rank test was utilized for group analysis ( $N = 6$ ). The differences in stuttering frequency throughout the initial and final data collection points (T1, T4) were considered for each collected speech sample (reading, monolog, dialog). Additionally, the reductions in stuttering frequency, both at the beginning and end of the trial, were compared to each other. This was done in an effort to differentiate whether or not the group would experience a greater fluency enhancement after longitudinal use, as compared to the reduction in dysfluency upon first using a device. Table 16 provides an additional summary of the percentage stuttered syllables (%SS) within the three speech samples collected.

##### **9.1.1.1. Stuttering Frequency during Reading**

For the scripted speech samples the participant group as a whole appeared to benefit from the use of a device in a statistically significant manner. This is true for the initial data collection point, T1:  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$  (No Device:  $Mdn = 1.65$ ; With Device:  $Mdn = .156$ ) as well as the final data accumulation, T4:  $z = -1.992$ ,  $p = .046$ ,  $r = -0.33$  (No Device:  $Mdn = 2.20$ ; With Device:  $Mdn = .512$ ). When comparing the reductions in stuttering frequency at both T1 and T2 a non-significant association is revealed,  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (T1:  $Mdn = 1.50$ ; T4:  $Mdn = .93$ ). This result indicates that the subject group did not experience a greater fluency-enhancement after having used a device for a three-month period.

#### 9.1.1.2. Stuttering Frequency during Monolog

During the monolog speech tasks results reveal a similar trend by showing a statistically significant reduction in stuttering both at the end and the beginning of the study, T1:  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$  (No Device:  $Mdn = 3.20$ ; With Device:  $Mdn = 1.50$ ). ; T4:  $z = -1.992$ ,  $p = .046$ ,  $r = -0.33$  (No Device:  $Mdn = 4.84$ ; With Device:  $Mdn = 2.08$ ). When comparing the reductions within the initial and final data collection points, a non-significant association is evident,  $z = -.314$ ,  $p = .753$ ,  $r = -.064$  (T1:  $Mdn = 1.39$ ; T4:  $Mdn = 1.04$ ). This result shows that for the current subject group, the long-term effects of using a device did not outweigh its immediate effects.

#### 9.1.1.3. Stuttering Frequency during Conversation

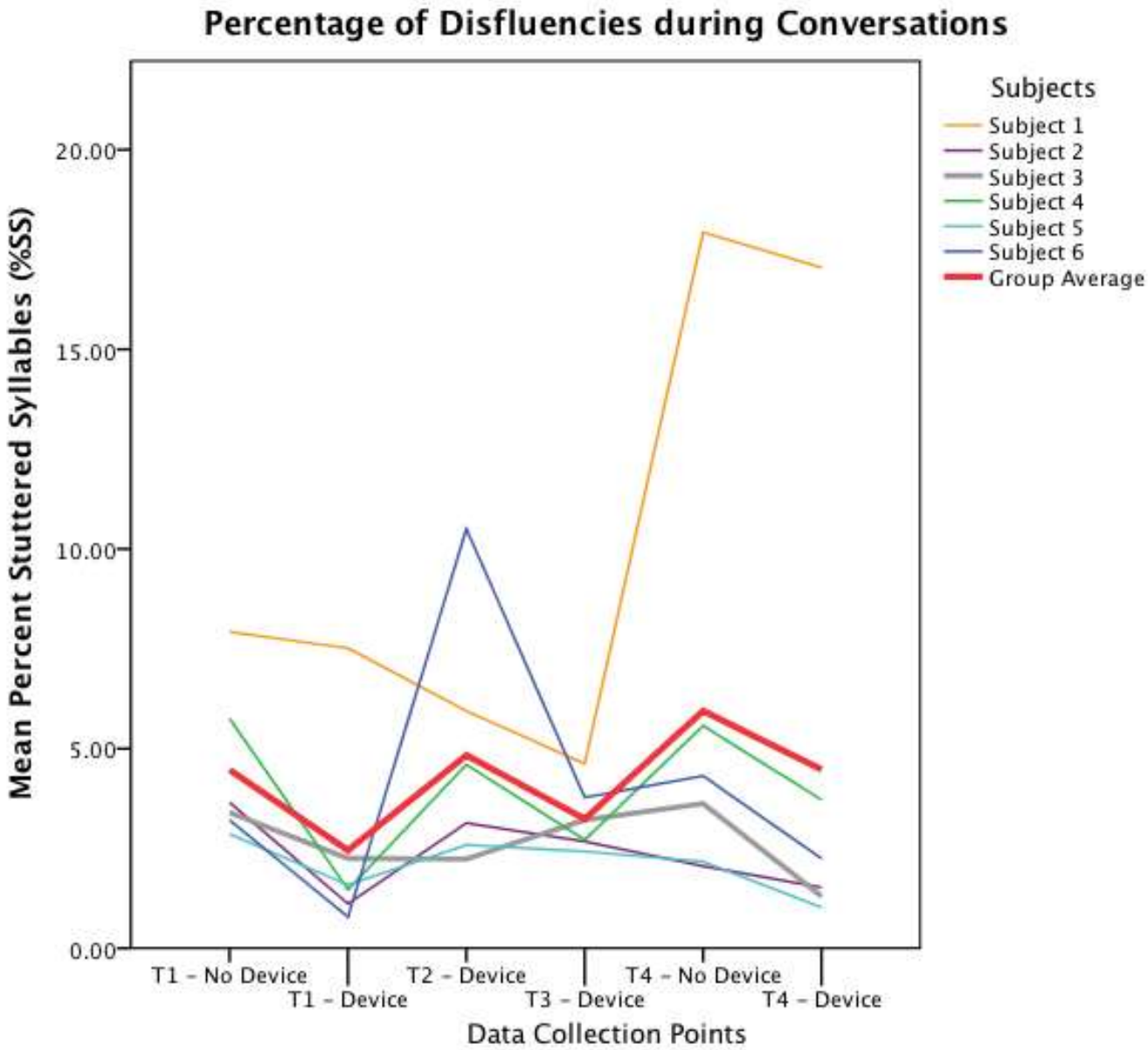
Results reveal that conversational speech was significantly more fluent when using a device during T1,  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$  (No Device:  $Mdn = 3.51$ ; With Device:  $Mdn = 1.53$ ). Likewise, during the conversational speech samples throughout T4 the use of a device also resulted in a statistically significant decrease in stuttering,  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$  (No Device:  $Mdn = 3.97$ ; With Device:  $Mdn = 1.89$ ). A comparison of the fluency enhancement experienced upon first using the device (T1) with the reduction in stuttering after the device had been used for a prolonged period of time (T4) revealed a non-significant association  $z = -.734$ ,  $p = .463$ ,  $r = -0.15$  (T1:  $Mdn = 1.85$ ; T4:  $Mdn = 1.50$ ).

Table 16: Summary of means (*M*) and standard deviations (*SD*) of percentage stuttered syllables (%SS) and reductions in %SS across initial and final data collection points

Data Collection Points Speech Samples	T1 (initial data collection)						T4 (final data collection)					
	Reading		Monolog		Dialog		Reading		Monolog		Dialog	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
%SS No Device	2.52	2.76	3.89	2.12	4.47	1.81	2.23	2.66	6.01	5.47	5.96	5.49
%SS With Device	.197	.237	2.15	1.67	2.45	2.31	.73	.78	4.12	4.30	4.48	5.69
Reductions in %SS	2.33	2.86	1.74	1.73	2.01	1.37	1.50	2.64	1.89	2.03	1.47	.71

When considering the limited effect sizes (cf. Cohen, 1992) within all speech samples and the generally large standard deviations across all data collection points (T1 – With Device:  $M = 2.45$ ,  $SD = 2.53$ ; T2:  $M = 4.83$ ,  $SD = 3.10$ ; T3:  $M = 3.23$ ,  $SD = .83$ ; T4 – With Device:  $M = 4.48$ ,  $SD = 6.23$ ) highly individualized responses to the device are evident. Figure 10 illustrates the individual frequencies of stuttering in comparison to the group average, across all quantitative data collection points for the conversational speech task.

Figure 10: Mean percentage stuttered syllables (%SS) across four data collection points for all participants



### **9.1.2. Effects on duration of moments of stuttering**

For group analysis the Wilcoxon signed-rank test was administered. The dependent variable considered was the average duration of moments of stuttering within the reading, monolog and dialog speech samples. The initial (T1) and final (T4) data collection points were considered. The average duration of moments of stuttering was measured in seconds.

#### **9.1.2.1. Average Duration of Moments of Stuttering while Reading**

There was a non-significant reduction in the average duration of the experienced dysfluencies when using a device. This was the case during both the initial data collection point, T1:  $z = -1.78$ ,  $p = .075$ ,  $r = -0.36$  (No Device:  $Mdn = 2.25$ ; With Device:  $Mdn = 1.80$ ) and the final data accumulation, T4:  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (No Device:  $Mdn = .83$ ; With Device:  $Mdn = .55$ ). .

#### **9.1.2.2. Average Duration of Moments of Stuttering during Monolog**

There was also a non-significant reduction in the average duration of the moments of stuttering during the monolog speech samples. The lengths of dysfluencies was not reduced significantly during both the initial data collection point, T1:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.26$  (No Device:  $Mdn = 2.10$ ; With Device:  $Mdn = .86$ ) and the final data accumulation, T4:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (No Device:  $Mdn = 1.58$ ; With Device:  $Mdn = 1.01$ ).

#### **9.1.2.3. Average Duration of Moments of Stuttering during Conversational Speech**

During conversational speech the differences in average duration of moments of stuttering when comparing the with and without a device samples were also non-significant. This means that the average lengths of dysfluencies remained unaltered when using a device during both, T1:  $z = -.420$ ,  $p = .674$ ,  $r = -0.09$  (No Device:  $Mdn = 1.68$ ; With Device:  $Mdn = 2.03$ ) and T4:  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (No Device:  $Mdn = .94$ ; With Device:  $Mdn = 1.25$ ).

### **9.1.3. Influence on speech and articulatory rate**

#### **9.1.3.1. Effects on Speech Rate**

Differences in speech rate were evaluated during the initial (T1) and final (T4) data collection points. Reading, monolog and dialog samples were collected both while using a device and without the use of an AAF device. The speech rates within the two experimental conditions (with and without device) were compared in order to assess whether or not the use of a device slowed the speaker's speech markedly. For all speech samples the change in speech rate was statistically non-significant, indicating that there were no distinct differences in the speed at which speech was produced.

Initial data collection (T1): reading:  $z = -1.57$ ,  $p = .116$ ,  $r = -0.32$  (No Device:  $Mdn = 176.66$ ; With Device:  $Mdn = 193.95$ ); monolog:  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (No Device:  $Mdn = 163.51$ ; With Device:  $Mdn = 180.73$ ); dialog:  $z = -1.57$ ,  $p = .116$ ,  $r = -0.32$  (No Device:  $Mdn = 190.38$ ; With Device:  $Mdn = 160.90$ );

Final data collection (T4): reading:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (No Device:  $Mdn = 190.17$ ; With Device:  $Mdn = 212.12$ ); monolog:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (No Device:  $Mdn = 171.52$ ; With Device:  $Mdn = 180.72$ ); dialog:  $z = -.734$ ,  $p = .463$ ,  $r = -0.15$  (No Device:  $Mdn = 176.06$ ; With Device:  $Mdn = 186.92$ );

#### **9.1.3.2. Effects on Articulatory Rate**

The term articulatory rate refers to the fluent parts of speech. It entails the speed at which an individual is able to produce speech output during fluent speech production. Much like speech rate, the difference in articulatory rate during the With Device and No Device conditions were compared during two data points (T1 & T2) for three speech samples (reading, monolog, dialog). For all speech samples the alterations in articulatory rate were statistically non-significant, indicating that there was no marked change in the speed at which fluent speech was produced.

Initial data collection (T1): reading:  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (No Device:  $Mdn = 189.70$ ; With Device:  $Mdn = 199.51$ ); monolog:  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (No Device:  $Mdn = 195.52$ ; With Device:  $Mdn = 196.52$ ); dialog:

$z = -.524$ ,  $p = .600$ ,  $r = -0.11$  (No Device:  $Mdn = 221.12$ ; With Device:  $Mdn = 217.45$ );

Final data collection (T4): reading:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (No Device:  $Mdn = 198.65$ ; With Device:  $Mdn = 219.05$ ); monolog:  $z = -.524$ ,  $p = .600$ ,  $r = -0.11$  (No Device:  $Mdn = 203.05$ ; With Device:  $Mdn = 199.68$ ); dialog:  $z = -.105$ ,  $p = .915$ ,  $r = -0.02$  (No Device:  $Mdn = 204.02$ ; With Device:  $Mdn = 216.77$ ).

#### **9.1.4. Impact of device usage on stuttering type**

In the determination whether or not specific core behaviors were reduced to a notable degree, three core behaviors were considered. For the analysis of these dependent variables total repetitions (sound and syllable repetitions), prolongations and total blocks (within-word and between-word blocks) were measured. For statistical analysis the accumulative average percentage of these three core behaviors was calculated for all collected speech samples (reading, monolog, dialog). Whenever the median for with and without device conditions are displayed, numbers show the percentage of each stuttering type within all dysfluencies considered (e.g. T1, No Device, Repetitions:  $Mdn = 31.76$  shows that 31.76% of all moments of stuttering experienced during this condition [100%] were repetitions).

##### **9.1.4.1. Effects on Repetitions**

There was a non-significant reduction in the percentage of total repetitions during T1:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (No Device:  $Mdn = 31.76$ ; With Device:  $Mdn = 17.17$ ). However, during the final data collection point (T4), during which the participant group experienced a small share of repetitions to begin with (No Device:  $M = 12.84$ ,  $SD = 12.13$ ) there was a statistically significant reduction in the average amount of repetitions among the participant group, T4:  $z = -2.20$ ,  $p = .028$ ,  $r = -0.44$  (No Device:  $Mdn = 8.44$ ; With Device:  $Mdn = 4.71$ ).

#### **9.1.4.2. Influence on Prolongations**

There was a non-significant difference in the average amount of prolongations. This was the case during T1:  $z = -0.67$ ,  $p = .500$ ,  $r = -0.14$  (No Device:  $Mdn = 13.74$ ; With Device:  $Mdn = 22.58$ ) as well as T4:  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (No Device:  $Mdn = 40.74$ ; With Device:  $Mdn = 35.92$ ).

#### **9.1.4.3. Impact on Blocks**

There was also a non-significant reduction in overall blocks when comparing the first use of the device to speaking without a device T1:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (No Device:  $Mdn = 54.26$ ; With Device:  $Mdn = 45.08$ ). Likewise, during the final data collection there was also no significant difference in the amount of blocks experienced when comparing the with device to the without device speech samples, T4:  $z = -0.11$ ,  $p = .971$ ,  $r = -0.02$  (No Device:  $Mdn = 50.03$ ; With Device:  $Mdn = 42.04$ ).

#### **9.1.5. Effects on Stuttering Severity**

Much like during the immediate effect trial, the SSI-4 (Riley, 2009) stuttering severity ratings for each client were determined. Both spontaneous speech samples and the reading sample were considered for the accumulation of the SSI-4 score. Severity ratings were determined twice for the initial data collection point (T1), both while using a device and without a device. Likewise, during the final data collection point (T4), two severity ratings for both experimental conditions (with and without a device) were determined. The Wilcoxon-signed rank test was performed to determine whether or not the use of a device lowered the SSI-4 score of the subject group to a statistically significant degree. During T1 there was a non-significant change in stuttering severity ratings when using a device,  $z = -1.63$ ,  $p = .102$ ,  $r = -0.33$ . However, when considering the individual SSI-4 based ratings, half of the subject group experienced a change in stuttering severity (subject1, 4 and 6) of one or two severity equivalents (from “moderate” to “very mild” or “mild” to “very mild”). During T4 the use of a device resulted in a statistically significant reduction of the SSI-4 based severity ratings,  $z = -2.00$ ,  $p = .046$ ,  $r = -0.41$ . Four out of the six participants (subjects 1,2,4 and 6) experienced a decline in their SSI-4 severity ratings of two severity

increments (from “moderate” to “very mild”). Additionally, the No Device and With Device conditions during the initial and final data collection point were compared. The aspiration was to see whether or not the severity rating would be impacted by the longitudinal use of a device, resulting in a lowered severity rating even when a device wasn’t present. For the comparison of the With Device conditions it was interesting to see whether prolonged use of a device would continuously lower the SSI-4 score as compared to initial use, thus resulting in a significantly lowered rating during T4. However, the results show, that there was no additional benefit to the prolonged use of a device as there was no statistically significant difference in the obtained SSI-4 severity ratings when comparing the initial use (T1, With Device) to three-month continued use (T4, With Device),  $z = -1.41$ ,  $p = .157$ ,  $r = -0.29$ . Likewise, the stuttering severity rating while speaking without a device did not improve to a statistically significant level after the device had been utilized for a consecutive period of time (T1, No Device vs. T4, No Device),  $z = -1.00$ ,  $p = .317$ ,  $r = -0.21$ . This result indicates that there was no carry-over effect into speaking situations during which a device was not utilized. Speech fluency when not wearing a device was not significantly more fluent (as indicated by stable SSI-4 ratings) even after a continued period of utilizing the speech aid.

## **9.2. Qualitative analysis of device usage in natural environments**

### **9.2.1. Frequency of device usage**

When looking at Table 17 it is quite apparent, that the frequency at which the individual subjects used their device varied widely.

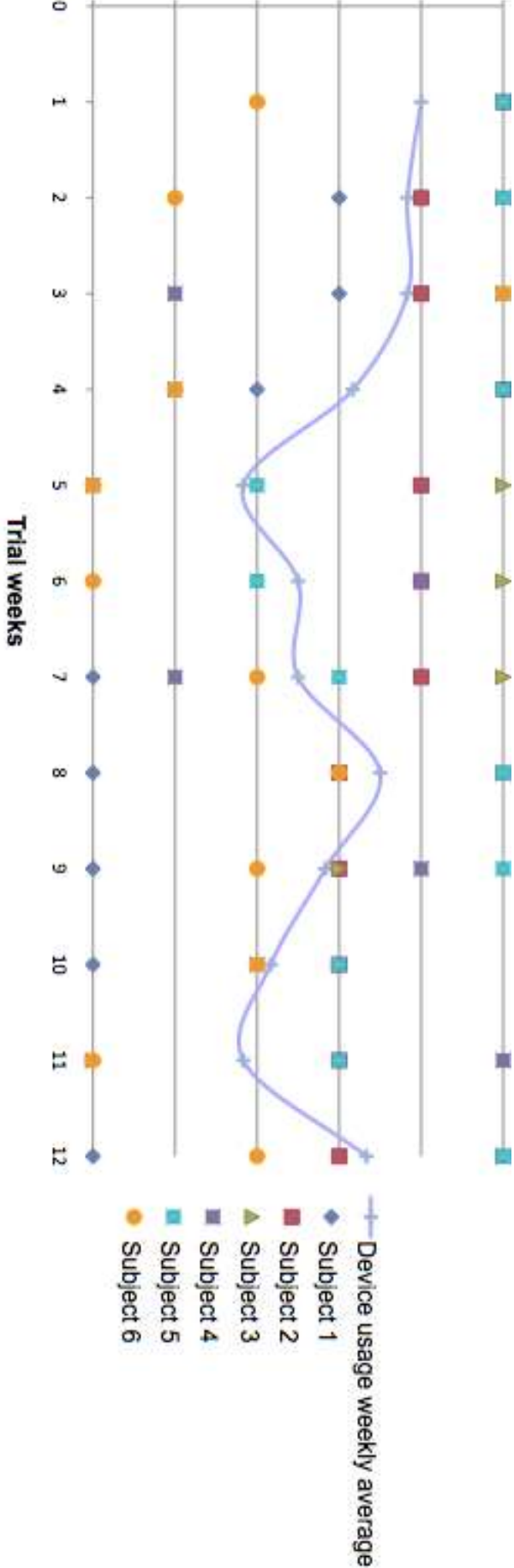
Table 17: Summary of weekly usage frequency for each participant across 12-week trial period

Trail weeks	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
1	2-3 times a week	Several times a day	Several times a day	Several times a day	Several times a day	2-3 times a week
2	4-5 times a week	Once a day	Several times a day	Several times a day	Several times a day	Not at all
3	4-5 times a week	Once a day	Several times a day	Not at all	Several times a day	Several times a day
4	2-3 times a week	Several times a day	Several times a day	Not at all	Several times a day	Not at all
5	Not at all	Once a day	Several times a day	Not at all	2-3 times a week	Not at all
6	Not at all	Once a day	Several times a day	Once a day	2-3 times a week	Not at all
7	Not at all	Once a day	Several times a day	Not at all	4-5 times a week	2-3 times a week
8	Not at all	4-5 times a week	Several times a day	Several times a day	Several times a day	4-5 times a week
9	Not at all	4-5 times a week	4-5 times a week	Once a day	Several times a day	2-3 times a week
10	Not at all	4-5 times a week	4-5 times a week	2-3 times a week	4-5 times a week	2-3 times a week
11	Not at all	4-5 times a week	Not at all	Several times a day	4-5 times a week	Not at all
12	Not at all	4-5 times a week	Several times a day	Several times a day	Several times a day	2-3 times a week

A clear pattern was evident with subject 1 who discontinued using his device in situations of daily living altogether after week 4. He only continued to

use his device for the scheduled phone conversations during T2 and T3 as well as for the recording of speech samples during T4. While he had tried to use the device in various situations during the initial trial month, he did not find the dependency on a technical device useful for his every-day life. With subject 2 and subject 3 it appears as if their motivation to utilize the device was strong during the initial weeks of the trial. Both of them used the device on a daily basis until week 7. After that point the instances during which a device was used decreased drastically to occasional uses on a weekly basis. Subjects 4, 5 and 6 showed more diffuse usage patterns that fluctuated between frequent daily usages to irregular, sporadic employment of a device. The group average usage pattern shows frequent use during the initial weeks of the study. Figure 11 also shows a trend of declining device utilization over the weeks, with occasional spurs in the middle (week 8) and end (week 11) of the clinical trial.

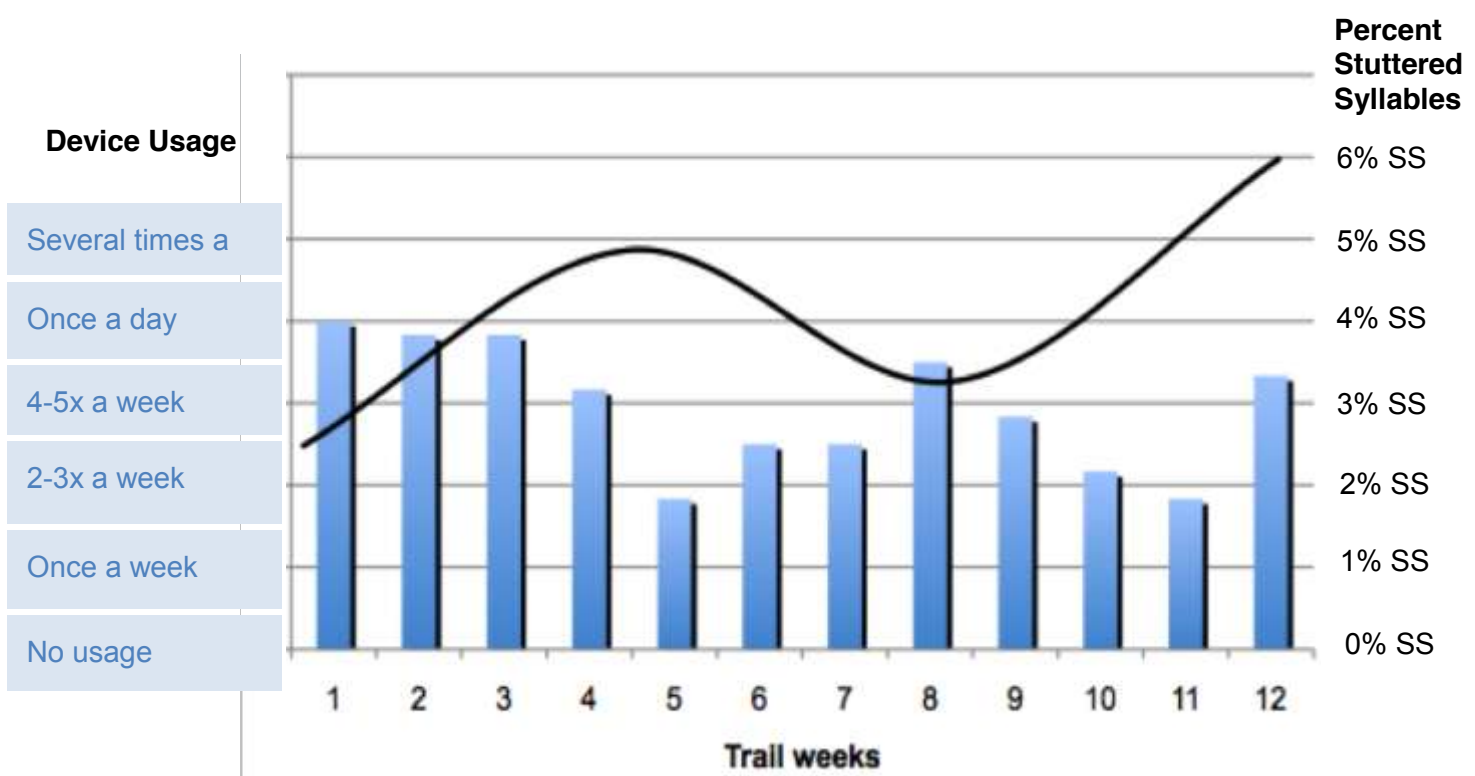
Figure 11: Individual device usage and group average trend of device utilization across 12 trial weeks



### 9.2.1.2 Relationship between usage frequency and occurrence of stuttering

A one-tailed Kendall's Tau correlation was calculated in order to determine whether or not the rate at which a device was used was related to a reduction in stuttering. This type of correlation is the suggested approach for non-parametric data that is based on a small data set (Field, 2009, p. 181). Results reveal that there was a non-significant relationship between the frequency of using a device and the occurrence of stuttering,  $r = -.67$ ,  $p = .087$  across the three month trial period. Figure 12 shows the average frequency at which a device was used within every week of the study in comparison to the average amount of stuttering exhibited by the subject group.

Figure 12: Summary of average weekly device usage and average amount of exhibited stuttering for whole participant group ( $N = 6$ )



### 9.2.2. Utilization patterns

#### 9.2.2.1. Communicative contexts

When considering the descriptive statistics of five conversational contexts in which a device could have been used, some interesting patterns emerge. The group modal scores for each week are displayed in Table 18.

Table 18: Weekly modal scores displaying frequencies at which a device was utilized in six different communicative contexts

Study weeks	1	2	3	4	5	6	7	8	9	10	11	12
Group conversation - familiar people	1	1	0	1	0	0	0	0	0	0	0	0
Group conversation - stranger	0	0	0	0	0	0	0	0	0	0	0	0
One-on-one conversation - familiar person	2	1	2	0	1	0	1	1	1	1	0	0
One-on-one conversation - stranger	1	1	1	0	0	0	1	1	1	0	0	0
Telephone call - familiar person	1	2	1	1	0	2	2	2	1	1	0	2
Telephone call - stranger	0	0	0	1	0	0	0	0	0	1	0	1

0 = no use, 1 = used sometimes, 2 = device was always used

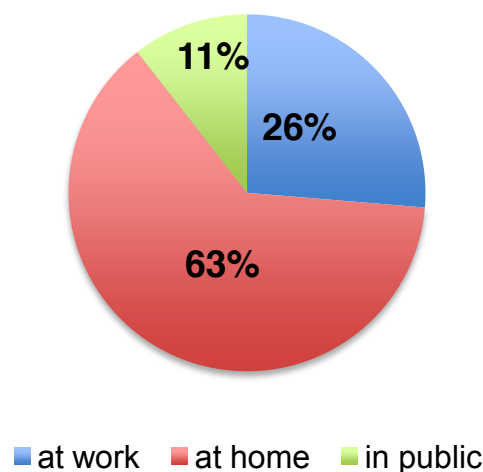
From this data it becomes evident that the device was utilized least often in speaking situations involving strangers (group conversation:  $Mdn = 0$ ; telephone call:  $Mdn = 0$ ). Group conversations also appeared to be the communicative context in which it generally appeared to be most difficult to utilize a device. The device was most often used during phone conversations

with familiar callers ( $Mdn = 1$ ) and one-on-one conversations with familiar conversation partners ( $Mdn = 1$ ).

#### **9.2.2.3. Usage environments**

On the weekly user questionnaire subjects were also asked to provide information on the environments in which a device was used. Each participant was asked to indicate whether or not a device was used in the following three environments: at home, at work, in public. Based on these weekly “yes” or “no” ratings it became evident that the device was utilized most commonly at home, as all three subjects reported usage at home for each trial week. When considering all 12 trail weeks and all times during which a device was used, the observation that a person’s home was the most common usage environment was strengthened. Figure 13 displays the percentage of overall usage time distributed among the three usage environments listed on the participant questionnaire.

Figure 13: Percentage of overall device usage within three usage environments



#### **9.2.3. Feature utilization**

The weekly user questionnaire further inquired about the utilization of specific device features. Such questions are interesting when trying to analyze which features of the device are being used in daily speaking

situations. Both, the qualitative examination the AAF settings utilized as well as the headphones that were used, were of interest. In terms of AAF settings, each device had three individualized DAF/FAF settings programmed (cf. Table 14, Chapter 8). Additionally, a fourth program was available, which played back masking noise upon detecting the speaker's voice through the microphone. Each device was given to the participants with two headphone options: a wired monaural earpiece or an inductive loop microphone in conjunction with a wireless ear-bud. The goal was to see which setting was preferred and which type of headset was used most often.

### 9.2.3.1. Setting preference

When considering all subjects and all trial weeks, the program used most commonly was program 1. This was also the setting combination, which was generally the least invasive combination of DAF and FAF – meaning that it commonly entailed a short delay and minor frequency shift. **Table 19** provides a brief summary of the most common program used by each subject.

Table 19: Summary of most commonly utilized program across all trial weeks (as determined by the modal score). Delay times are displayed in milliseconds (ms) and shifts in frequency are displayed in Hertz (Hz)

Subjects	Sub. 1	Sub. 2	Sub. 3	Sub. 4	Sub. 5	Sub. 6
Preferred Program	1	2	1	1	1	1
Setting of preferred program	60ms/100Hz	60ms/100Hz (T1) 80ms/100Hz (T2) 126ms/2Hz (T3 - T4)	60ms/100Hz (T1 - T2) 50ms/247Hz (T1 - T2)	50ms/250Hz	60ms/100Hz	60ms/100Hz (T1 - T2) 180ms/1500Hz (T3 - T4)

Subjects were asked whether or not they utilized the masking feature by providing a simple “yes” or “no” answer. The question generally inquired about the utilization of this 4<sup>th</sup> optional program, rather than attempting to quantify the number of times masking had been used each week. Even though, this feature had been introduced to the subjects within their pick-up briefing, only one subject attempted to use it (subject 3). He implemented the masking feature for three consecutive weeks mid-trial (weeks 5-7) and again

at the end of the study (week 12). He did not have any specific comments about his experience with the masking feature as displayed by his weekly user diary. The remaining five participants did not report the use of the masking feature.

#### **9.2.3.2. Headphone preference**

The user questionnaire also included a question on the headset option used. As mentioned previously, each device was equipped with either a one-sided wired head-set including an ear-bud and a microphone or a wireless ear-piece that connects to an inductive loop microphone worn around one's neck. Even though the earpiece is least intrusive, as it does not involve any visible wires, it was not the preferred headset option of this subject group. Whenever a device was utilized the wireless earphone was only employed in 23.43% of all cases. This indicates that there appears to be an issue with the wireless headphone option that made the subjects utilize the wired option more often. Various comments in the user diaries spoke to this assumption. Several users commented on a "distracting static noise" when using the wireless earpiece. Other participants explained that they preferred the wired option because the microphone was closer to their mouth and therefore background noise and additional contact noise (such as shirt collars rubbing against the microphone) were minimized.

#### **9.2.4. User perception of device utilization**

The participants' subjective impressions of the device were also of interest. In this regard the participants were asked to rate their overall satisfaction on a three-point scale. Additionally, the user diary provided space to expand on their individual experience with the device. Participants often used this space to elaborate on concerns or problems they had encountered while using the device that week.

##### **9.2.4.1. Overall user satisfaction**

Each participant provided a weekly satisfaction rating. The subjects had the option to choose one of three answer options to express how satisfied they were with the overall use of their device for each week (0 = not satisfied,

1 = mediocre satisfaction level, 2 = very satisfied). When looking at the modal scores of the combined 12 ratings for each trial week, diverse individual patterns emerge. Two subjects gave an overall modal rating of “not satisfied” while two other participants labeled their experience with a “mediocre satisfaction level”. Only one subject rated her contentment with the trial use as “very satisfied”. Yet another participant choose to not provide an answer and stay neutral on expressing his satisfaction. However, this subject chose to discontinue the use of a device altogether after trial week 4. He therefore decided not to provide an answer when it came to rating satisfaction as he felt he did not have enough experience with the device. Nonetheless, the fact that he did not perceive the use of an AAF device suitable, does not speak to a high satisfaction level on his part.

#### **9.2.4.2. Prominent concerns during device usage**

When looking at the problem reports in the user diaries, it becomes evident that the initial trial weeks were the ones during which the majority of problems was reported. It can be assumed that some problems in that time frame may be linked to an emerging familiarity with the device. For instance, four subjects reported a technical problem during the first trial week. While in later weeks a maximum of two problems were reported per week. Among those initial problems were complaints in regard to the individualized AAF settings and the disruptiveness of the AAF effect in general. Subjects also reported true technical issues such as difficulties with the charger or an empty battery upon turning the device on. Such concerns rarely reemerged throughout continuous trial weeks. Dominant concerns that were restated as the clinical trial continued, were generally related to the AAF effect itself. Three participants (subjects 2,3 and 5) reported continuously that the altered vocal feedback was too much of a contortion and therefore considered an additional burden in many attempts of communication. Subjects who felt impaired by the unaccustomed feedback unanimously expressed no desire to continue to use such an aid beyond the clinical trial.

## **Chapter 10: Discussion – longitudinal effects**

### **10.1. Summary of findings and conclusion**

This longitudinal study attempted to investigate the longevity of quantitative changes in speech fluency, when a device is used over a longer period of time. The calculated group effects show that there are statistically significant reductions in the percentage of stuttered syllables during all collected speech samples. Table 20 provides a summary of the different variables considered in the computation of group effects.

Table 20: Summary of  $p$ -values effects at initial (T1) and final (T4) data collection points when comparing No Device to With Device conditions (alpha level:  $p < .05$ )

Data Collection Points	T1			T4		
Speech Samples	RD*	MO**	DI***	RD*	MO**	DI***
Stuttering Frequency (%SS)	<i>p</i> = .028	<i>p</i> = .046	<i>p</i> = .028	<i>p</i> = .046	<i>p</i> = .046	<i>p</i> = .028
Stuttering Duration	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>
Speech Rate	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>
Articulatory Rate	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>
Percentage of Repetitions	Three speech samples combined			Three speech samples combined		
	<i>NS</i>			<i>NS</i>		
	<i>NS</i>			<i>NS</i>		
	<i>NS</i>			<i>NS</i>		
SSI-4 ratings	<i>NS</i>			<i>p</i> = .046		
Speech Samples	T1 vs. T4 <sup>H</sup>					
	RD*		MO**		DI***	
	<i>NS</i>		<i>NS</i>		<i>NS</i>	
	<i>NS</i>		<i>NS</i>		<i>NS</i>	

<sup>H</sup> = Reductions during the With Device conditions during T1 and T4 are compared.

\* = reading, \*\* = monolog, \*\*\* = dialog

With such a small sample group ( $N = 6$ ) it is important to look beyond the general trends presented by the calculation of group effects and consider

individual reactions. When looking at Figure 10 in Chapter 9, fluctuations in the reductions in stuttering are visible. While the use of a device always resulted in an at least slight improvement of the percentage stuttered syllables during the initial and final data collection points, the range and quality of these reductions varied widely. For many participants (i.e. subjects 1, 2, 3 and 5) the use of a device only resulted in a decrease of stuttering, which was less than one percent. Taking into consideration that the use of a device also entails inconveniences, such as distraction when speaking due to the AAF effect or amplifications of background noise (cf. Section 9.2.4.2), it is rather unlikely that the use of a Device is always considered beneficial. Minor changes in the percentage of stuttered syllables are hardly noticeable to the speaker or observer. As such, many of the fluency-enhancements achieved, even though statistically significant, cannot be considered clinically or practically significant improvements.

Another data set that was of interest during this trial was the collection of qualitative information on the extended use of a device. Two other studies have previously included reports on subjective user impressions (O'Donnell et al., 2008, Pollard et al., 2009). This study expands the evidence on accounts of personal experience while using a device in numerous ways. Both previous studies included suggestions on how often a device should be implemented each day. Generally, subjects were encouraged to use their device as often as possible. This study on the other hand, did not provide any guidelines to how often a device should be utilized. Rather, the intention was to document the natural pattern at which a user decides to employ their device. This provides some unbiased insight into the communicative contexts and environments in which a device is used and therefore perceived helpful. Such data can be useful in the identification of situations, which may be too difficult to attempt when using a device without additional therapeutic support. Undoubtedly, it takes courage to partake in speaking situations, which usually would have been avoided. The availability of a technical aid alone may not be enough to strengthen one's confidence and enter such unaccustomed situations. Gaining insight into circumvented speaking situations could therefore serve a clinical purpose by identifying scenarios during which an integrative therapeutic component may be helpful (e.g. desensitization in the

context of traditional stuttering modification treatment). Such an individualized integrated approach may be what is necessary to maximize the usefulness of a technical speech aid and offer long-term support to those who stutter. Additionally, the open format of the weekly questionnaires and user diaries allows for a closer investigation of the encountered difficulties while using a device. Data analysis shows that some subjects who partook in this study perceived similar burdens when using a device. For example, half of the sample group felt distracted by the AAF signal and found it more difficult to focus on verbal interactions. While this was tolerable for the other half, it comes to show that the presence of an additional feedback signal is not something everyone is willing to endure. In this context it should be noted that all longitudinal study subjects also partook in the immediate effect trial (Chapters 5-7) and expressed a desire to continuously use the device in their natural environments. The fact that the device was not perceived beneficial once available in the context of every-day life shows that it is necessary to include communication in natural environments when testing a device. The AAF effect may be perceived too invasive if communicative demands rise, even though it was considered tolerable in contained conditions. Purchasing or deciding to keep a device after usage has only been attempted in quiet environments with one conversational partner, may not represent an accurate trial experience.

An interesting trend that was revealed through the detailed collection of user perceptions pertains to the preferred equipment used. The device utilized for this trial came with two headset options – a wired and a wireless earpiece. Surprisingly, the less visible wireless option was not the one that was unanimously preferred by the six subjects. All participants reported increased technical shortcomings of the wireless option (i.e. increased static noises, poor differentiation of background noise etc.), resulting in a preferred use of the wired earpiece. Such reports are interesting because many potential customers are likely drawn to those devices that are most modest and non-invasive in appearance.

## **10.2. Limitations and future research directions**

An obvious shortcoming of the current study is the limited number of participants. Results derived from a larger subject set would be more valid and reliable in identifying group effects. This study was only able to pick up some general trends in regards to device usage in everyday life. However, finding volunteers who are willing to dedicate their time to continuous data collections over an extended period of time is a complicated endeavor. It takes a very dedicated group of subjects to continuously keep the motivation for participation alive, particularly once the initial enthusiasm for a research purpose has faded. With the utilization of AAF devices in particular it is sometimes difficult to resolve technical problems immediately, which can have an impact on motivation. For ones, customer service may not be available in any other language but English. Another reason may be that there is often no physical person to consult with but rather the online distribution system of many devices makes it necessary to send the aid in for problem analysis. In some cases it also takes time for replacement parts to be delivered by mail, which may entail not being able to use a fully functioning device for a while.

On the same note, another limitation certainly is the recruitment process of the six subjects. In essence, all subjects volunteered for the study by agreeing to partake in further research. While this option was extended to all 30 clients, only 6 showed an interest in participating in a longitudinal trail. This ‘self-nomination’ certainly results in a somewhat biased sample group, as it entails participants who have a generally positive attitude towards the use of a device. Subjects who previously had no or more diverse experience would have been desirable to create a balanced sample. A new recruitment process, which excluded participants that have already partaken in the immediate effect trail, may have been the better choice. However, with the limiting prerequisites of a longitudinal study, keeping the commitment to continuous data collections in mind, a new search for participants may or may not have been successful.

Another variable, which should be extended in further studies, is time. It would certainly be interesting to investigate both quantitative and qualitative data if a device was available to the user for an entire year. During such a long period of time some of the trends revealed by this study may be

confirmed. Most importantly, additional therapeutic intervention components may be identified more clearly. Predominantly the qualitative data analysis of this study has shown that there are remaining needs a client has, even if a device is available. Among those are threatening speaking situations such as group conversations, which through learning processes have been conditioned to be avoided by some. It seems a speech aid has the potential to become a stable element in an integrated, multidimensional treatment approach. However, the key to creating a therapeutic long-term solution for most clients will be to understand both the strengths and shortcomings of technical speech aids more distinctly and fill the gaps in the treatment plan with suitable therapeutic counterparts.

On this note it would be interesting to conduct a longitudinal trial that was based on such an integrative treatment approach. As such, a possible design may be based on a between-groups design with some subjects receiving a combination of stuttering modification treatment in conjunction with the use of an AAF device, while another group receives fluency shaping treatment in addition to the use of a technical speech aid. A third group may only utilize a device without an additional evidence-based speech pathological treatment component. Results of such a study may reveal which combination of treatment components has the potential to be most effective in creating long-term fluency enhancements within various contexts and environments.

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**Chapter 11: The professionalization of speech aid implementation in the treatment of stuttering: a proposal**

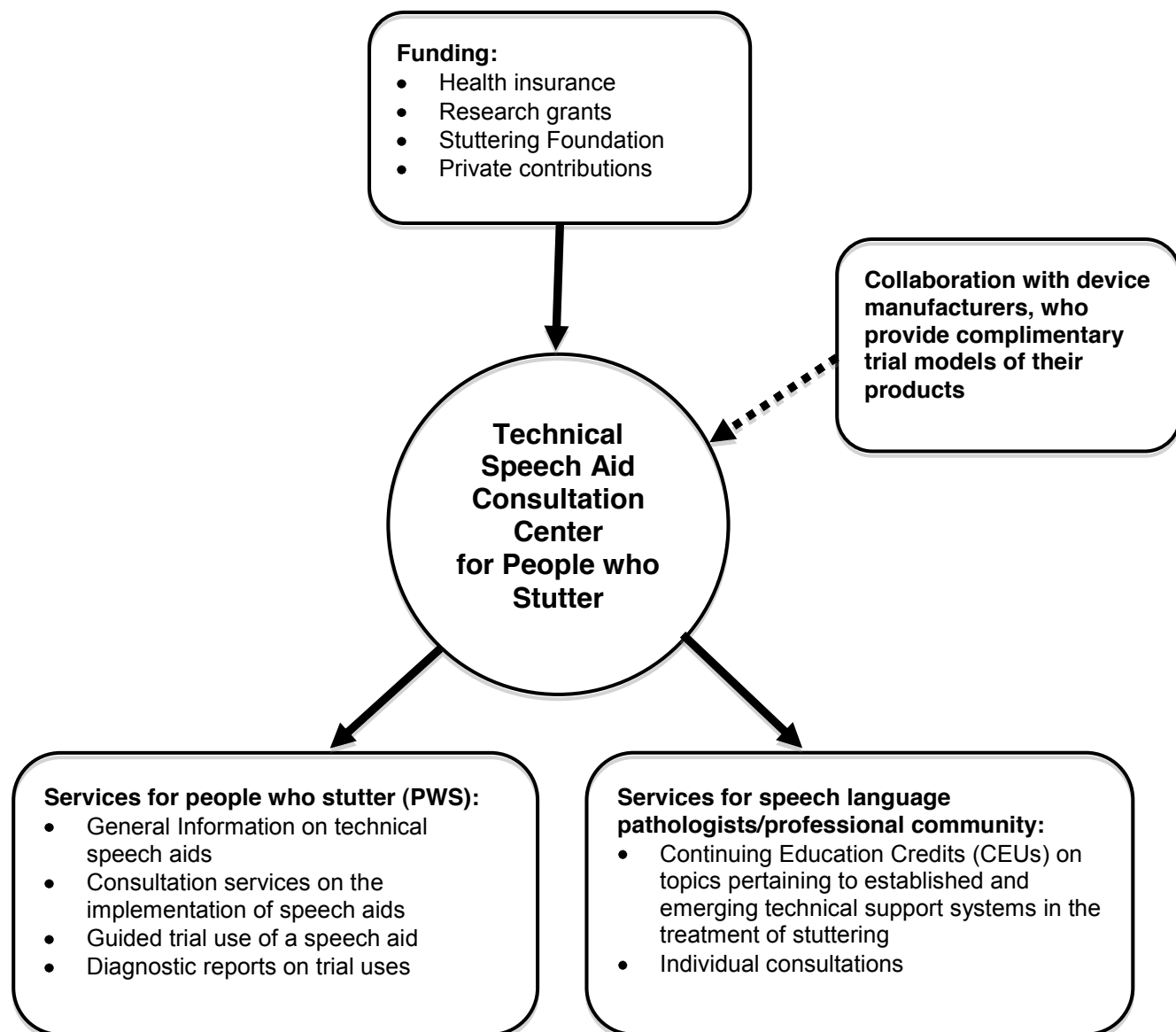
It has been established that technical speech aids such as AAF devices do not turn a PWS into a fluent speaker. However, such aids have the capacity to improve speech fluency situationally and thus the potential to function as an additional means in an individual ‘toolbox’ of therapeutic methods, which ideally are available to each PWS. Furthermore, the use of AAF in particular can facilitate the acquisition of speech techniques (cf. table 8) or serve as a motivational tool (cf. van Riper, 1970) in the establishment of speech techniques within a traditional speech pathological intervention.

A problem that persists - and ultimately may be a partial contributor to the absence of technical speech aids in the individualized therapeutic ‘toolbox’ of many clients - is the lack of knowledge about the availability and/or potential of such aids among clinicians. Bakker (2006, p. 208) points out that most PWS who utilize a technical speech aid purchase the device without the involvement of an objective professional source such as “the help of a speech-language pathologist”. The same author suggests, that objective information on a professional level is best conveyed through continuing education activities (Bakker, 2006). However, at present objective training sessions on the availability, capacity and implementation of technical speech aids is non-existing. While individual device manufacturers offer training sessions on their own products to professionals willing to distribute their devices (cf. VoiceAmp, Janus Development) such workshops by no means offer an objective perspective on available therapeutic aids in the big picture.

A possible solution to the lack of unbiased information and training may be the establishment of AAF consultation centers (cf. Figure 14). Certified speech-language pathologists who possess in-depth knowledge on evidence-based therapeutic options available to a PWS would form the heart of such an institution. These clinicians would also have state-of-the-art understanding of recent trends in the technology sector and are familiar with established and emerging technical aids relevant to the therapeutic process. Such an institution would serve a dual purpose of providing continuing education services to clinicians by providing objective information on technical speech

aids to interested professionals. The second mission would be to provide consultation and assessment services to PWS who are interested in exploring technical support options. It would be important that a consultation center maintains its objective state by being independent of financial contributions by the technical manufacturing industry. At present, some device producers choose to have their aids distributed by speech-language pathologists or audiology acousticians who are manufacturer-trained and receive a commission for every device sold. A consultation center would have to be free of such financial interests in order to maintain integrity to its core mission of providing objective services. Alternate funding sources of such a center could instead be secured through health insurance companies, federal research funds, the stuttering association or consultation/continuing education fees paid directly by the client/clinician. All of these possible funding sources should have a common interest in the existence of objective professional services of this nature. The technical aid manufacturers, whether it may be producers of portable AAF units, computer-based biofeedback or mobile smart-phone applications, would certainly also be invited to the collaborative process. Their contribution towards the professionalization of speech aid implementation in the treatment of stuttering would be to provide trial products and usage tutorials to the consultation center. Such a contribution would serve as an additional marketing tool to the manufacturer as willingness to submit a product increases professional credibility.

Figure 14: Proposal of core structures for a technical speech aid consultation center



In terms of the services provided to PWS, the client would initiate a consultation by completing an initial case history form. Such a form would provide preliminary information on the individual therapeutic background and specific needs of each client. For those PWS who seek general information on technical aids, a consultation meeting could be arranged, which aims at providing an overview of the different technical support structures available. If the client in collaboration with the consulting clinician finds a particular aid to be promising for their situation, a trial use could be initiated. A trial usage should follow a specific protocol and include at least three speaking situations

in the clinical environment on a one-on-one basis (reading, monolog, dialog) both with and without a device in place. In addition, speech samples should be collected outside of the consultation facility in order to test the device-specific features in the presence of background noise. If the device proves to be beneficial throughout the initial use, a thorough trial period of at least two weeks in the client's natural environment should follow. This time should be used to experience different device settings and accessories (i.e. different headphone options) in various situations of daily living. Continuous data collection should document this extended trial use. The client ultimately returns the trial device to the consultation center and discusses the results of a summarizing diagnostic report with a consulting clinician. Should the report reveal improvements in speech fluency and should the client perceive the device usage as beneficial, information on how to purchase and/or fund the desired device would be shared.

Appendix 3-4 shows examples of case history and data collection forms, which could be modified and used in a consultation facility or generally in clinical practice, when exploring the effects of technical speech aids. Each of the 30 subjects who partook in the studies presented herein, received a diagnostic report following the immediate effect study that summarized the impact of the two used devices on their speech fluency (see Appendix 2). Such a report may serve as the basis for a request of funding with an individual's health insurance company.

The future will show in how far technological aids will manifest themselves as supportive means in the treatment of stuttering. Based on the current level of knowledge, it would be desirable to professionalize the distribution and supply of such aids in order to be able to offer PWS another transparent, evidence-based tool as a component of an individualized treatment plan.

## References

- Agency for healthcare research and quality (2002). *Systems to rate the strength of scientific evidence* Summary, evidence report/technology assessment: Number 47. Rockville, MD. Agency for healthcare research and quality. Retrieved from: [www.ahrq.gov/clinic/epcsums/strengthsum.htm](http://www.ahrq.gov/clinic/epcsums/strengthsum.htm)
- Alm, P. (2005). *On the causal mechanisms of stuttering* (Doctorate Dissertation). Lund University, Lund, Sweden.
- Alm, P. (2006). *A new framework for understanding stuttering: The dual premotor model*. 15th World Congress on Fluency Disorders. *International Fluency Association*. Dublin, Ireland.
- Ambrose, N., Cox, N., & Yairi, E. (1997). The genetic basis of persistence and recovery in stuttering. *Journal of Speech, Language and Hearing Research*, 40, 567-580.
- Ambrose, N., & Yairi, E. (1999). Normative dysfluency data for early childhood stuttering. *Journal of Speech, Language, and Hearing Research*, 42, 895–909.
- American Educational Research Association; National Council on Measurement in Education; American Psychological Association. Standards for educational & psychological tests. (1985). *Standards for educational and psychological testing*. Washington, DC: American Psychological Association.
- American Psychiatric Association. (2004). *Diagnostic and statistical manual of mental disorders*. (4<sup>th</sup>). American Psychiatric Publishing. Arlington, V.A.
- American Speech-Language and Hearing Association. (1995). Guidelines for practice in stuttering treatment [Guidelines]. Available from [www.asha.org/policy](http://www.asha.org/policy)
- American Speech-Language and Hearing Association. (2007). *Scope of practice in Speech-Language Pathology*. Retrieved from [www.asha.org/policy](http://www.asha.org/policy)

- American Speech, Language and Hearing Association (2011). *EBP – Assessing the evidence: systematic reviews*. Available from <http://www.asha.org/members/ebp/assessing.htm>.
- Anderson, T.K., & Felsenfeld, S. (2003). A thematic analysis of late recovery from stuttering. *American Journal of Speech Language Pathology*, 12, 243-253
- Andrade, C., Cervone, L., & Sassi, F. (2003). Relationship between the stuttering severity index and speech rate. *Sao Paulo Medical Journal*, 121, 81–84.
- Andrews, G. (1984). The epidemiology of stuttering. In R. Curlee & W. Perkins (Eds.), *Nature and treatment of stuttering* (pp. 1-12). San Diego, CA: College Hill.
- Andrews, G., & Ingham, R. (1971). Stuttering: Considerations in the evaluation of treatment. *British Journal of Disorders of Communication*, 6, 427–429.
- Andrews, G., & Cutler, J. (1974). Stuttering therapy: The relationship between changes in symptom level and attitudes. *Journal of Speech and Hearing Disorders Monograph*, 38, 312–319.
- Andrews, G., Craig, A. & Feyer, A.-M., Hoddinott, S., Howie, P., & Neilson, M. (1983). Stuttering: A review of research findings and theories circa 1982. *Journal of Speech and Hearing Disorders*, 48, 226-246.
- Andrews, G., & Craig, A. (1988). Prediction of outcome after treatment for stuttering. *British Journal of Psychiatry*, 153, 236–240.
- Andrews, G., Garside, R. F., & Harris, M. M., (1964). *The syndrome of stuttering*. London: Spastics Society Medical Education & Information Unit in association with William Heinemann Medical Books.
- Andrews, G., & Harris, M (1964). *The syndrome of stuttering: clinics in developmental medicine*. No. 17. London: Spastics Society Medical Education and Information Unit in association with Wm. Heinemann Medical Books.

- Antipova, E., Purdy, S., Blakeley M., & Williams, S. (2008). Effects of altered auditory feedback (AAF) on stuttering frequency during monologue speech production. *Journal of Fluency Disorders*, 33(2), 274–290.
- Arends, N., Povel, D., & Kolk, H. (1988). Stuttering as an attentional phenomenon. *Journal of Fluency Disorders*, 13(1), 141–151.
- Armson, J., Foote, S., Witt, C., & Kalinowski, J. & S. A. (1997). Effect of frequency altered feedback and audience size on stuttering. *European Journal of Disorders of Communication*, 32(3), 359–366.
- Armson, J., & Stuart, A. (1998). Effect of extended exposure to frequency-altered feedback on stuttering during reading and monologue. *Journal of Speech, Language and Hearing Research*, 41, 479–490.
- Artone inductive neckloop [apparatus]. (2008). EU, Middle East, Russia & US: Artone Communication Solutions.
- Bakker, C. (2006) Technical support for stuttering treatment. In Bernstein Ratner, N. & Tetnowski, J. (Eds.). *Current issues in stuttering research and practice*. Mahwah, N.J.: Erlbaum Publishers.
- Barnard, T. (1987). *The effectiveness of the Precision Fluency Shaping Training*. (Master Thesis). Brock University, Ontario, Canada.
- Beech, H. R., & Fransella, F. (1968). Research and experiment in stuttering. *International series of monographs in experimental psychology*. 6, 211-224. Pergamon Press: Oxford, UK.
- Beichtman, J., Nair, R., Clegg, M., & Patel, P.G. (1986). Prevalence of speech and language disorders in 5-year-old kindergarten children in the Ottawa-Carleton region. *Journal of Speech and Hearing Disorders*, 51, 98-110.
- Bernstein Ratner, N. (1997). Stuttering: a psycholinguistic perspective. In Curlee, R. & Siegel, G. (Eds.), *Nature and treatment of stuttering: new directions* (2nd ed., pp. 99–127). Needham, MA: Allyn & Bacon.
- Bernstein Ratner, N. (2005). Evidence-based practice in stuttering: some questions to consider. *Journal of Fluency Disorders*, 30(4), 163–188.
- Bernstein Ratner, N., & Tetnowski J. (Ed.). (2006). *Current Issues in Stuttering Research and Practice*. London: Lawrence Erlbaum Associates Publishers.

- Blomgren, M., Roy, N., Callister, T., & Merrill, R. (2005). Intensive stuttering modification therapy: A multidimensional assessment of treatment outcomes. *Journal of Speech, Language, and Hearing Research*, 48, 509–523.
- Bloodstein, O. (1944). Studies in the psychology of stuttering: XIX. The relationship between oral reading rate and severity of stuttering. *Journal of Speech Disorders*, 9, 161–173.
- Bloodstein, O. (1960a). The development of stuttering: I. Changes in nine basic features. *Journal of Speech and Hearing Disorders*, 25, 219-237.
- Bloodstein, O. (1960b). The development of stuttering: II. Developmental phases. *Journal of Speech and Hearing Disorders*, 25, 366-376.
- Bloodstein, O. (1961). The development of stuttering III: Theoretical and clinical implications. *Journal of Speech and Hearing Disorders*, 26, 67-82.
- Bloodstein, O. (1987). *A handbook on stuttering* (4<sup>th</sup>). Chicago, IL: The National Easter Seal Society.
- Bloodstein, O. (1995). *A handbook on stuttering* (5<sup>th</sup>). Clifton Park, N.Y.: Thomson-Delmar.
- Bloodstein, O. (2002). Early stuttering as a type of language difficulty. *Journal of Fluency Disorders*, 27(2), 163–166.
- Bloodstein, O., & Benstein Ratner, N. (2008). *A handbook on stuttering* (6<sup>th</sup>). Clifton Park, NY: Thomson/Delmar Learning.
- Bluemel, C. (1932). Primary and secondary stammering. *Quarterly Journal of Speech*, 18, 187-200.
- Boberg, E., & Kully, D. (1994). Long-term results of an intensive treatment program for adults and adolescents who stutter. *Journal of Speech and Hearing Research*, 37, 1050-1059.
- Bock, K., & Levelt, W. (1994). Language production: grammatical encoding. In Gernsbacher, J. (Ed.), *Handbook of psycholinguistics* (pp. 945–978). San Diego, CA: Academic Press.
- Bohr, J. (1963). The effects of electronic and other external control methods on stuttering. *Journal of the South African Logopedics Society*, 10, 4–12.

- Bray, M., & James, S. (2009). An evaluation of a telephone assistive device (TAD) for people who stutter. *International Journal of Speech-Pathology*, 11, 54–60.
- Brady, W.A., & Hall, D.E. (1976). The prevalence of stuttering among school-age children. *Journal of Speech and Hearing Services in Schools*, 7, 75-81.
- Brecht, B. (1940). Auszug aus: Der Augsburger Kreidekreis. Das Hirschgraben Lesebuch 9 (pp.117–124). Berlin: Cornelsen. (Abbreviated work published in 2008).
- Bricker-Katz, G., Lincoln, M., & McCabe, P. (2009). A life-time of stuttering: How emotional reactions to stuttering impact activities and participation in older people. *Disability and Rehabilitation*, 31(21), 1742–1752
- Bryngelson, B. (1938). The prognosis of stuttering. *Journal of Speech and Hearing Disorders*, 3, 121-123.
- Buck, S., Lees, R., & Cook, F. (2002). The influence of family history of stuttering on the onset of stuttering in young children. *Folia Phoniatica et Logopaedica*, 54, 117-124.
- Campbell, J.H., & Hill, D.G. (1987). *Systematic dysfluency analysis*. Poster session presented at the annual convention of the American Speech-Language-Hearing Association, New Orleans, L.A.
- Canon, FS100 [apparatus]. (2009). Lake Success, NY: Canon Inc.
- Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear and rage: An account of recent researches into the function of emotional excitement* (2<sup>nd</sup>). New York, London: D. Appleton.
- Canter, G.J. (1971). Observations on neurogenic stuttering: A contribution to differential diagnosis. *British Journal of Disorders of Communication*, 6, 139-143.
- Carey, B., O'Brian, S., Onslow, M., Block, M., Jones, M., & Packman, A. (2010) Randomized controlled non-inferiority trial of a tele-health treatment for chronic stuttering: the Camperdown Program. *International Journal of Speech-Language Disorders*, 45, 108-120
- Chase, R., Sutton, S., & Rapin, I. (1961). Sensory feedback influences on motor performance. *Journal of Auditory Research*, 1, 212–223.

- Cherry, C., & Sayers, B. (1956). Experiments upon the total inhibition of stammering by external control, and some clinical results. *Journal of Psychosomatic Research*, 1, 233–246.
- Cherry, C., Sayers, B., & Marland, F. (1956). Some experiments on the total suppression of stammering and a report on some clinical trials. *Bulletin of the British Psychology Association*, 30, 43-52.
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112(1), 155–159.
- Conture, E., Walden, T., Arnold, H., Graham, C., & Hartfield, K., & Karrass, J. (2006). A communication-emotional model of stuttering. In Bernstein Ratner, N., & Tetnowski J.(Eds.), *Current Issues in Stuttering Research and Practice* (pp. 17–46). Mahwah, N.J.: Lawrence Erlbaum Associates Publishers.
- Conture, E., & Kelly, E. (1991). Young stutterers' non-speech behaviors during stuttering. *Journal of Speech, Language, and Hearing Research*, 34, 1041-1056.
- Conture, E. G. (1990). *Stuttering* (2<sup>nd</sup>). Remediation of communication disorders series. Englewood Cliffs N.J: Prentice Hall.
- Conture, E. G., & Curlee, R. F. (2007). *Stuttering and related disorders of fluency* (3<sup>rd</sup>). New York: Thieme.
- Cook, D., Guyatt, G., Laupacis, A., Sackett, D., & Goldberg, R. (1995). Clinical recommendations using levels of evidence for antithrombotic agents. *Chest*, 108(4), 227–230.
- Cooper, E.B. (1993). Chronic perseverative stuttering syndrome: a harmful or helpful construct? *American Journal of Speech-Language Pathology*. 2, 11-15.
- Cooper, E.B. (1987). The chronic perseverative stuttering syndrome: Incurable stuttering. *Journal of Fluency Disorders*, 12(3), 381–388.
- Corey, D., & Cuddapah, V. (2008). Delayed auditory feedback effects during reading and conversation tasks: gender differences in fluent adults. *Journal of Fluency Disorders*, 33(2), 291–305.
- Craig, A., Hancock, K., Chang, E., McCreedy, C., Shepley, A., McCaul, A., Costello, D., Harding, S., Kehren, R., Masel, C., & Reilly, K. (1996). A

- controlled clinical trial for stuttering in persons aged 9-14 years. *Journal of Speech and Hearing Research*, 39, 808–826.
- Craig, A. (November 2007). *Evidence-based practice in the treatment of adolescent and adult stuttering: what do we know and what works?* Fluency Division Seminar, ASHA Convention, Boston.
- Crichton-Smith. (2002). Communication in the real world: accounts from people who stammer. *Journal of Fluency Disorders*, 27(2), 333–352
- Curlee, R., & Perkins, W. (1969). Conversational rate control therapy for stuttering. *Journal of Speech and Hearing Disorders Monograph*, 34, 245–250.
- Curlee, R., & Yairi, E. (1997). Early intervention with early childhood stuttering: A critical examination of the data. *American Journal of Speech-Language Pathology*, 6, 8-18.
- DAF Assistant (Version 1.4.1.) [application]. (2011). Artefact LLC. Retrieved from: <http://itunes.apple.com/us/app/daf-assistant/id309496166?mt=8>
- Dalrymple-Alford, E. (1973). The effect of delayed auditory feedback on reading as a function of the syllabic length of the words. *Language and Speech*, 16(2), 182.
- Dalton, P., & Hardcastle, W. J. (1977). Disorders of fluency and their effects on communication. *Studies in language disability and remediation: Vol. 3*. London: Edward Arnold.
- Dankovicova, J. (1994). *Variability in articulation rate in spontaneous Czech speech*. Unpublished Master thesis.
- Dell, G., & O'Seaghdha, P. G. (1991). Mediated and convergent lexical priming in language production: A comment to Levelt et al. (1991). *Psychological Review*, 98, 604–614.
- De Nil, L. (1999). Stuttering: A neurophysiologic perspective. In Bernstein Ratner, N. & Healey, E. C. (Eds.), *Stuttering research and practice. Bridging the gap*. (pp. 85–102). Mahwah, N.J.: Lawrence Erlbaum Associates Publishers.
- De Nil, L., Kroll, R., Lafaille, S., & Houle, S. (2003). A positron emission tomography study of short- and long-term treatment effects on functional

- brain activation in adults who stutter. *Journal of Fluency Disorders*, 28(3), 357–381.
- De Nil, L., & Kroll, R. (Summer 2009). Neural bases of stuttering and its treatment: *Stuttering Foundation of America Newsletter*.
- De Nil, L., Jokel, R., & Rochon, E. (2007). Etiology, symptomology, and treatment of neurogenic stuttering. In E.G. Conture & R. curlee (Eds.), *Stuttering and related disorders of fluency* (3<sup>rd</sup>), pp. 143-158. New York, US: Thieme.
- DER SPIEGEL. SPIEGELnet GmbH: Hamburg, Germany.
- Dewan A., Dewan, D., & Barnes, H. (1976). Automatic triggering of auditory feedback masking in stammering and cluttering. *British Journal of Disorders of Communication*, 11(1), 19–26.
- Donovan, G. (1971). A new device for the treatment of stammering. *British Journal of Disorders of Communication*, 6, 86–93.
- Druce, T., Debney, S., & Byrt, T. (1997). Evaluation of an intensive treatment program for stuttering in young children. *Journal of Fluency Disorders*, 22(2), 169–186.
- Erikson, R.L. (1969). Assessing communication attitudes among stutterers. *Journal of Speech and Hearing Research*, 12, 711-724.
- Euler, H., Wolf zu Guddenberg, A., Jung, K., & Neumann, K. (2009). Computergestützte Therapie bei Redeflussstörungen: die langfristige Wirksamkeit der Kasseler Stottertherapie. *Sprache, Stimme, Gehör*, 33, 193–201.
- Evesahm, M., & Fransella, F. (1985). Stuttering relapse: The effect of a combined speech and psychological reconstruction programme. *British Journal of Disorders of Communication*, 20, 237–248.
- Field, A. (2009). *Discovering statistics using SPSS: Introducing statistical methods* (3<sup>rd</sup>). London, UK: SAGE Publications Inc.
- Forster, D., & Webster, W. (2001). Speech-motor control and interhemispheric relations in recovered and persistent stuttering. *Developmental Psychology*, 19(2), 125–145.

- Foundas, A., Bollich, A., Corey, D., Hurley M., & Heilman, K. (2001). Areas in adults with persistent developmental stuttering. *Neurology*, 57(2), 207–215.
- Foundas, A., Bollich A., & Feldman, J. (2004). Aberrant auditory processing and atypical planum temporale in developmental stuttering. *Neurology*, 63(9), 1640–1646.
- Foundas, A., & Conture, E. (Summer 2009). Research on electronic devices. *Stuttering Foundation Newsletter*.
- Fox, P., Ingham, R., & Ingham, J. (1996). A PET study of the neural systems of stuttering. *Nature*, 382, 158–162.
- Frank, A. (1947). *Aus dem Tagebuch*. Das Hirschgraben Lesebuch 9 (pp. 71–79). Berlin: Cornelsen. (Abbreviated work published in 2008).
- Frasier, M. (2007). Self-therapy for the stutterer. (10<sup>th</sup> ed.). Memphis, TN, US: Stuttering Foundation of America.
- Freund, H. (1932). Der induktive Vorgang im Stottern und seine therapeutische Verwertung. *Zeitschrift fuer Neurologie und Psychiatrie*, 141, 180–192.
- Froeschels, E. (1943). Pathology and therapy of stuttering. *Nervous Child*, 2, 148–161.
- Froeschels, E. (1950). A technique for stutterers - "ventriloquism". *Journal of speech and Hearing Disorders Monograph*, 15, 336–337.
- Geschwind, N., & Galaburda, A. (1985). Cerebral lateralization: Biological mechanisms, associations, and pathology: I.: A hypothesis and program for research. *Archives of Neurology*, 42, 429–459.
- Gibney, N. J. (1975). Delayed auditory feedback: changes in the volume intensity and the delay intervals as variables affecting the fluency of stutterers' speech. *British Journal of Psychology*, 64(1), 55.
- Gillespie, S.K., & Cooper, E.B. (1973). Prevalence of speech problems in junior and senior high schools. *Journal of Speech and Hearing Research*, 16, 739-743.
- Giraud, A., Neumann, K., Bachoud-Levi, A-C., Wolf von Gudenberg, A., Euler, H., Preibisch, C., & Lanfermann, H. (2008). Severity of dysfluency

- correlates with basal ganglia activity in persistent developmental stuttering. *Brain and Language*, 104, 190–199.
- Girden, E. (1992). *ANOVA: repeated measures*. Thousand Oaks, CA: SAGE University Paper Series on Qualitative Applications in the Social Sciences.
- Glück, C. (2003). *FluencyMeter Science: Die objektive Sprechflüssigkeitsmessung und Stotterdiagnostik*. München: Urban & Fischer.
- Goebel, M. (1988). CAFET - a computer-aided fluency establishment trainer: A clinician's perspective. *Clinical Connection*, 2, 1-5.
- Goldberg, G. (1985). Supplementary motor area structure and function. *The Behavioral and Brain Science*, 8, 567–616.
- Goldiamond, I. (1965). Stuttering and fluency as manipulatable operant response classes. In L. & U. L. Krasner (Ed.), *Research in Behavior Modification* (pp. 106–156). New York: Holt, Rinehart & Winston.
- Greenhouse, S.W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika*, 24, 95–112.
- Gregory, H., & Mangan, J. (1982). Auditory processes in stutterers. In N. Lass (Ed.), *Speech and Language: Advances in basic research and practice*. New York: Academic Press.
- Griffiths, J., & Warren, J. (2002). The planum temporale as a computational hub. *Trends in Neuroscience*, 25, 348–353.
- Guitar, B. & Bass, C. (1978). Stuttering therapy: the relationship between attitude change and long-term outcome. *Journal of speech and Hearing Disorders Monograph*, 43, 392–400.
- Guitar, B. (1998). *Stuttering: An integrated approach to its nature and treatment* (2<sup>nd</sup>). Baltimore, MD: Lippincott-Williams & Wilkins.
- Guitar, B. (2006) *Stuttering: An integrated approach to its nature and treatment* (3<sup>rd</sup>). Baltimore, MD: Lippincott-Williams & Wilkins.
- Gwet, K. (2011). *The wilcoxon test with excel: A practical guide for students and professionals*. Gaithersburg, MD: Advanced Analytics, LLC.
- Hall, D., Lynn, J., & Altieri, J. (1987). Inter-Intrajudge reliability of the stuttering severity instrument. *Journal of Fluency Disorders*, 12(2), 167–173.

- Ham, R. (1986). *Techniques of stuttering therapy*. Englewood Cliffs N.J: Prentice-Hall.
- Ham, R., & Steer, M. (1967). Certain effects of alternations in auditory feedback. *Folia Phoniatrica*, 19, 53–64.
- Hand C.R., & Haynes, W. (1986). Linguistic processing and reaction time differences in stutterers and nonstutterers. *Journal of Speech and Hearing Research*, 26, 181–185.
- Hansen, B., & Iven C. (2010). Diagnostik des Stotterns bei Kindern: Ein Diskussionsbeitrag zur Umsetzung der ICF. *Sprachheilarbeit*, 55, 71–78.
- Hargrave, S., Kalinowski, J., Stuart, A., Armson, J., & Jones, A. (1994). Stuttering reduction under frequency-altered feedback at two speech rates. *Journal of Speech and Hearing Research*, 37, 1313–1320.
- Harrington, J. (1988). Stuttering, delayed auditory feedback, and linguistic rhythm. *Journal of Speech, Language, and Hearing Research*, 31, 36–47.
- Hashimoto, Y., & Sakai, K. (2003). Brain activations during conscious self-monitoring of speech production with delayed auditory feedback: An fMRI study. *Human Brain Mapping*, 20, 22–28.
- HDC 5, wired monaural earphone [apparatus]. (2007). White Plains, NY: Nokia Corporation
- Helm, N.A., Butler, R.B., & Benson, D.F. (1978). Acquired stuttering. *Neurology*, 28, 1159-1165.
- Helps, R., & Dalton, P. (1979). The effectiveness of an intensive group speech therapy program for adult stammerers. *British Journal of disorders of Communication*, 14, 17–30.
- of America.
- Hemingway, E. (1941). Auszug aus: Das Ende von Etwas. Das Hirschgraben Lesebuch 9 (pp. 58–61). Berlin: Cornelsen. (Abbreviated work published in 2008).
- Hesse, H. (1906). Auszug aus: Unterm Rad. Das Hirschgraben Lesebuch 9 (pp. 33–36). Berlin: Cornelsen. (Abbreviated work published in 2008)
- Hood, S. B. (Ed.) (1998). *Advice to those who stutter* (2nd Ed.). Memphis, TN: Stuttering Foundation

- Howell, P., El-Yaniv, N., & Powell, D. (1987). Factors affecting fluency in stutterers. In Peters, H. & Hulstijn, W. (Eds.), *Speech Motor Dynamics in Stuttering* (pp. 361–369). New York: Springer Verlag.
- Howell, P., Sackin S., & Williams, R. (1999). Differential effects of frequency shifted feedback between child and adult stutterers. *Journal of Fluency Disorders*. 24(1), 127–136
- Howell, P. (2004). Assessment of some contemporary theories of stuttering that apply to spontaneous speech. *Contemporary Issues in Communication Science and Disorders*, 31, 123–140.
- Howie, P., Tanner, S., & Andrews, G. (1981). Short- and long-term outcome in an intensive treatment program for adult stutterers. *Journal of speech and Hearing Disorders Monograph*, 46, 104–109.
- HRT-80 [apparatus] (1986) Köln, Germany: Schwarzhaupt Medizintechnik GmbH.
- Hunt, B. (1987). Self-help for stutterers — experience in Britain. In Rustin, L., Purser, H., & Rowley, D. (Eds.), *Progress in the treatment of fluency disorders* (pp. 198–214). London: Taylor & Francis.
- Huynh, H., & Feldt, L.S. (1976) Estimation of the box correction for degrees of freedom from sample data in randomized block and split-plot designs. *Journal of Educational Statistics*, 1, 69–82.
- Ingham, R., & Cordes, A. (1998). Treatment decisions for young children who stutter: Further concerns and complexities. *American Journal of Speech-Language Pathology*, 7, 10-19.
- Ingham, R., Fox, P., Costello, I., & Zamarripa, T. (2000). Is overt stuttered speech a prerequisite for the neural activations associated with chronic developmental stuttering? *Brain and Language*, 75, 163–194.
- Ingham, R., Kilgo, M., Ingham, J., Moglia, R., Belknap, H., & Sanchez, T. (2001). Evaluation of a stuttering treatment based on reduction of short phonation intervals. *Journal of Speech, Language and Hearing Research*, 44, 1229–1244.
- Ingham, R., Moglia, R., Frank, P., & Ingham, J. (1997). Experimental investigation of the effects of frequency-altered auditory feedback on the

- speech of adults who stutter. *Journal of Speech, Language and Hearing Research*, 40, 361–372.
- Ingham, R., & Montgomery, J. (1983). The effect of manipulating phonation duration on stuttering. *Journal of Speech and Hearing Research*, 26, 579–587
- Irani, F., Gabel, R., Daniels, D., & Hughes, S. (November, 2010). *Evaluating treatment outcomes for intensive stuttering therapy: A mixed-method approach*. Philadelphia, PA.
- Iverach, L., O'Brian, S., Jones, M., Block, S., Lincoln, M., Harrison, E., Hewat, S., Menzies, R.G., Packman, A., & Onslow, M. (2009). Prevalence of anxiety disorders among adults seeking speech therapy for stuttering. *Journal of Anxiety Disorders*, 23(7), 928-934.
- Iverach, L., Menzies, R., O'Brian, S. Packman, A., & Onslow, M. (2011). Anxiety and Stuttering: Continuing to Explore a Complex Relationship. *American Journal of Speech Language Pathology*, 20(3), 221-232.
- Johnson, W. (1942). A study of the onset and development of stuttering. *Journal of Speech Disorders*, 7, 251–257.
- Johnson, W. (1961). Measurement of oral reading and speaking rate and dysfluency of adult male and female stutterers and non-stutterers. *Journal of speech and Hearing Disorders Monograph*, 7, 1–20.
- Johnson, W., & Colley, W.H. (1945). The relationship between oral reading rate and severity of stuttering. *Journal of Speech Disorders*, 10, 35–38.
- Johnson, W., Darley, F. L., & Spriestersbach, D. C. (1963). *Diagnostic Methods in speech pathology*. New York, NY: Harper & Row.
- Jones, B., & Kenward, M. (2003). *Design and analysis of Cross-Over Trials* (2nd). London: Chapman & Hall.
- Kalinowski, J. (1993). Effects of alterations in auditory feedback and speech rate on stuttering frequency. *Language and Speech*, 36, p. 1.
- Kalinowski, J., Armson, J., Roland-Mieszkowski, M., Stuart, A., & Gracco, V. (1993). Effects of alterations in auditory feedback and speech rate on stuttering frequency. *Language and Speech*, 36, 1–16.

- Kalinowski, J., Stuart, A., Sark, S., & Armson, J. (1996). Stuttering amelioration at various auditory delays and speech rates. *European Journal of Disorders of Communication*, 31, 259–269.
- Kalinowski, J., Stuart, A., Wamsley, L., & Rastatter, M. (1999). Effects of monitoring conditions and altered auditory feedback on stuttering frequency. *Journal of Speech, Language and Hearing Research*, 42, 1347–1354.
- Kang, C., Riayudin, S., Mundorff, J., Krasnewich, D., Friedman, P., Mulkin J., & Drayna, D. (2010). Mutations in the lysosomal enzyme-targeting pathway and persistent stuttering. *New England Journal of Medicine*, 362, 677–685.
- Kern, A. (1931). Der Einfluss des Hörens auf das Stottern. *Archiv für Psychiatrie und Nervenkrankheit*, 97, 429.
- Kimura, D. (1961). Cerebral dominance and the perception of verbal stimuli. *Canadian Journal of Psychology*, 15, 156–165.
- Kolk, H. (1991). Is stuttering a symptom of adaptation or of impairment? In H. W., Hulstijn & S. C. Peters (Ed.), *Speech Motor Control and Stuttering* (pp. 127–139). Amsterdam: Elsevier.
- Kolk, H., & Postma, A. (1997). Stuttering as a covert repair phenomenon. In R. F. Curlee & G. M. Siegel (Ed.), *Nature and treatment of stuttering: New directions* (2nd ed., pp. 182–203). Needham, MA: Allyn & Bacon.
- Koller, W.C. (1982). Dysfluency (stuttering) in extrapyramidal disease. *Archives of Neurology*, 40, 175–177.
- Koslow, S., & Mandell, A. & S. M. (Eds.). (1987). *Perspectives in biological dynamics and theoretical medicine*. New York: The New York Academy of Sciences.
- Krauss-Lehrman, T., & Reeves, L. (1989). Attitudes toward speech–language pathology and support groups: Results of a survey of members of the National Stuttering Project. *Texas Journal of Audiology and Speech Pathology*, XV(1), 22–25
- Kroll, R. & De Nil, L. (Summer, 2000). Neural bases of stuttering and its treatment. *Stuttering Foundation of America Newsletter*. Retrieved from [www.stutteringhelp.org/deskleftdefault.aspx?tabid=167](http://www.stutteringhelp.org/deskleftdefault.aspx?tabid=167)

- Kully, D. & Langevin, M. (2005). Evidence-based practice in fluency disorders. *The ASHA Leader*, 10, 10–15.
- Langevin, M., & Boberg, E. (1993). Results of an intensive stuttering therapy program. *Journal of Speech-Language Pathology and Audiology*, 17, 158–166.
- Langevin, M., Kully, D., Teshima, S., Hagler, P., & Prasad, N. (2010). Five-year longitudinal treatment outcomes of the ISTAR comprehensive stuttering program. *Journal of Fluency Disorders*, 35(1), 123–140.
- Lechner, B. (1979). The effects of delayed auditory feedback and masking on the fundamental frequency of stutterers and nonstutterers. *Journal of Speech and Hearing Research*, 22, 343–353.
- Le, C.T., & Boen J.R. (1995) *Health and numbers: basic biostatistical methods*. Chichester, UK: John Wiley.
- Lee, B. (1950). Effects of delayed speech feedback. *Journal of the Acoustical Society of America*, 22, 824–826.
- Lee, B. (1951). Artificial Stutter. *Speech Disorders*, 16, 53–55.
- Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. In W.J.M. Levelt (Ed.) *ACL-MIT Press series in natural-language processing*. Cambridge, Mass: MIT Press.
- Lewis, K. (1995). Do SSI-3 scores adequately reflect observations of stuttering behaviors? *American Journal of Speech-Language Pathology*, 14, 46–59.
- Lincoln, M., & Packman, A. (2002). Measuring stuttering. In M. Onslow, Harrison, E., & Packman, A. (Eds.), *The Lidcombe Program of early stuttering intervention: a clinician's guide* (pp. 59–68). Austin, TX: Pro-Ed.
- Lincoln, M., Packman, A., & Onslow, M. (2006). Altered auditory feedback and the treatment of stuttering: A review. *Journal of Fluency Disorders*, 31(1), 71–89.
- Lincoln, M., Packman, A., Onslow, M., & Jones, M. (2010). An experimental investigation of the effect of altered auditory feedback on the conversational speech of adults who stutter. *Journal of Speech, Language and Hearing Research*, 53, 1122–1133.

- Lincoln, M., & Walker, C. (2007). A survey of Australian adult users of altered auditory feedback devices for stuttering: Use patterns, perceived effectiveness and satisfaction. *Disability and Rehabilitation*, 29(19), 1510-1517
- Lotzmann, G. (1961). Zur Anwendung variierter Verzögerungszeiten bei Balbuties. *Folia Phoniatica*, 13, 276–312.
- Low, J., & Duncan, L. (1979). A body-worn delayed auditory feedback fluency aid for stammerers. *Journal of Biomedical Engineering*, 1, 235–239.
- Mackesey, T. (2004). *Stuttering: When Attempted Solutions Become the Problem*. Retrieved from <http://www.stutteringtherapycenter.com/articles/solutions.htm>
- Mackey, M., & Multon J. (1987). Dynamical Diseases. In Koslow, S. & Mandell, S. (Eds.), *Perspectives in biological dynamics and theoretical medicine* (pp. 16–32). New York: The New York Academy of Sciences.
- MacLeod, J. Kalinowski, J., Stuart, A., & Armson, J. (1995). Effect of single and combined altered auditory feedback on stuttering frequency at two speech rates. *Journal of Communication Disorders*, 28, 217–228.
- Mahr, G., & Leith, W. (1992). Psychogenic stuttering of adult onset. *Journal of Speech and Hearing Research*, 35, 283-286.
- Mansson, H. (2006). *Complexity and diversity in early childhood stuttering*. Paper presented at the 5<sup>th</sup> International Congress of Fluency Disorders, Dublin, Ireland.
- Mansson, H. (2000). Childhood stuttering: Incidence and development. *Journal of Fluency Disorders*, 25(1), 47–57.
- Marista, J., & Hutton, C. (1957). Effects of auditory masking upon the speech of stutterers. *Journal of speech and Hearing Disorders Monograph*, 22, 85–92.
- Martin, R., & Haroldson, S.K. (1979). Effects of Five Experimental Treatments of Stuttering, *Journal of Speech and Hearing Research*, 21, 132-146.
- Marshall, J. (2000). Planum of the apes: A case study. *Brain and Language*, 71, 145–148.

- Mauchly, J. W. (1940). Significance test for sphericity of a normal n-variate distribution. *The Annals of Mathematical Statistics* 11(2), 204–209.
- Mazzucchi, A., Moretti, G., Carpeggiani, P., Parma, M., & Painsi, P. (1981). Clinical observations on acquired stuttering. *British Journal of Disorders of Communication*, 16, 19-30.
- McCauley, R. J., & Swisher, L. (1984). Psychometric review of language and articulation tests for preschool children. *Journal of Speech and Hearing Disorders Monograph*, 49, 34–42.
- McCauley, R. J. (1996). Familiar strangers: criterion-referenced measures in communication disorders. *Language, Speech, and Hearing Services in Schools*, 27, 122–131.
- McCormick, B. (1975). Therapeutic and diagnostic applications of delayed auditory feedback. *British Journal of Disorders of Communication*, 10, 98–100.
- McCoy, S., Tun, P., Cox, L., & Wingate, A. (2005). Aging in a Fast-Paced World: Rapid speech and Its Effect on Understanding. *The ASHA Leader*, 12, 30–31.
- Messenger, M., Onslow, M., Packman, A., & Menzies, R. (2004). Social anxiety in stuttering: measuring negative social expectancies. *Journal of Fluency Disorders*, 29(2), 201-212.
- Meyers, S. (1986). Qualitative and quantitative differences and patterns of variability in dysfluencies emitted by preschool stutterers and nonstutterers during dyadic conversations. *Journal of Fluency Disorders*, 9(3), 293–306.
- Molt, L. (2006). *SpeechEasy AAF device long-term clinical trial: Attitudinal/perceptual measures*. Poster presented to the American Speech-Language-Hearing Association, Miami, FL.
- Moore, H., W., Jr. (1980). Alpha hemispheric asymmetry and stuttering: Some support for a segmentation dysfunction hypothesis. *Journal of Speech and Hearing Research*, 23, 229-224.

- Moore, W. H., Jr. (1984). Central nervous system characteristics of stutterers. In Curlee, R.F., & Siegel, G.M. (Eds.), *Nature and treatment of stuttering: New directions* (pp. 49–72). San Diego: College-Hill Press.
- Moscicki, E. (1994). Fundamental methodological considerations in controlled clinical trials. *Journal of Fluency Disorders*, 18(2), 183–196.
- MyoTrac [apparatus]. (2011). Montreal, Canada: Thought Technology, Ltd.
- National Institutes of Health – National institute on Deafness and other Communication Disorders. (2010). Stuttering. NIH Pub. No. 10-4232. Bethesda, MD., US: NIDCD Information Clearinghouse.
- Natke, U. (2000). Stotterreduktion unter verzögerter und frequenzverschobener auditiver Rückmeldung: Reduction of stuttering frequency using frequency-shifted and delayed auditory feedback. *Folia Phoniatrica et Logopaedica*, 52(4), 151-159.
- .
- Natke, U. Alperam, A., Heil, W., Kuckenberg, S., & Zückner, H. (2010). Langzeitergebnisse der Intensiv-Modifikation-Stottern. *Sprache, Stimme, Gehör*, 34, 155–164.
- Natke, U., & Kalveram, K.-T., & Grosser, J. (2001). Fluency, fundamental frequency, and speech rate under frequency-shifted auditory feedback in stuttering and non-stuttering persons. *Journal of Fluency Disorders*, 26, 227–241.
- Neumann, K., Euler, H., Wolf von Gudenberg, A., Giraud, A.-L., Lanfermann, H., & Gall, V. (2003). The Nature and Treatment of Stuttering as revealed by fMRI: a within- and between-group comparison. *Journal of Fluency Disorders*, 28(2), 381–411.
- Neumann, K., Preibisch, C., Euler, H., Wolf von Gudenberg, A., Lanfermann H., & Gall, V. (2005). Cortical plasticity associated with stuttering therapy. *Journal of Fluency Disorders*, 30(1), 23–29.
- Nicolosi, L., Harryman, E., & Kresheck, J. (1978). *Terminology of communication disorders in speech, language, hearing sciences*. Baltimore, MD, US: Williams & Wilkins.

- O'Brian, S., Onslow, M., Cream, A., & Packman, A. (2003). The Camperdown Program: Outcomes of a New Prolonged-Speech Treatment Model. *Journal of Speech, Language, and Hearing Research*, 46, 933–946.
- O'Donnell, M., Armson, J., & Kieft, M. (2008). The effectiveness of SpeechEasy during situations of daily living. *Journal of Fluency Disorders*, 33(1), 99-119.
- Öst, L., Götestam, K., & Merlin, G. (1976). A controlled study of two behavioral methods in the treatment of stuttering. *Behavior Therapy*, 7, 587–592.
- Onslow, M., Costa, L., & Rue, S. (1990). Direct early intervention with stuttering: some preliminary data. *Journal of speech and Hearing Disorders Monograph*, 55, 405–416.
- Onslow, M., Costa, L., Andrews, C., Harrison, E., & Packman, A. (1996). Speech outcomes of a prolonged-speech treatment for stuttering. *Journal of Speech and Hearing Research*, 39, 734–749.
- Orton, S. (1928). A physiological theory of reading disability and stuttering. *New England Journal of Medicine*, 199, 1046–1052.
- Oxford Centre for Evidence- Based Medicine. (2011). *CEBM (Centre for Evidence-Based Medicine) Levels of Evidence*. Retrieved from <http://www.cebm.net/index.aspx?o=5653>
- Packman, A., & Attanasio, J. (2004). *Theoretical issues in Stuttering*. New York: Psychology Press.
- Packman, A., Onslow, M., van Richard, M., & van Doorn, J. (1996). Syllabic stress and variability: a model of stuttering. *Clinical Linguistics and Phonetics*, 10, 235-263.
- Passingham, R. (1987). Two cortical systems for directing movement. *Ciba Foundation Symposium Proceedings*, 132, 151–164.
- Perkins, W. H. (1993). The early history of behavior modification of stuttering: A view from the trenches. *Journal of Fluency Disorders*, 18(1), 1–11.
- Perkins, W. H., & Curlee, R. (1969). Clinical impressions of a portable masking unit: Effects in stuttering. *Journal of speech and Hearing Disorders Monograph*, 34, 360–362.

- Perkins, W. H., Kent, R., & Curlee, R. (1991). A theory of neuropsycholinguistic function in stuttering. *Journal of Speech, Language, and Hearing Research*, 34, 734-752.
- Petkov, D., & Iosifov, I. (1960). Our experience with the treatment of stuttering in a treatment-logopedic camp. *Zeitschrift für Neuropathology und Psychiatrie*, 60, 903-904.
- Pollard, R., Ellis, J., Finan, D., & Ramig, P. (2009). Effects of the SpeechEasy on objective and perceived aspects of stuttering: a 6-months, Phase I clinical trial in naturalistic environments. *Journal of Speech, Language and Hearing Research*, 52, 516-533.
- Postma, A., & Kolk, H. (1993). The covert repair hypothesis: Prearticulatory repair processes in normal and stuttered dysfluencies. *Journal of Speech and Hearing Research*, 36, 472-487.
- Prasse, J.E., & Kikano, G.E. (2008) Stuttering: an overview. *American Family Physician*. 77(9), 1271-1276.
- Price, I. (2000). *Research design: between groups vs. repeated measures designs*. Retrieved from [http://www.une.edu.au/WebStat/unit\\_materials/c2\\_research\\_design/between\\_repeated\\_measure.htm](http://www.une.edu.au/WebStat/unit_materials/c2_research_design/between_repeated_measure.htm)
- Prins, D., & Nichols, A. (1974). Client impressions of the effectiveness of stuttering therapy: A comparison of two programs. *International Journal of Speech and Communication Disorders*, 9(2), 123-133.
- Prosek, R., Walden, B., Montgomery, A., & Scheer, D. (1979). Some correlates of stuttering severity judgments. *Journal of Fluency Disorders*, 4(2), 215-222.
- Quinn, P.T., & Andrews, G. (1977). Neurological stuttering A clinical entity? *Journal of Neurology, Neurosurgery & Psychiatry*, 40, 699-701.
- Ramig, P. (1993). The impact of self-help groups on persons who stutter: A call for research. *Journal of Fluency Disorders*, 18, 351-361.
- Ramig, P., Ellis, J., & Pollard, R. (2010). Application of the SpeechEasy to Stuttering Treatment: Introduction, Background, and Preliminary Observations. In B. & M. R. Guitar (Ed.), *Treatment of Stuttering:*

- Established and Emerging Interventions* (pp. 312–342). Baltimore, MD: Wolters, Kluwer, Lippincott, Williams & Wilkins.
- Rastatter, M., & Dell, C. (1987). Vocal reaction times of stuttering subjects to tachistoscopically presented concrete and abstract words: A closer look at cerebral dominance and language processing. *Journal of Speech and Hearing Research, 30*, 306–310.
- Rentschler, G. (2004). *Stuttering Therapy: Behaviors Associated with Stuttering*. Retrieved from <http://courses.duq.edu/rentschler/index.htm>
- Riley, G. (1972). A stuttering severity instrument for children and adults. *Journal of Speech and Hearing Disorders Monograph, 3*, 314–322.
- Riley, G. (2009). *Stuttering Severity Instrument - 4th Edition. Examiner's Manual and Picture Plates* (4th ed.). Austin, TX: ProEd.
- Roach, P., Arnfield, S., & Hallum, E. (1996). BABEL: A multi-language database. In *Proceedings of the Australian International Conference on Speech* (pp. 351–402).
- Rosenbek, J., Messert, B., Collins, M., & Werty, R.T. (1978). Stuttering following brain damage. *Brain and Language, 6*, 82-96.
- Roth, C.,R., Aronson, A.,E., & Davis, L.,J., Jr. (1989). Clinical studies in psychogenic stuttering of adult onset. *Journal of Speech and Hearing Disorders, 54*, 634-646.
- Rustin, L., Rustin, B., & Ryan, B. (1987). Use of the Monterey Programmed Stuttering Therapy in Great Britain. *British Journal of Disorders of Communication, 22*, 151–162.
- Ryan, B. (2001a). A longitudinal study of articulation, language, rate and fluency of 22 preschool children who stutter. *Journal of Fluency Disorders, 26*(1), 107-127.
- Ryan, B. (2001b). Programmed stuttering therapy for children and adults. In B. Ryan, & van Kirk, B. (Ed.), *Monterey Fluency Program* (pp. 114–121). Monterey, CA: Behavioral Science Institute.
- Ryan, B. (Nov. 16<sup>th</sup>-18<sup>th</sup>, 2006). *EBP in stuttering for universities: Assessment/management GILCU, transfer, and maintenance*. ASHA convention, Miami, FL.

- Ryan, B., & Ryan, B. (1995). Programmed stuttering treatment for children: Comparison of two establishment programs through transfer, maintenance, and follow-up. *Journal of Speech and Hearing Research*, 38, 61-75
- Ryan, B., & van Kirk B. (1974). The establishment, transfer, and maintenance of fluent speech in 50 stutterers using delayed auditory feedback and operant procedures. *Journal of Speech and Hearing Research*, 39, 3–10.
- Sackett, D. Strauss, S., Richardson, W., Rosenberg, W., & Haynes, R. (2000). *Evidence-based medicine: how to practice and teach EBM*. Edinburgh: Churchill Livingstone.
- Sackett, D. (1998). Evidence/based medicine. *SPINE*, (23), 1085–1086.
- Saltuklaroglu, T., Kalinowski, J., Robbins, M., & Crawcour, S., & Bowers, A. (2009). Comparisons of stuttering frequency during and after speech initiation in unaltered feedback, altered auditory feedback and choral speech conditions. *International Journal of Language and Communication Disorders*, 44(6), 1000–1017.
- Schwartz, D., & Webster, L. (1975). More on the efficacy of a protracted precision fluency shaping program. *Journal of Fluency Disorders*, 2, 205–215.
- Seemann, M. (1995). *Sprachstörungen bei Kindern*. Halle, Germany: Marhold.
- Sennheiser PC 131 binaural headset [apparatus]. (2005). Old Lyme, CT, USA: Sennheiser Electronics Corporation.
- Shames, G., & Flores, C. (1980). *Stutter-free speech: A goal for therapy*. Columbus, Ohio: Charles E. Merrill.
- Shane, M. (1955). Effect on stuttering of alternation of auditory feedback. In W. Johnson (Ed.), *Stuttering in children and adults*. Minneapolis, MN: Uni. of Minnesota Press.
- Sheehan, J. G. (1970). *Stuttering: Research and therapy: (Under the advisory editorship of J. Jeffery Auer)*. New York, Evanston, and London: Harper & Row.
- Sheehan, J.G., & Martyn, M. (1966). Spontaneous recovery from stuttering. *Journal of Speech and hearing Research*, 9, 121-135.

- Sherman, D. (1952). Clinical and experimental use of the Iowa Scale of Severity of Stuttering. *Journal of speech and Hearing Disorders Monograph*, 17, 316–320.
- Shine, R. (1983). How Parents and Professionals Can Help the Stuttering Child. *The Official Journal of the North Carolina Medical Society*, 44, 8–12.
- Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: uses in assessing rater reliability. *Psychological Bulletin*, 2, 420–428.
- Silverman, E.M. (1972). Generality of dysfluency data collected from preschoolers. *Journal of Speech and Hearing Research*, 15, 84–92.
- Silverman, F. H. (1996). *Stuttering and other fluency disorders* (2nd). Boston; London: Allyn and Bacon.
- Sima, SDW-150 induction microphone [apparatus]. (2009). Hauppauge, NY: Sima Products Corporation.
- Skinner, B. F. (1938). *Behavior of organisms*. New York: Apple-century-crofts.
- SmallTalk [apparatus]. (2007). Boulder, CO, USA: Casa Futura Technologies.
- Smith, A. (1999). Stuttering: A unified approach to a multi- factorial, dynamic disorder. In Bernstein Ratner, N., & Healey, E.C. (Eds.), *Stuttering research and practice: Bridging the gap* (pp. 27–44). Mahwah, NJ: Erlbaum.
- Smith, A., & Kelly, E. (1997). Stuttering: A dynamic multifactorial model. In R. Curlee, & G. Siegel (Eds.) *Nature and treatment of stuttering: new directions*, (2nd ed.). Needham Heights, MA: Allyn & Bacon.
- Sommer, M. (September 1st-4th, 2011). *On currents, fibers and action potentials: neurophysiology of stuttering*. 9th Oxford Dysfluency Conference, Oxford, UK.
- SPSS Inc. (2010). SPSS Base 18.0 for Mac User's Guide. SPSS Inc. Chicago IL.
- SPSS Inc. (2011). SPSS Base 19.0 for Mac User's Guide. SPSS Inc. Chicago IL
- Sparks, G., Grant, D., Millay, K., Walker-Baston, D., & Hill, L. The effect of fast speech rate on stuttering frequency during delayed auditory feedback. *Journal of Fluency Disorders*, 27(2), 187–201.

- SpeechEasy device [application]. (2011). Greenville, NC: Janus Development Group Inc.
- St. Louis, K. O. (1997). Six reasons why clinicians may fear stuttering. *Perspectives on Fluency and Fluency Disorders*, 7, 4-6.
- Stager, S., & Ludlow, C. (1993). Speech production changes under fluency-evoking conditions in non-stuttering speakers. *Journal of Speech, Language and Hearing Research*, 36, 245–253.
- Starkey In The Ear (ITE) device [apparatus]. (2009). Eden Prairie, MN: Starkey Laboratories, Inc.
- Starkweather, C. W. (1987). *Fluency and stuttering*. Englewood Cliffs N.J: Prentice-Hall.
- Starkweather, C.W., Gottwald, S., & Halfond, M. (1990). *Stuttering prevention: A clinical method*. Englewood Cliffs, N.J.: Prentice Hall.
- Stromsta, C. (1957). A methodology related to the determination of the phase angle of bone-conducted speech sound energy of stutterers and nonstutterers. *Speech Monographs*, 24, 147–148.
- Stromsta, C. (1958). *The effects of altering the fundamental frequency of masking on the speech performance of stutterers*. Technical Report, National Institute of Health, Project B-1331.
- Stromsta, C. (1972) Interaural phase disparity of stutterers and nonstutterers. *Journal of Speech and Hearing Research*, 15, 771–780.
- Stuart, A., Kalinowski, J., & Rastatter, M. (1997). Effects of monaural and binaural altered auditory feedback on stuttering. *Journal of the Acoustical Society of America*, 6, 3806–3809.
- Stuart, A., & Kalinowski, J. (2004). The perception of speech naturalness of post-therapeutic and altered auditory feedback speech of adults with mild and severe stuttering. *Folia Phoniatrica et Logopaedica*, 56(6), 347–357.
- Stuart, A., Kalinowski, J., Rastatter, M., Saltuklaroglu, T., & Dayalu V. (2004). Investigations of the Impact of Altered Auditory Feedback In-The-Ear Devices on the Speech of People Who Stutter: Initial Fitting and 4-Month Follow-up. *International Journal of Language and Communication Disorders*, 39(1), 93-113.

- Stuart, A., Kalinowski, J., Saltuklaroglu, T., & Guntupalli, V. (2006). Investigations of the impact of altered auditory feedback in the ear devices on the speech of people who stutter: One year follow up. *Disability and Rehabilitation*, 28, 757–765.
- Stuart, A., Frazier, C., Kalinowski, J., & Voss P. (2008). The effect of frequency altered feedback on stuttering duration and type. *Journal of Speech, Language and Hearing Research*, 51, 889–897.
- Susca, M., & Healey, E. (2000). Multi-factorial issues in the assessment of stuttering. In. Bosshardt, H.-G & Peters, H.F.M (Ed.), *Fluency disorders, theory, research, treatment and self-help. Proceedings of the third world congress on fluency disorders in Nyborg Denmark* (pp. 213–218). Nijmegen, Denmark: Nijmegen University Press.
- Takaso, H., Eisner, F., Weis, R., & Scott, S. (2010). The effect of delayed auditory feedback on activity in the temporal lobe while speaking:: A positron emission tomography study. *Journal of Speech, Language, and Hearing Research*, 53, 226–236.
- Tasko, S., McClean, M., & Runyan, C. (2007). Speech motor correlates of treatment-related changes in stuttering severity and speech naturalness. *Journal of Communication Disorders*, 40, 42–65.
- Teeson, K., Packman, A., & Onslow, M. (2003). The Lidcombe Behavioral Data Language of Stuttering. *Journal of Speech, Language, and Hearing Research*, 46, 1009–1015.
- Thompson, A. (1985). A test of the distraction explanation of dysfluency modificatino in stuttering. *Journal of Fluency Disorders*, 10(1), 35–50.
- Toyomura, A., Koyama, S., Miyamaoto, T., Terao, A., Omori, T., Murohashi, H., & Kuriki, S. (2007). Neural correlates of auditory feedback control in humans. *Neuroscience*, 146, 499–503.
- Travis, L. (1931). *Speech Pathology*. New York: Appleton and Company.
- Tsiamtsiouris, J., & Krieger, K. (2010). The successful stuttering management program (SSMP): A preliminary report on outcomes. *Perspectives on Fluency and Fluency Disorders*, 20, 20–25.

- Unger, J.P., Glück, C.W., & Cholewa, J. (2012). The immediate effects of AAF devices on the characteristics of stuttering: a clinical analysis. *Journal of Fluency Disorders*, 37(2), 122-134.
- van Borsel, J., Reunes, G., & van den Bergh, N. (2003). Delayed auditory feedback in the treatment of stuttering: clients as consumers. *International Journal of Language and Communication Disorders*, 38(2), 119–129.
- van Riper, C.G. (1954). *Speech Correction: principles and methods* (3<sup>rd</sup>). New York, US: Prentice Hall.
- van Riper, C. G. (1970). The Use of DAF in Stuttering Therapy. *British Journal of disorders of Communication*, 5, 40–45.
- van Riper, C. G. (1971). *The Nature of Stuttering*. Englewood Cliffs, N.J: Prentice Hall.
- van Riper, C. G. (1973). *The Treatment of Stuttering* (2<sup>nd</sup>) . Englewood Cliffs, N.J.: Prentice-Hall.
- van Riper, C.G. (1982). *The Nature of Stuttering* (2<sup>nd</sup>). Englewood Cliffs, N.J.: Prentice-Hall.
- Vanryckeghem, M., Brutten, G.,J., Uddin, N., & van Borsel, J. (2004) A comparative investigation of the speech-associated coping responses reported by adults who do and do not stutter. *Journal of Fluency Disorders*, 29(3), 237-250.
- VoiceAmp 601i Fluency Enhancer [apparatus and software]. (2008). Cape Town, South Africa: VoiceAmp Speech Aids.
- Wada, J., & Rasmussen, T. (1960). Intracartoid injection of sodium amytal for the lateraliation of cerebral speech dominance. Experimental and clinical observations. *Journal of Neurosurgery*, 17, 266–282.
- Wall, M., & Myers, F. (1995). *Theories of stuttering and therapeutic implications in clinical management of childhood stuttering*. Austin, TX: Pro-Ed.
- Waterloo, K. K., & Gotestam, K. (1988). The regulated-breathing method for stuttering: An experimental evaluation. *Journal of Behavior Therapy and Experimental Psychiatry*, 19, 11–19.

- Watson, B., Freeman, F., Devous, M, Chapman, S., Finizo, T., & Pool, K.D. (1994). Linguistic performance and regional cerebral blood flow in persons who stutter. *Journal of Speech, Language, and Hearing Research*, 37, 1221–1228.
- Webster, R. (1974). A Behavioral Analysis of Stuttering. In Adams, K.M., & K.S. Calhoun (Ed.), *Innovative Treatment Methods in Psychopathology*. New York: Wiley.
- Webster, W. (1988). Neural mechanisms underlying stuttering: evidence from bimanual handwriting performance. *Brain and Language*, 33, 226–244.
- Wilcoxon, F. (1945). Individual comparison by ranking methods. *Biometrics Bulletin*, 1(6), 80–83.
- Wingate, M. (1964) A standard definition of stuttering. *Journal of speech and Hearing Disorders Monograph*, 29, 484–489.
- Wingate, M. (1969). Sound and pattern in artificial fluency. *Journal of Speech and Hearing Research*, 12, 677–686.
- Wingate, M. (1988). *The structure of stuttering: a psycholinguistic analysis*. New York: Springer.
- Woolf, G. (1967). The assessment of stuttering as struggle, avoidance, and expectancy. *British Journal of Disorders of Communication*, 2, 158–171.
- World Health Organization. (2001). International classification of functioning, disability and health (ICF). Geneva: World Health Organization.
- World Health Organization (2012). Classifications: The international classification of functioning, disability and health (ICF). Retrieved from: <http://www.who.int/classifications/icf/en/>.
- Yairi, E. (1981). Dysfluencies of normally speaking two-year old children. *Journal of Speech and Hearing Research*, 24, 490-495.
- Yairi, E. (1997). Dysfluency characteristics of childhood stuttering. In Curlee, R. F. & Siegel, G. (Eds.), *Nature and Treatment of Stuttering New Directions* (2<sup>nd</sup>, pp. 49–78). Boston, M.A.: Allyn & Bacon.
- Yairi, E. & Ambrose, N. (1992). A longitudinal study of stuttering in children: A preliminary report. *Journal of Speech and Hearing Research*, 35, 775-760.
- Yairi, E., & Ambrose, N. (2005). Early childhood stuttering. Austin, Tx: Pro-Ed.

- Yairi, E., & Lewis, B. (1984). Dysfluencies at the onset of stuttering. *Journal of Speech and Hearing Research*, 27, 154–159.
- Yairi, E., & Seery, C.H. (2011). *Stuttering: Foundations and clinical applications*. Upper Saddle River, N.J.: Pearson Education Inc.
- Yaruss, J. S. (1998). Describing the consequences of disorders: Stuttering and the International Classification of Impairments, Disabilities, and Handicaps. *Journal of Speech, Language, and Hearing Research*, 49, 249-257
- Yaruss, J. S. (2000). Converting between word and syllable counts in children's conversational speech samples. *Journal of Fluency Disorders*, 25(3), 305–316.
- Yaruss, J. S. (June 19th 2008). *Overall assessment of the speaker's experience of stuttering (OASES)*. SpeechPathology.com Webinar.
- Yaruss, J. S., LaSalle, L., R., & Conture, E., G. (1998). Evaluating stuttering in children: Diagnostic data. *American Journal of Speech-Language Pathology*, 7(4), 62-76
- Yaruss, J. S., & Quesal, R. (2008). *OASES: Overall Assessment of the Speaker's Experience of Stuttering*. Bloomington, MN: Pearson Assessments.
- Yaruss, J. S., & Quesal, R. W. (2004). Stuttering and the international classification of functioning, disability, and health (ICF): An update. *Journal of Communication Disorders*, 37(1), 35–52.
- Yaruss, J. S., & Quesal, R. (2006). Overall Assessment of the Speaker's Experience of Stuttering (OASES): Documenting multiple outcomes in stuttering treatment. *Journal of Fluency Disorders*, 31, 90-115.
- Yaruss, J.S., Quesal, R.W., Reeves, L, Molt, L.F., Kluetz, B. Caruso, A.J., McClure, J.A., & Lewis, F. (2002). Speech treatment and support group experiences of people who participate in the National Stuttering Association. *Journal of Fluency Disorders*. 27(2), 115-134.
- Young, M. (1981). A reanalysis of "Stuttering therapy: The relation between attitude change and long-term outcome". *Journal of Speech and Hearing Disorders Monograph*, 46, 221–222.

- Speech Delayer SV2-10105 [apparatus]. (1973). Randolfzell am Bodensee, Germany: ZAK Medizin Technik.
- Zebrowski, P. (1991). Duration of speech dysfluency of beginning stutterers. *Journal of Speech and Hearing Research, 34*, 483–491.
- Zimmermann, G. (1984). Articulatory dynamics of stutterers. In R.F. Curlee & W.H. Perkins (Eds.), *Nature and Treatment of Stuttering: New Directions*, (pp. 131-147). San Diego, CA: College-Hill Press.
- Zimmermann, S., Kalinowski, J., Stuart, A., & Rastatter, M. (1997). Effect of altered auditory feedback on people who stutter during scripted telephone conversations. *Journal of Speech, Language and Hearing Research, 40*, 1130–1134.

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## **Appendix 1: Deutsche Zusammenfassung der Englischen Originalarbeit**

Technisch unterstützte Reduktion des Stotterns (TURS):

Die sofortige und langfristige Wirkung von  
modifiziertem auditivem Feedback (MAF) auf  
das chronische Stottern

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Deutsche Zusammenfassung der Englischen Originalarbeit:

The Immediate and Long-term Effects  
of Altered Auditory Feedback (AAF) on the  
Characteristics of Persistent Developmental Stuttering

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Anmerkung zur deutschen Zusammenfassung

Die Deutsche Zusammenfassung dient dem Zweck, eine übersichtliche Darstellung der Hauptmerkmale beider Studien wiederzugeben. Um den Rahmen dieser Übersicht nicht zu sprengen, wurden bestimmte Inhalte verkürzt. Im Vergleich zur englischen Gesamtarbeit fallen beispielsweise die Ergebnisteile kompakter aus. Bei der Darstellung der Resultate der Querschnittstudie wurden die Effekte jeweils für alle Sprechbeispiele (lautes Lesen, Monolog, Dialog) zusammengefasst. Für detaillierte Aussagen im Hinblick auf den Geräteeinfluss innerhalb der einzelnen Sprechproben ist die englische Gesamtarbeit heranzuziehen. Ebenso wurde in der Zusammenfassung der Längsschnittergebnisse auf detaillierte Ausführungen in der qualitativen Analyse verzichtet. Hier wurden lediglich ersichtliche Trends der Gerätenutzung wiedergegeben. Auf ausführliche Beschreibung der gerätetypischen Einstellungsmöglichkeiten und Zusatztechnik wurde jedoch nicht eingegangen.

### Abstract

#### Hintergrund/Background:

Das modifizierte auditive Feedback (MAF) in Form von tragbaren technischen Sprechhilfen ermöglicht es Stotternden seit zirka einem Jahrzehnt diese Technologie mobil in alltagsnahen Situationen einzusetzen. Auch, wenn eine Verbesserung der Sprechflüssigkeit durch die Anwendung von MAF in verschiedenen Studien belegt wurde, so ist es nach wie vor schwierig vorherzusagen, ob und inwieweit ein Betroffener in alltäglichen Sprechsituationen von einem solchen Gerät profitieren wird.

#### Fragestellung/Ziele/Aims

Die beiden in diesem Artikel vorgestellten Studien setzten sich daher zum Ziel, die spezifische Wirkung zwei verschiedener MAF Geräte genauer einzugrenzen. Zum einen werden die sofortigen Effekte dieser technischen Sprechhilfen auf klinische Indikatoren des Stotterschweregrades (z.B. Kernsymptome, Prozentsatz gestotterter Silben, Sprechgeschwindigkeit etc.) erforscht. Zum anderen hat sich diese Forschungsarbeit zum Ziel gesetzt die Langzeiteffekte einer Gerätenutzung im Alltag zu erfassen.

#### Methodik/Methods

Im Rahmen der Querschnittstudie wurde der Effekt verschiedener MAF Kombinationsgeräte auf den Redefluss von 30 Erwachsenen im Alter zwischen 18-68 Jahren ( $M = 36.5$ ;  $SD = 15.2$ ), die an chronischem Stottern leiden, erfasst. Von jedem Probanden wurden 10 Sprechbeispiele gesammelt (4x vorstrukturierte Sprache, 6x Spontansprache). Während der Datenerhebung wurden jeweils 3 Sprechsituationen ohne Einfluss eines MAF Gerätes aufgenommen. Ein Sprechbeispiel wurde unter Einfluss einer Placebokondition erhoben und 6 Sprechproben unter Einwirkung verschiedener Kombinationsgeräte. In der darauf folgenden Längsschnittstudie erhielten sechs der 30 Probanden die Möglichkeit eine technische Sprechhilfe für einen Zeitraum von drei Monaten im Alltag einzusetzen. Die Wirkung dieser kontinuierlichen Gerätenutzung bezüglich

quantitativer und qualitativer Störungsgrößen wurde im Anschluss evaluiert.

### Ergebnisse/Results

In der Datenauswertung zeigte sich eine statistisch signifikante Minderung des Prozentsatzes gestotterter Silben unter Verwendung beider Geräte ( $p = .000$ ) in allen erhobenen Sprechbeispielen. Auch während der Placeboeinstellung zeigten die Probanden mit deutlicher Symptomatik (SSI-4, Riley 2009, Schweregrade mittelschwer-sehr schwer) eine statistisch signifikante Ausweitung des flüssigen Sprechanteils ( $p = .024$ ). Die kontinuierliche Nutzung einer Sprechhilfe im Rahmen der 3-monatigen Längsschnittstudie zeigte ebenfalls, sowohl zu Beginn als auch zum Ende der Studienzeit, eine statistisch signifikante Reduktion der Stottersymptomatik. Der subjektive Eindruck der Studienteilnehmer bezüglich der Gerätenutzung war äußerst heterogen.

### Schlussfolgerungen/Diskussion

Die Gruppeneffekte zeigen, dass eine technische Sprechhilfe sowohl unmittelbare als auch langfristige Verbesserungen des Redeflusses bewirken kann. Jedoch nahmen die Probanden die Nutzung der Geräte sehr unterschiedlich wahr. Ob der Einzelne von einem derartigen Gerät profitiert, muss individuell entschieden werden. Eine ausführliche Probenutzung in verschiedenen kommunikativen Umfeldern und Kontexten scheint eine sinnvolle Grundlage vor dem Erwerb eines Gerätes darzustellen.

### 1. Einleitung

Modifiziertes auditives Feedback (MAF) wird als Oberbegriff für alle elektronischen Veränderungen des Sprechsignals gesehen (Lincoln, Packman, & Onslow, 2006). Zu den bekanntesten Formen der MAF zählen die sogenannte zeitverzögerte auditive Rückmeldung [delayed auditory feedback (DAF)] und die frequenzverschobene auditive Rückmeldung [frequency altered feedback (FAF)]. Beim DAF hört der Sprecher seine eigene Stimme durch Kopfhörer oder ein Ohrteil nochmals – jedoch aufgrund der technischen Veränderung zeitlich etwas später als das luftgeleitete Sprechsignal. Bei FAF wird das Sprechsignal ebenfalls in elektronisch veränderter Weise, abweichend von der eigentlichen mittleren Sprechstimmlage, entweder höher oder tiefer wieder an das Ohr des Sprechers zurückgeführt. Seit zirka 10 Jahren ist es gelungen, diese Technologie in Form von kleinen tragbaren Geräten herzustellen. Diese Geräte kombinieren zumeist das DAF mit dem FAF und erzeugen somit eine duale Modifikation, welche häufig als „Choreffekt“ beschrieben wird. Sowohl das DAF als auch das FAF hat sich im Rahmen von Studien als effektives Mittel zur Minderung der Stottersymptomatik für viele Betroffene erwiesen. Auch wenn Besserungen in der hörbaren Stottersymptomatik wissenschaftlich belegt sind, so ermöglichen diese Geräte alleine jedoch keine völlige Behebung des Stotterns. Eine Vielzahl der durchgeführten Studien erprobten den Einfluss der Geräte auf vorstrukturierte Sprechsituationen, wie beispielsweise das laute Vorlesen. Bislang gibt es nur sehr wenige Hinweise darauf, ob und inwieweit sich die positiven Effekte der Gerätenutzung während des vorstrukturierten Sprechens auch auf komplexere, alltagsnahe Kommunikationssituationen übertragen lassen. Einige Forscher zweifeln jedoch aufgrund von ersten Ergebnissen daran, dass sich die Gerätenutzung in gleichem Umfang positiv auf die Spontansprache auswirkt (Foundas & Conture, 2009; Ramig, Ellis, & Pollard, 2010). Es besteht relativ geringes Wissen darüber, in welchem Ausmaß sich eine Minderung in der Stottersymptomatik auch auf längere Sicht erhält. In der Literatur gibt es bereits Vermutungen die darauf hinweisen, dass sich der Nutzer eventuell an die technischen Modifikationen des Sprechsignals gewöhnt (Bloodstein &

Bernstein Ratner, 2008) und sich eine stottermindernde Wirkung somit auf lange Sicht verliert.

### 2. Fragestellungen/Zielsetzungen

Aufgrund der nach wie vor offenen Fragen bezüglich der sofortigen und langfristigen Wirkung des MAF teilt sich dieses klinische Forschungsprojekt in zwei Teilstudien.

#### 2.1. Querschnittstudie

Die Hauptzielsetzung dieser Teilstudie ist der Vergleich der Effekte zweier MAF Geräte während des strukturierten und spontanen Sprechens. Zusätzlich wird der Effekt des aktiven MAF selbst mit einer inaktiven Einstellung, also einem Placeboeffekt verglichen. Die bestimmten stottertypischen Charakteristiken, die als abhängige Variablen untersucht wurden, beinhalten die folgenden klinischen Marker:

- 1.1. Stotterhäufigkeit (gemessen als Prozentsatz gestotterter Silben, %GS) und Stotterdauer (gemessen in Sekunden).
- 1.2. Sprech- und Artikulationsgeschwindigkeit (Silben pro Minute)
- 1.3. Häufigkeit von drei Kernsymptomen (Wiederholungen, Dehnungen, Blockaden)
- 1.4. Stottereschweregrad (laut Stuttering Severity Instrument, 4. Auflage, SSI-4, Riley, 2009)

Diese störungsrelevanten Größen wurden in folgenden Kontexten und Konditionen analysiert:

1. Drei Kontexte: strukturiertes Sprechen (lautes Lesen) und Spontansprache (Monolog, Dialog)
2. Vier experimentelle Konditionen: Kein Gerät, Placebokondition, Gerät A und Gerät B.

### 2.2. Längsschnittstudie

Die dreimonatige Folgestudie hatte nun zum Ziel, die Einwirkung eines Gerätes auf die oben genannten abhängigen Variablen (siehe 1.1. – 1.4.), über einen kontinuierlichen Zeitraum zu dokumentieren. Hierzu wurden eben diese quantitativen Größen zu zwei Messzeitpunkten unter folgenden Konditionen erhoben:

- 1.5. Datenerhebungspunkt 1 – zu Beginn der Studie (Zp1):
  - a) Drei Kontexte: lautes Lesen, Monolog, Dialog
  - b) Zwei experimentelle Konditionen: Kein Gerät, Mit Gerät
- 1.6. Datenerhebungspunkt 4 – nach 3 Monaten bzw. Abschluss der Studie (Zp4):
  - a) Drei Kontexte: lautes Lesen, Monolog, Dialog
  - b) Zwei experimentelle Konditionen: Kein Gerät, Mit Gerät

Des Weiteren wurden zwei Kontrolldialoge in den Studienwochen 4 (Zp2) und 8 (Zp3) aufgenommen, die jeweils nur unter Verwendung eines Gerätes erhoben wurden.

In der Längsschnittuntersuchung stand darüber hinaus die Analyse von qualitativen Daten im Vordergrund. Dies ist für die Evaluation der Alltagstauglichkeit derartiger technischer Sprechhilfen unerlässlich. Zu diesem Zweck wurden in Form von wöchentlichen Fragebögen und Anwendertagebüchern das Verhalten und die Erfahrung der Probanden mit der alltäglichen Gerätenutzung dokumentiert. Hierfür wurden die nachstehenden abhängigen Variablen analysiert:

- 1.7. Analyse des subjektiven Nutzerverhaltens bezüglich der Geräteanwendung im Alltag:
  - a) Nutzungshäufigkeit
  - b) Nutzungsumgebung
  - c) Funktionsnutzung
    - a. Favorisierte MAF Einstellung
    - b. Kopfhörerpräferenz
- 1.8. Analyse der subjektiven Nutzereindrücke bezüglich der Geräteanwendung im Alltag:
  - a) Nutzerzufriedenheit bezüglich des Geräteinsatzes
  - b) Probleme während der Gerätenutzung

### 3. Darstellung der Methode

#### 3.1. Querschnittstudie

An der initialen Querschnittstudie nahmen 30 Erwachsene, Alter 18-68 Jahre ( $M = 36.5$ ;  $SD = 15.2$ ), die an chronischem Stottern leiden, teil. Diese kamen zur Aufnahme der Sprechproben an die Sprachambulanz der Pädagogischen Hochschule Heidelberg. Keiner der Teilnehmer hatte bislang praktische Erfahrung mit MAF gesammelt. Jedoch befanden sich einige Probanden zum Zeitpunkt der Datenerhebung in sprachtherapeutischer Behandlung. Zum Zwecke der Aufnahme erhielten die Teilnehmer die Anweisung, auf das Verwenden von erlernten Sprechtechniken zu verzichten.

Im Rahmen der Datenerhebung wurde jeder Proband gebeten, für 5-minütige Sequenzen Textpassagen vorzulesen, 5-minütige Monologe zu halten und 10-minütige Dialoge mit der Studienleiterin zu führen. Textpassagen wurden aus einem Lesebuch der 9. Klasse entnommen, da dies dem Leseniveau des Durchschnittsdeutschen entspricht und somit Unflüssigkeiten aufgrund von Enkodierungsfehlern minimiert werden. Die gewählten Auszüge stammten beispielsweise aus den Werken von Hermann Hesse, Anne Frank, Ernest Hemingway und Berthold Brecht. Die Monologe wurden jeweils durch Themenkarten angeregt. Auf jeder Karte waren alltägliche Themen in Stichwortformat abgebildet (z.B. „Mein Beruf“, „Mein Lieblingsfilm“, „Urlaub“ usw.). Zusammen mit kurzen gedankenanstoßenden Hilfsfragen auf der Rückseite sollte sich so eine 5-minütige Erzählung durch den Probanden entwickeln. Zur Gestaltung der Dialoge zogen die Teilnehmer jeweils Karten, auf denen potenziell kontroverse Diskussionsthemen aus Nachrichten, Politik, Wirtschaft oder Kultur geschrieben waren. Nachdem der Teilnehmer das Thema laut vorgelesen und seine Meinung eingehend erläutert hatte, entwickelte sich so ein 10-minütiges themenspezifisches Gespräch.

Diese Aufnahmen wurden mit unterschiedlichen Texten und Themen dreimal wiederholt. Jede dreigliedrige Aufnahme von lautem Lesen, Monolog und Dialog wurde jeweils ohne den Einfluss von MAF, als auch unter Einwirkung zweier MAF Geräte aufgenommen. Für die MAF-Konditionen wurden die

kommerziell erhältlichen technischen Sprechhilfen der Firmen VoiceAmp<sup>2</sup> (Model: VA601i, Fluency Enhancer) und CasaFutura<sup>3</sup> (Model: SmallTalk) verwendet. Beide Sprechhilfen wurden mit der gerätespezifischen MAF-Grundeinstellung von 50ms Zeitverzögerung (DAF) und einer FAF Frequenzverschiebung auf 250Hz (VA601i) sowie -0,4 Oktaven (SmallTalk) eingestellt. Zusätzlich ermöglichte es die softwaregesteuerte Bedienung des Gerätes A, die DAF und FAF Einstellung auf 0 zu setzen. Unter Einfluss dieser Einstellung wurde eine zusätzliche Lesepassage aufgenommen. In dieser inaktiven Einstellung erfuhren die Teilnehmer somit keinen MAF-Effekt. Sie hörten lediglich ein leises statisches Geräusch über die Kopfhörer des Gerätes. Allerdings wurden die Probanden in dem Glauben gelassen, der erwartete duale MAF-Effekt sei geschaltet. Um diesen Placeboeffekt nicht zu enttarnen, musste die Aufnahmenfolge nach einem statischen Prinzip durchgeführt werden:

1. Aufnahmen ohne Gerät
2. Placeboaufnahme
3. Aufnahmen unter Einfluss der Grundeinstellung von Gerät A
4. Aufnahmen unter Einfluss der Grundeinstellung von Gerät B.

Die Reihenfolge der Kontexte (lautes Lesen, Monolog, Dialog) variierte jedoch innerhalb der Aufnahmen. Die innerhalb der Sprechproben erhobenen stottertypischen Merkmale (abhängige Variablen), wurden mit Hilfe der Diagnostiksoftware FluencyMeter Science (Glück, 2003) ermittelt.

#### 3.2. Längsschnittstudie

Von den 30 Teilnehmern, die an der Querschnittstudie mitwirkten, erhielten sechs Probanden die Möglichkeit, eine technische Sprechhilfe für einen weiteren Zeitraum im Alltag zu nutzen. Diese sechs Teilnehmer zeigten allgemeines Interesse, ein MAF-Gerät weiterhin einsetzen zu wollen und waren darüber hinaus bereit, an den regelmäßigen Datenerhebungen über einen dreimonatigen Zeitraum teilzunehmen. Daten wurden sowohl im Bezug

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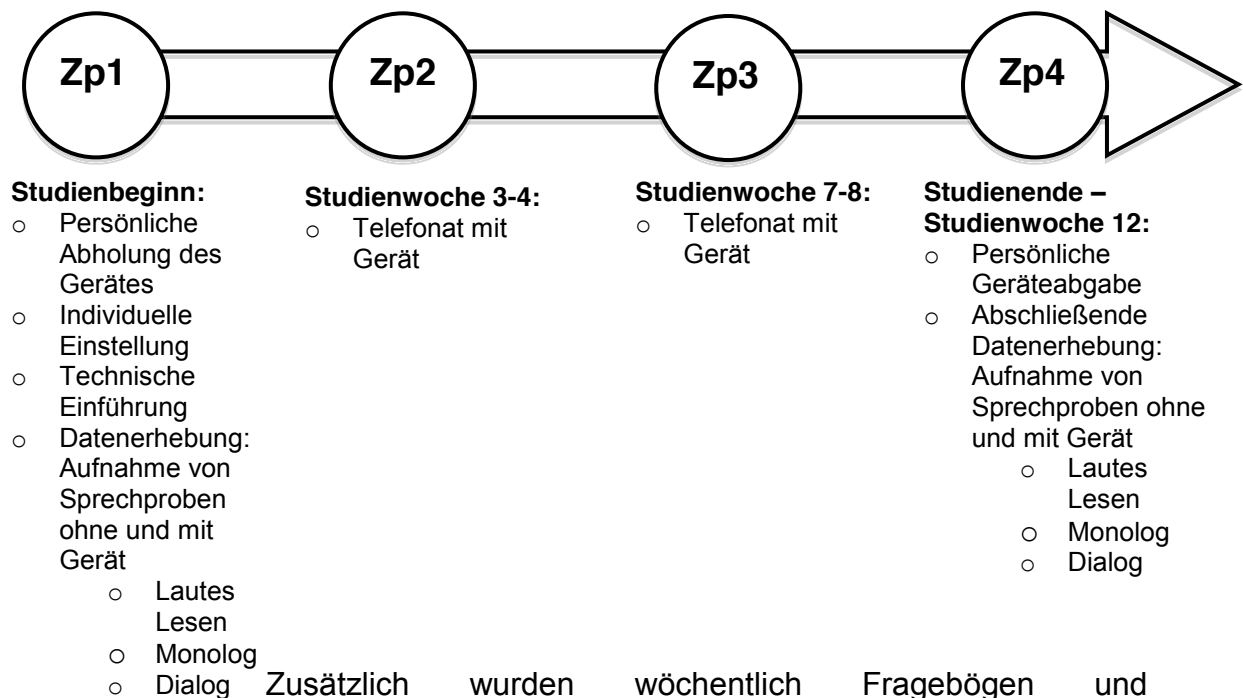
<sup>2</sup> abgekürzt: Gerät A

<sup>3</sup> abgekürzt: Gerät B

auf quantitative Störungsgrößen, als auch subjektive Verhaltensmuster und Reflexionen gesammelt. Quantitative Daten wurden wiederum durch die Aufnahme von Sprechbeispielen gesammelt. Hierzu wurden vier Zeitpunkte (Zp1 – Zp4) vereinbart, zu denen die Probanden persönlich an der Hochschule erschienen (Zp1 & Zp4), bzw. zu denen sie zu einem Telefonat Zeit einräumen sollten (Zp2 & Zp3). Zu den persönlichen Treffen zu Beginn und am Ende der Studie (Zp1 & Zp4) wurden jeweils drei Sprechbeispiele (lautes Lesen, Monolog, Dialog) in den Konditionen ohne Gerät und mit Gerät aufgenommen. Zu den Zwischenzeitpunkten (Zp2 & Zp3) wurde jeweils ein 10-minütiges Gespräch unter Einfluss des Gerätes aufgezeichnet. Während die Sprechproben zu den Zeitpunkten 1 & 4, wie auch im Querschnitt durch ein Kartensystem evoziert wurden bestanden die Telefonate aus freien Gesprächen, die u.a. aktuelle persönliche Ereignisse oder genauere Berichte der Gerätenutzung beinhalteten. Lesetexte zur anfänglichen und abschließenden Datengewinnung bestanden aus Magazinartikeln zu historischen Themen (DER SPIEGEL). Abbildung 1 zeigt eine Zusammenfassung der qualitativen Datenerhebungen innerhalb des dreimonatigen Längsschnitts.

## 4. Darstellung der Ergebnisse

Abbildung 1: Übersicht der quantitativen Datenerhebungen innerhalb der dreimonatigen Studiendauer.



Zusätzlich wurden wöchentlich Fragebögen und Anwendertagebücher in elektronischer Form eingereicht. Während die Fragebögen multiple-choice Fragen zu Themen wie Nutzungshäufigkeit, Nutzungsumgebung und Anwenderzufriedenheit beinhalteten, boten die Anwendertagebücher ein freies Format, um Erfahrungen mit der Gerätenutzung näher zu beschreiben.

## 4. Darstellung der Ergebnisse

### 4.1. Querschnittstudie

Im Folgenden sind die untersuchten abhängigen Variablen als übergeordnete Punkte aufgelistet. Um diese Variablen innerhalb der Kontrollkondition (kein Gerät) und den Therapiebedingungen (Verwendung von Gerät A und Gerät B) miteinander zu vergleichen, wurden ANOVAs mit Messwiederholung errechnet.

#### 4.1.1. Stotterhäufigkeit und Stotterdauer

Die Stotterhäufigkeit wurde als Prozentsatz gestotterter Silben (%GS) gemessen. Die durchschnittliche Dauer der auftretenden stottertypischen

Unflüssigkeiten wurde in Sekunden gemessen. Vergleicht man die Stotterhäufigkeit innerhalb aller erhobenen Sprechproben (lautes Lesen, Monolog & Dialog) zwischen den Konditionen mit Gerät und ohne Gerät, so zeigt sich eine statistisch signifikante Minderung von Stotterereignissen  $F(1.76, 51.08) = 4.89, p = .014, \eta^2 = .145$ . Dies war sowohl beim Vergleich der Sprechbeispiele ohne Gerät mit den Sprechproben unter Einfluss des Gerätes A ( $p = .000$ ), als auch unter Benutzung des Gerätes B ( $p = .000$ ) der Fall.

Bezüglich der durchschnittlichen Stotterdauer konnte keine statistisch signifikante Änderung ermittelt werden,  $F(2, 58) = .27, p = .762, \eta^2 = .009$ . Dies bedeutet, dass die durchschnittliche Dauer von auftretenden Unflüssigkeiten unter Benutzung eines Gerätes nicht merklich kürzer war.

##### 4.1.2. Sprech- und Artikulationsgeschwindigkeit

Die Werte Sprech- und Artikulationsgeschwindigkeit wurden beide in Silben pro Minute gemessen. Der Begriff „Sprechgeschwindigkeit“ bezeichnet das Tempo, mit dem ein Sprecher alle gesprochenen Silben produziert. Gegensätzlich beschreibt „Artikulationsgeschwindigkeit“ die Schnelligkeit des flüssigen Sprechanteils. Die Ergebnisse der statistischen Berechnung zeigen, dass weder in der allgemeinen Sprech-,  $F(2.08, 60.18) = 1.18, p = .323, \eta^2 = .038$  noch in der Artikulationsgeschwindigkeit,  $F(2.09, 60.54) = 1.98, p = .145, \eta^2 = .064$ , eine statistisch signifikante Verlangsamung zu erkennen ist. Folglich werden sowohl flüssige als auch unflüssige Sprechanteile unter Einfluss eines MAF-Gerätes mit zirka der gleichen Geschwindigkeit produziert.

##### 4.1.3. Häufigkeit von drei Kernsymptomen (Wiederholungen, Dehnungen, Blockaden)

Zur Ermittlung der drei Hauptsymptomgruppen wurden, mit Ausnahme der Dehnungen, verschiedene Einzelsymptome zusammengefasst. Laut- und Silbenwiederholungen bildeten die Gruppe der Wiederholungen, während „Blockaden zwischen den Wörtern“ und „Blockaden im Wort“ zu der Symptomhauptgruppe Blockaden gezählt wurden. Die statistische

Berechnung zeigt, dass es weder bei Wiederholungen,  $F(1.52, 44.11) = .861$ ,  $p = .402$ ,  $\eta^2 = .029$ , noch bei Dehnungen,  $F(1.75, 50.62) = .645$ ,  $p = .508$ ,  $\eta^2 = .022$ , zu einer signifikanten Minderung der prozentualen Auftretenshäufigkeit kam. Jedoch traten Blockaden unter Einsatz eines Gerätes bei der hier untersuchten Probandengruppe gemindert auf,  $F(1.73, 50.06) = 9.35$ ,  $p = .001$ ,  $\eta^2 = .244$ . Dies war sowohl beim Sprechen unter Einfluss von Gerät A ( $p = .017$ ), als auch von Gerät B ( $p = .049$ ) der Fall.

##### 4.1.4. Stotterschweregrad

Zur Ermittlung des Stotterschweregrades wurde das Verfahren SSI-4 (Stuttering Severity Instrument, 4. Auflage, SSI-4, Riley, 2009), eingesetzt. Auch, wenn dieser Test für das Deutsche nicht in standardisierter Version vorliegt, so dient die entstehende Messung des Schweregrades dennoch als umfangreiche informelle Einschätzung der relativen Schwere der Redeflussstörung. Laut SSI-4 lässt sich der Stotterschweregrad in 5 Stufen unterteilen, welche den Grad der Einschränkung ausdrücken (1: sehr leicht; 2: leicht; 3: mittelschwer; 4: schwer; 5: sehr schwer). Zur Ermittlung der statistischen Signifikanz der Unterschiede zwischen den SSI-4 Schweregraden wurde der Wilcoxon signed-rank test verwendet. Schweregrade wurden jeweils für die Kontrollkondition (Sprechen ohne Gerät) und die beiden aktiven Gerätebedingungen (Sprechen unter Benutzung von Gerät A & B) ermittelt.

In erster Instanz sollte herausgefunden werden, ob die Verwendung eines Gerätes den Stotterschweregrad beeinflusst. Unter Einsatz von Gerät A ergab sich eine statistisch signifikante Änderung in der Bewertung der Stotterschwere,  $z = 3.75$ ,  $p = .000$ ,  $r = -0.48$ . Im Vergleich zur Kontrollkondition verringerte sich der Stotterschweregrad bei 17 der 30 Teilnehmer, unter Verwendung von Gerät A. Folglich blieb der Stotterschweregrad unter Verwendung von Gerät A bei 13 Probanden konstant. Unter Einsatz von Gerät B kam es im Vergleich zur Kontrollkondition ebenfalls zu einer statistisch signifikanten Minderung der Stotterschweregrade  $z = 3.63$ ,  $p = .000$ ,  $r = -0.47$ . In fast gleichem Umfang, wie auch bei Gerät A, bewirkte Gerät B eine Minderung der SSI-4 basierten Stotterschwere bei 16

der 30 Teilnehmer – 14 Probanden erfuhren keine Minderung der Stotterschwere unter Verwendung des Gerätes.

In zweiter Instanz war es nun interessant herauszufinden, ob eine Verbesserung der Sprechflüssigkeit (gemessen in %GS) unter Verwendung eines Gerätes mit der Ausprägung der Stotterschwere in Zusammenhang steht. Hierzu wurde die Probandengruppe ( $N = 30$ ) in zwei Subgruppen unterteilt: Teilnehmer mit fortgeschrittenem Schweregrad (mittelschwer, schwer & sehr schwer;  $N = 14$ ) und Probanden mit niedrigerem Schweregrad (sehr leicht & leicht;  $N = 16$ ). Mit Hilfe von MANOVAs, die für jede der beiden Gruppen ermittelt wurden, sollte nun ergründet werden, ob eine der beiden Gruppen stärker von der Nutzung eines Gerätes profitiert. Zusätzlich war es bedeutend zu erfahren, in welchem sprachlichen Kontext (lautes Lesen, Monolog, Dialog) welche Gruppe am stärksten profitiert.

##### 4.1.4.1. Lautes Lesen

Für die Gruppe mit niedrigem Stotterschweregrad ergab sich keine statistisch signifikante Minderung des Prozentsatzes gestotterter Silben (%GS),  $F(2,12) = 2.98$ ,  $p = .089$ ,  $\eta^2 = .332$ , während des lauten Lesens. Dies war sowohl unter Verwendung von Gerät A,  $F(1, 13) = 3.57$ ,  $p = .081$ ,  $\eta^2 = .261$ , als auch unter Einsatz von Gerät B,  $F(1, 13) = 2.69$ ,  $p = .125$ ,  $\eta^2 = .171$ , der Fall. Die Subgruppe mit fortgeschrittenem Stotterschweregrad erfuhr jedoch eine statistisch signifikante Minderung des %GS während des lauten Lesens  $F(2, 14) = 3.75$ ,  $p = .049$ ,  $\eta^2 = .349$ . Eine statistisch signifikante Minderung des %GS trat sowohl unter Einsatz von Gerät A,  $F(1, 15) = 7.60$ ,  $p = .015$ ,  $\eta^2 = .336$ , als auch unter Verwendung von Gerät B,  $F(1, 15) = 7.59$ ,  $p = .015$ ,  $\eta^2 = .336$ , auf.

##### 4.1.4.2. Monolog

Beim Halten von Monologen erfuhren beide Subgruppen - sowohl diejenigen mit niedrigem,  $F(2, 12) = 7.79$ ,  $p = .007$ ,  $\eta^2 = .565$ , als auch jene mit fortgeschrittenem,  $F(2, 14) = 15.49$ ,  $p = .000$ ,  $\eta^2 = .689$ , SSI-4 basiertem Stotterschweregrad - eine statistisch signifikante Minderung im Prozentsatz gestotterter Silben (%GS). Eine solche mathematisch bedeutende Reduktion

trat unter Einsatz beider Geräte auf; Gerät A: niedriger Stotterschweregrad,  $F(1, 13) = 58.26$ ,  $p = .001$ ,  $\eta^2 = .554$ ; fortgeschrittener Stotterschweregrad,  $F(1,15) = 21.81$ ,  $p = .000$ ,  $\eta^2 = .592$ . Gerät B: niedriger Stotterschweregrad,  $F(1, 13) = 51.98$ ,  $p = .018$ ,  $\eta^2 = .359$ ; fortgeschrittener Stotterschweregrad,  $F(1, 15) = 30.13$ ,  $p = .000$ ,  $\eta^2 = .668$ .

##### 4.1.4.3. Dialog

Ähnlich wie bei den erhobenen Monologen erfuhren beide Subgruppen, also jene Probanden mit niedriger Stotterschweregrad:  $F(2, 12) = 8.49$ ,  $p = .005$ ,  $\eta^2 = .586$  und diejenigen mit fortgeschrittener Stotterschwere:  $F(2, 14) = 14.04$ ,  $p = .000$ ,  $\eta^2 = .667$ , bei spontansprachlicher Konversation eine statistisch signifikante Abnahme des %GS. Bei den Probanden mit niedriger Stotterschwere war dies sowohl bei der Benutzung von Gerät A,  $F(1, 13) = 18.37$ ,  $p = .001$ ,  $\eta^2 = .586$ , als auch von Gerät B,  $F(1, 13) = 15.84$ ,  $p = .002$ ,  $\eta^2 = .549$ , der Fall. Ebenso, erfuhren die Subgruppe mit fortgeschrittener Symptomatik eine statistisch signifikante Minderung des %GS unter Einsatz von Gerät A,  $F(1,15) = 27.24$ ,  $p = .000$ ,  $\eta^2 = .645$  als auch Gerät B,  $F(1,15) = 28.95$ ,  $p = .000$ ,  $\eta^2 = .659$ .

Zusammengefasst ist festzustellen, dass beide Schweregrad-Subgruppen (niedrige und fortgeschrittene SSI-4 basierte Stotterschwere) während der Spontansprache (Monolog & Dialog) von der Nutzung eines Gerätes profitierten. Beim vorstrukturiertem Sprechen allerdings erfuhren nur die Gruppe mit fortgeschrittener Symptomatik eine Minderung des unflüssigen Sprechanteils.

##### 4.1.5. Placebokondition

Neben den beiden experimentellen Konditionen unter Einsatz eines aktiven MAF-Gerätes, wurde auch eine Placebokondition untersucht. Diese beinhaltete das Tragen eines Gerätes, welches jedoch keinen MAF-Effekt wiedergab. Stattdessen hörten die Probanden ein leichtes statisches Geräusch durch die Kopfhörer des Gerätes A. Dieses Geräusch stellte in keinem Fall einen Maskingeffekt dar, sondern war lediglich ein Mittel, die

Probanden von der Funktion des Gerätes zu überzeugen. Die Placebokondition war nach der Kontrollkondition (Sprechen ohne Gerät) die erste experimentelle Kondition der die Probanden ausgesetzt wurden. Die Teilnehmer waren aufgefordert, einen Text unter einer derartigen 0-Einstellung vorzulesen. Das Ziel war es festzustellen, ob der pure Glaube an den Einfluss von MAF schon einen verflüssigenden Effekt bewirkt.

##### 4.1.5.1. Stotterhäufigkeit

Die Stotterhäufigkeit (gemessen in %GS) wurde für das Sprechbeispiel „lautes Lesen“ zwischen der Kontroll- und der Placebokondition verglichen. Zur Ermittlung der statistischen Signifikanz des Unterschiedes im %GS wurde eine ANOVA durchgeführt. Die Ergebnisse zeigen eine statistisch signifikante Abnahme der Stotterhäufigkeit unter Einfluss der Placebokondition,  $F(1, 29) = 5.34$ ,  $p = .028$ ,  $\eta^2 = .155$ .

Um festzustellen ob die Wirkung der Placebokondition mit der Stotterschwere zusammenhängt, wurden zusätzlich ANOVAs für die beiden SSI-4 basierten Stotterschweregrade errechnet. Interessanterweise ergab sich durch diese Rechnung, dass nur diejenigen mit fortgeschrittener Stotterschwere eine statistisch signifikante Minderung der Stotterhäufigkeit unter Einfluss der Placeboeinstellung erfuhren,  $F(1, 15) = 6.30$ ,  $p = .024$ ,  $\eta^2 = .296$ . Die Probandensubgruppe mit niedriger Stotterschwere erfuhr jedoch keine statistisch signifikante Verbesserung der Stotterhäufigkeit,  $F(1, 13) = .245$ ,  $p = .629$ ,  $\eta^2 = .018$ .

Bei der genaueren Untersuchung des Einflusses einer Placebokondition auf das laute Lesen zeigt sich eine statistisch signifikante Minderung der Stotterhäufigkeit (Kontrollkondition:  $M = 5.79$ ,  $SD = 4.72$ ; Placebokondition:  $M = 3.97$ ,  $SD = 5.47$ ). Bei anschließender Betrachtung der einzelnen Schweregradsgruppen (niedriger und fortgeschrittener Stotterschwere) konnte eine statistisch signifikante Abnahme der Stotterschwere nur für die Subgruppe mit fortgeschrittener Symptomatik bestätigt werden. Eine Erklärung für die nicht-signifikante Verbesserung der Stotterhäufigkeit bei der Subgruppe mit niedrigem Stotterschweregrad mag darin liegen, dass diese Gruppe bereits in der Kontrollkondition nur sehr wenig Stottersymptome

zeigte ( $M = 1.52$ ,  $SD = 2.33$ ). Aufgrund dieses niedrigen Ausgangswertes ist die Annahme wahrscheinlich, dass keine statistisch signifikante Minderung dieses Wertes mehr möglich ist.

##### 4.1.6. Qualitative Untersuchung

Nach der Aufnahme aller Sprechproben wurden die Probanden gebeten, in Form eines kurzen Fragebogens, ihren Eindruck bezüglich der Gerätenutzung zusammenzufassen. Die gesammelten Antworten ergaben einige interessante Trends bezüglich der subjektiven Gerätewahrnehmung. Nur 16 der 30 Probanden gaben an, eine Verbesserung ihres Redeflusses während der Gerätenutzung wahrgenommen zu haben. Hierbei lag keine signifikante Verbindung zwischen dem benutzten Gerät und der Wahrnehmung einer Verbesserung vor,  $\chi^2(1) = 0$ ,  $p = 1.00$ . Eine weitere Frage betraf den subjektiven Eindruck der Probanden bezüglich des Tragekomforts der Geräte. Eine Analyse der berichteten Eindrücke verdeutlichte eine statistisch signifikante Verbindung zwischen der Geräteart und der Höhe des angegebenen Tragekomforts. Dabei bevorzugte die Probandengruppe das monaurale Gerät A (durchschnittliche Tragekomfortbewertung: gut) im Vergleich zu dem binauralen Gerät B (durchschnittliche Tragekomfortbewertung: mittelmäßig). Auch im Hinblick auf den potenziellen Einsatz eines Gerätes im alltäglichen Leben gab die Probandengruppe an, sich eher vorstellen zu können das Gerät A einzusetzen,  $z = 3.16$ ,  $p = 0.02$ ,  $r = -.041$ .

##### 4.2. Längsschnittstudie

Im Längsschnitt kam das Gerät A zum Einsatz, da dies aufgrund der monauralen Signaleückspielung im Alltag besser einsetzbar ist. Um den langfristigen Einfluss des Gerätes zu erforschen wurden die vier quantitativen Variablen sowohl unter Benutzung eines Gerätes, als auch ohne ein Gerät erfasst. Dies geschah sowohl zu Beginn (Zp1), als auch zum Ende (Zp4) der Studie. Aufgrund der kleinen Stichprobengröße ( $N = 6$ ) und der nicht-parametrischen Datenverteilung wurde für die statistische Analyse der Wilcoxon signed-rank test gewählt.

### 4.2.1. Stotterhäufigkeit

Zur Ermittlung des Einflusses der technischen Sprechhilfe auf die Auftretenshäufigkeit von Stotterereignissen wurden jeweils zu Zp1 und Zp4 die erhobenen Sprechproben (lautes Lesen, Monolog, Dialog) ohne und mit Gerät miteinander verglichen. Zu Zp1 ergab sich für das laute Lesen, T1:  $z = -2.201$ , (%GS ohne Gerät:  $Mdn = 1.65$ ; %GS mit Gerät:  $Mdn = .156$ ), die Monologe, (%GS ohne Gerät:  $Mdn = 3.20$ ; %GS mit Gerät:  $Mdn = 1.50$ ) und die Dialoge (%GS ohne Gerät:  $Mdn = 3.51$ ; %GS mit Gerät:  $Mdn = 1.53$ ) eine statistisch signifikante Minderung, T1,  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$ , der Stotterhäufigkeit unter Einfluss des Gerätes. Gleichmaßen konnte auch zum Zp4 ein statistisch signifikanter Rückgang der Stottersymptomatik nachgewiesen werden. Dies war wiederum während des lauten Lesens (%GS ohne Gerät:  $Mdn = 2.20$ ; %GS mit Gerät:  $Mdn = .512$ ), und dem Monolog  $z = -1.992$ ,  $p = .046$ ,  $r = -0.33$  (%GS ohne Gerät:  $Mdn = 4.84$ ; %GS mit Gerät:  $Mdn = 2.08$ ), der Fall. Auch war bei den Dialogen zu Studienabschluss die Sprechprobe unter Benutzung des Gerätes auf statistisch signifikante Weise flüssiger,  $z = -2.201$ ,  $p = .028$ ,  $r = -0.37$  (%GS ohne Gerät:  $Mdn = 3.97$ ; %GS mit Gerät:  $Mdn = 1.89$ ). Vergleicht man die Reduktionen in der Stotterhäufigkeit zu den beiden Zeitpunkten miteinander, so zeigt sich kein statistisch signifikanter Unterschied: lautes Lesen,  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (Zp1:  $Mdn = 1.50$ ; Zp4:  $Mdn = .93$ ); Monologe,  $z = -.314$ ,  $p = .753$ ,  $r = -.064$  (Zp1:  $Mdn = 1.39$ ; Zp4:  $Mdn = 1.04$ ); Dialoge,  $z = -.734$ ,  $p = .463$ ,  $r = -0.15$  (Zp1:  $Mdn = 1.85$ ; Zp4:  $Mdn = 1.50$ ). Dies weist darauf hin, dass die technische Sprechhilfe im Großen und Ganzen zwar eine Verbesserung der Sprechflüssigkeit mit sich führte jedoch kann nicht davon ausgegangen werden, dass die langfristige Nutzung eine größere Wirkung hat.

### 4.2.2. Stotterdauer

Zur Untersuchung der durchschnittlichen Dauer der auftretenden Stottersymptome wurde diese während Zp1 und Zp4 in beiden experimentellen Konditionen (mit & ohne Gerät) miteinander verglichen. Keine der erhobenen Sprechproben ergab eine statistisch signifikante Änderung in der Durchschnittsdauer der auftretenden Unflüssigkeiten. Dies

war sowohl während Zp1: lautes Lesen,  $z = -1.78$ ,  $p = .075$ ,  $r = -0.36$  (ohne Gerät:  $Mdn = 2.25$ ; mit Gerät:  $Mdn = 1.80$ ); Monolog,  $z = -1.36$ ,  $p = .173$ ,  $r = -0.26$  (ohne Gerät:  $Mdn = 2.10$ ; mit Gerät:  $Mdn = .86$ ); Dialog,  $z = -1.36$ ,  $p = .173$ ,  $r = -0.26$  (ohne Gerät:  $Mdn = 2.10$ ; mit Gerät:  $Mdn = .86$ ), als auch während Zp4: lautes Lesen,  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (ohne Gerät:  $Mdn = .83$ ; mit Gerät:  $Mdn = .55$ ). Monolog, T4:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (ohne Gerät:  $Mdn = 1.58$ ; mit Gerät:  $Mdn = 1.01$ ). ); Dialog,  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (ohne Gerät:  $Mdn = .94$ ; mit Gerät:  $Mdn = 1.25$ ) der Fall.

#### 4.2.3. Sprech- und Artikulationsgeschwindigkeit

##### 4.2.3.1. Sprechgeschwindigkeit

Der Begriff „Sprechgeschwindigkeit“ beschreibt das durchschnittliche Tempo, gemessen in Silben pro Minute, mit dem sowohl flüssige als auch unflüssige Sprechanteile produziert werden. Die Sprechgeschwindigkeit wurde wiederum mit und ohne Gerät zu den Zeitpunkten 1 und 2 miteinander verglichen. Die Ergebnisse zeigen, dass keine statistisch signifikante Minderung der Sprechgeschwindigkeit unter Benutzung eines Gerätes auftrat. Dies ergab sich für beide Zeitpunkte (Zp1 & Zp4) und alle Sprechproben (lautes Lesen, Monolog, Dialog).

Zp1: lautes Lesen:  $z = -1.57$ ,  $p = .116$ ,  $r = -0.32$  (ohne Gerät:  $Mdn = 176.66$ ; mit Gerät:  $Mdn = 193.95$ ); Monolog:  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (ohne Gerät:  $Mdn = 163.51$ ; mit Gerät:  $Mdn = 180.73$ ); Dialog:  $z = -1.57$ ,  $p = .116$ ,  $r = -0.32$  (ohne Gerät:  $Mdn = 190.38$ ; mit Gerät:  $Mdn = 160.90$ );

Zp4: lautes Lesen:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (ohne Gerät:  $Mdn = 190.17$ ; mit Gerät:  $Mdn = 212.12$ ); Monolog:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (ohne Gerät:  $Mdn = 171.52$ ; mit Gerät:  $Mdn = 180.72$ ); Dialog:  $z = -.734$ ,  $p = .463$ ,  $r = -0.15$  (ohne Gerät:  $Mdn = 176.06$ ; mit Gerät:  $Mdn = 186.92$ );

##### 4.2.3.2. Artikulationsgeschwindigkeit

Der Ausdruck „Artikulationsgeschwindigkeit“ bezieht sich auf die Geschwindigkeit mit der der flüssige Sprechanteil produziert wird. Wie auch bei der Sprechgeschwindigkeit wird dieser Wert in Silben pro Minute

gemessen. Im Rahmen dieser Untersuchung wurde die Artikulationsgeschwindigkeit jeweils zu Beginn und zum Ende der Studie (Zp1 & Zp4) mit und ohne ein Gerät aufgenommen. Die Ergebnisse zeigen, ähnlich wie die Berechnung zur Sprechgeschwindigkeit, keine statistisch signifikante Verbesserung der Geschwindigkeit mit der flüssiges Sprechen produziert wird.

Zp1: lautes Lesen:  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (ohne Gerät:  $Mdn = 189.70$ ; mit Gerät:  $Mdn = 199.51$ ); Monolog:  $z = -.105$ ,  $p = .917$ ,  $r = -0.02$  (ohne Gerät:  $Mdn = 195.52$ ; mit Gerät:  $Mdn = 196.52$ ); Dialog:  $z = -.524$ ,  $p = .600$ ,  $r = -0.11$  (ohne Gerät:  $Mdn = 221.12$ ; mit Gerät:  $Mdn = 217.45$ );

Zp4: lautes Lesen:  $z = -.943$ ,  $p = .345$ ,  $r = -0.19$  (ohne Gerät:  $Mdn = 198.65$ ; mit Gerät:  $Mdn = 219.05$ ); Monolog:  $z = -.524$ ,  $p = .600$ ,  $r = -0.11$  (ohne Gerät:  $Mdn = 203.05$ ; mit Gerät:  $Mdn = 199.68$ ); Dialog:  $z = -.105$ ,  $p = .915$ ,  $r = -0.02$  (ohne Gerät:  $Mdn = 204.02$ ; mit Gerät:  $Mdn = 216.77$ ).

##### 4.2.4. Auftretenshäufigkeit von drei Kernsymptomgruppen

Wie auch im Querschnitt wurden in der Längsschnittuntersuchung drei Kernsymptomgruppen untersucht: Wiederholungen, Dehnungen und Blockaden. Diese wurden in anteiligen Prozent gestotterter Silben gemessen, z.B. 31.76% Wiederholungen gibt den Anteil der Wiederholungen unter allen unflüssigen Silben an. Die Anteile der drei Kernsymptome wurden wiederum zu Beginn und zum Ende der Studie unter zwei experimentellen Konditionen in allen drei Kontexten untersucht. Die Ergebnisse fassen die drei Kontexte lautes Lesen, Monolog und Dialog zusammen. Die Berechnungen ergeben, dass Wiederholungen zum Zp1 unter Verwendung eines Gerätes nicht signifikant vermindert auftraten,  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (ohne Gerät:  $Mdn = 31.76$ ; mit Gerät:  $Mdn = 17.17$ ). Während Zp4 bewirkte das Tragen des Gerätes jedoch eine statistisch signifikante Reduktion von Wiederholungen,  $z = -2.20$ ,  $p = .028$ ,  $r = -0.44$  (ohne Gerät:  $Mdn = 8.44$ ; mit Gerät:  $Mdn = 4.71$ ). Dehnungen verringerten sich weder zum Zp1,  $z = -0.67$ ,  $p = .500$ ,  $r = -0.14$  (ohne Gerät:  $Mdn = 13.74$ ; mit Gerät:  $Mdn = 22.58$ ), als auch zu Zp4,  $z = -1.15$ ,  $p = .249$ ,  $r = -0.23$  (ohne Gerät:  $Mdn = 40.74$ ; mit Gerät:  $Mdn = 35.92$ ).

Gleichermaßen trat keine statistisch signifikante Minderung von Blockaden zu Beginn, Zp1:  $z = -1.36$ ,  $p = .173$ ,  $r = -0.28$  (ohne Gerät:  $Mdn = 54.26$ ; mit Gerät:  $Mdn = 45.08$ ). oder zum Ende, Zp4:  $z = -0.11$ ,  $p = .971$ ,  $r = -0.02$  (ohne Gerät:  $Mdn = 50.03$ ; mit Gerät:  $Mdn = 42.04$ ) der Studie auf.

##### 4.2.5. Stotterschweregrad

Die Bemessung des Stotterschweregrades wurde ebenfalls mit dem SSI-4 (Riley, 2009) ermittelt. Bezüglich der Schweregradbemessung war in erster Instanz von Interesse, ob die Nutzung eines Gerätes zu einem der beiden Messzeitpunkte zu einer statistisch signifikanten Minderung des Stotterschweregrades führt. Zum Zp1 war dies im Gruppenvergleich nicht der Fall:  $z = -1.63$ ,  $p = .102$ ,  $r = -0.33$ . Zu diesem Zeitpunkt verringerte sich in der Einzelbetrachtung der Stotterschweregrad von drei Probanden (Proband 1,4 und 6), um ein oder mehrere Schweregradstufen (von "mittelschwer" auf "leicht" oder "leicht" auf "sehr leicht"). Zum Zp4 jedoch ergab sich eine statistisch signifikante Reduktion des Stotterschweregrades unter Verwendung eines Gerätes,  $z = -2.00$ ,  $p = .046$ ,  $r = -0.41$ . In der Einzelbetrachtung hieß dies, dass vier von sechs Probanden eine Minderung des Stotterschweregrades erfuhren (Probanden 1,2,4 und 6). In zweiter Instanz war es von Interesse die beiden Konditionen ohne Gerät zu den beiden Messzeitpunkten miteinander zu vergleichen. Dies kann Auskunft darüber geben, ob die Stotterschwere sich nach langfristigem Einsatz eines Gerätes auch ohne dessen Einfluss vermindert. Die Ergebnisse zeigen jedoch, dass dies nicht der Fall war und keine statistisch signifikante Minderung des Stotterschweregrades ohne Einsatz eines Gerätes zu verzeichnen war,  $z = -1.00$ ,  $p = .317$ ,  $r = -0.21$ .

##### 4.2.6. Qualitative Untersuchung

Qualitative Informationen zur Gerätenutzung wurden im Rahmen von wöchentlichen Fragebögen und Anwendertagebüchern gesammelt. Die folgenden Absätze fassen die Informationen dieser wöchentlich eingereichten subjektiven Eindrücke zusammen.

Die Nutzungshäufigkeit des Gerätes war innerhalb der 12 Studienwochen für die einzelnen Probanden sehr unterschiedlich. Während Proband 1 nach Studienwoche 4 den alltäglichen Gebrauch des Gerätes völlig einstellte, zeigte sich beispielsweise bei Proband 2 und 3 eine hohe Nutzungsrate während der ersten Studienwochen (bis Woche 7 tägliche Nutzung des Gerätes). Aufgrund dieser höchst unterschiedlichen Nutzungsmuster war es interessant herauszufinden, ob die stottermindernde Wirkung in irgendeiner Weise mit der Nutzungshäufigkeit in Verbindung steht. Hierzu wurde eine Korrelation (Kendall's Tau) berechnet. Die Ergebnisse zeigen, dass die Nutzungshäufigkeit und der Grad der Sprechflüssigkeit während der dreimonatigen Studie nicht miteinander in Verbindung standen,  $r = -.67$ ,  $p = .087$ .

Des Weiteren ergaben sich aus den Fragebögen Informationen zu den kommunikativen Kontexten in denen ein Gerät eingesetzt wurde. Hier zeigte sich interessanterweise, dass das Gerät am seltensten in Gesprächssituationen mit Fremden eingesetzt wurde. Stattdessen waren häufigere Einsätze in der verbalen Kommunikation mit vertrauten Sprechern zu verzeichnen (z.B. Anrufe und Einzelgespräche). Dies zeigt deutlich, dass bestimmte Vermeidungsverhalten bestehen bleiben, bzw. dass es bezüglich der Verwendung eines Gerätes bestimmte innere Hürden gibt, die ein Sprecher überwinden lernen muss, bevor ein Gerät uneingeschränkt genutzt werden kann. Ein ähnliches Bild zeigt sich auch bezüglich der Nutzungsumgebung. Hier wird nochmals der Verdacht auf das Bestehen von bestimmten Vermeidungsmustern deutlich. Die Probandengruppe berichtete, das Gerät am häufigsten zu Hause (63%) und lediglich zu einem geringen Anteil in der Öffentlichkeit (11%) oder in beruflichen Kontexten (26%) einzusetzen.

### 5. Schlussfolgerungen und Diskussion

Die Ergebnisse der Querschnittstudie zeigen, dass beide Geräte in spontansprachlichen Kontexten zu einer statistisch signifikanten Minderung der Stotterhäufigkeit führten. Tabelle 1 fasst die statistisch signifikanten Ergebnisse bezüglich der Stotterhäufigkeit zusammen. Dies ist eine wichtige

Erkenntnis, da derartige MAF-Geräte vor allem zur Verwendung in alltäglichen Gesprächen angepriesen werden und somit zumindest auf den ersten Blick ihre Bestimmung erfüllt haben. In diesem Zusammenhang ist es jedoch auch von Bedeutung, die Nutzungsmuster der Längsschnittstudie mit in Betracht zu ziehen. Hier ergab sich der Trend, dass die technische Sprechhilfe vor allem in vertrauten Kontexten benutzt wurde und nur zu einem geringen Anteil in öffentlichen Situationen. Dies zeigt deutlich, dass ein MAF-Gerät das Potential zur Verbesserung der Sprechflüssigkeit hat, es jedoch von verschiedenen individuellen Faktoren abhängt ob dieses Gerät im Alltag eingesetzt werden kann. Die bloße Verfügbarkeit einer technischen Sprechhilfe scheint es einem Betroffenen nicht zu ermöglichen, sich in vorbelastete kommunikative Situationen zu begeben. Um derartige konditionierte Vermeidungsverhalten abzubauen und letztendlich ein Gerät in allen alltäglichen Kontexten frei einsetzen zu können, scheint eine begleitende desensibilisierende Therapiekomponente sinnvoll.

Tabelle 1: *p*-Werte für alle statistisch signifikanten Effekte auf die Stotterhäufigkeit in allen experimentellen Konditionen und Sprechkontexten.

	Placebo		Gerät A		Gerät B		
	LL <sup>w</sup>	LL <sup>w</sup>	MO <sup>ww</sup>	DI <sup>www</sup>	LL <sup>w</sup>	MO <sup>ww</sup>	DI <sup>www</sup>
% SS							
Ganze Probandengruppe (N = 30)	<i>p</i> = .028	<i>p</i> = .002	<i>p</i> = .009	<i>p</i> = .048	<i>p</i> = .007	<i>p</i> = .001	<i>p</i> = .005
Niedrige Stotterschwere (N = 16)	NS	NS	<i>p</i> = .001	<i>p</i> = .001	NS	<i>p</i> = .018	<i>p</i> = .002
Fortgeschrittene Stotterschwere (N = 14)	<i>p</i> = .008	<i>p</i> = .015	<i>p</i> = .000	<i>p</i> = .000	<i>p</i> = .015	<i>p</i> = .000	<i>p</i> = .000
Blockaden		<i>p</i> = .017			<i>p</i> = .049		
SSI-4 severity rating		<i>p</i> = .000			<i>p</i> = .000		

w = lautes Lesen, ww = Monolog, www = Dialog

Bei vorstrukturiertem Sprechen erfuhr nur die Gruppe mit fortgeschrittener Symptomatik eine statistisch signifikante Verbesserung des Redeflusses. Dieses Ergebnis steht im Gegensatz zu anderen Studienresultaten (e.g. Macleod, Kalinowski, Stuart, 1995; Zimmermann, Kalinowski, Stuart, Rastatter, 1997; Armson, Foote, Witt, Kalinowski, Stuart, 1997; Armson & Stuart, 1998; Van Borsel, Reunes, Van den Bergh, 2003), welche eine deutliche Minderung der Stotterhäufigkeit während des lauten Lesens nachwiesen. Eine mögliche Erklärung für die eingeschränkte Verbesserung des Redeflusses der Subgruppe mit niedrigem Stottereschweregrad kann an dem minimalen Auftreten von Unflüssigkeiten während des lauten Lesens liegen. Diese Subgruppe erfuhr während des vorstrukturierten Sprechens in der Kontrollkondition lediglich eine durchschnittliche Stotterrate von 1,52 %GS ( $M = 1,52$ ,  $SD = 2,33$ ). Mit einer so geringen Ausgangssymptomatik mag es unter Umständen nicht möglich sein, eine statistisch signifikante Verbesserung zu erzielen.

Diesbezüglich ist die Evaluation der Ergebnisse aus einer praktischen Sicht von Bedeutung. Nicht jede statistisch signifikante Verbesserung gleicht einer klinisch signifikanten Verbesserung. Dies wird deutlich, wenn man die Verbesserung in der Auftretenshäufigkeit von Stotterereignissen in der Subgruppe mit niedrigem Stottereschweregrad während des Monologs (Kontrollkondition:  $M = 2,77$ ,  $SD = 2,39$ ; Gerät A:  $M = 2,04$ ,  $SD = 1,90$ ; Gerät B:  $M = 1,93$ ,  $SD = 2,67$ ) und Dialogs (Kontrollkondition:  $M = 2,28$ ,  $SD = 1,37$ ; Gerät A:  $M = 1,98$ ,  $SD = 1,73$ ; Gerät B:  $M = 2,09$ ,  $SD = 1,96$ ) betrachtet. Unter Verwendung eines Gerätes betrug die Verbesserung weniger als ein Prozent gestotterter Silben. Selbst wenn eine solche Verbesserung einem statistisch signifikanten Ergebnis gleicht, so mag ein derartig geringer Unterschied nicht unbedingt eine relevante Besserung in den Augen des Betroffenen darstellen. Ein weiteres Ergebnis, welches den Nutzen eines Gerätes relativiert, ist die Beobachtung, dass bereits eine Placeboeinstellung zu einer statistisch signifikanten Minderung der Stotterhäufigkeit führte. Für die Patienten mit fortgeschrittener Stottereschwere ( $N = 14$ ) reichte also bereits der Glaube an das Vorhandensein des MAF-Effektes, um eine statistisch relevante Verbesserung zu erzielen. Dieses Ergebnis unterstützt die sogenannte

*Novum-Effekt Theorie* von Bloodstein und Bernstein Ratner (2008). Diese Hypothese besagt, dass jede von der gewohnten Weise abweichende auditive Wahrnehmung des eigenen Sprechsignals die Stottersymptomatik, wenn auch nur temporär, lindert. Die Präsenz von Kopfhörern, durch die ein leichtes statisches Geräusch zu hören ist, erzeugt vielleicht schon ein derartig neues auditives Sprechsignal und führt dadurch zu einer Verbesserung der Sprechflüssigkeit. Die besagte Theorie geht natürlich auch davon aus, dass sich der verflüssigende Effekt des „neuen“ Sprechsignals verliert, sobald man sich an die fremdartig anmutende auditive Wahrnehmung gewöhnt hat. Geht man nun davon aus, dass die *Novum-Effekt Hypothese* auch für die Wirksamkeit des eigentlichen MAF-Effektes verantwortlich ist, so liegt die Vermutung nahe, dass sich die Wirksamkeit einer solchen technischen Sprechhilfe mit der Zeit verliert, bzw. relativiert. Diese Vermutung konnte jedoch aufgrund der Ergebnisse der hier präsentierten Längsschnittstudie nicht belegt werden. Der vorher-nachher Vergleich der Stotterhäufigkeit im Rahmen einer dreimonatigen Gerätenutzung zeigt, dass es sowohl zu Beginn als auch zum Ende der Nutzungsperiode zu einer statistisch signifikanten Verbesserung der Stottersymptomatik kommt. Vergleicht man die Reduktionen im Prozentsatz gestotterter Silben unter Einfluss eines Gerätes miteinander kann kein signifikanter Unterschied festgestellt werden. Dies lässt die Schlussfolgerung zu, dass sich die stottermindernde Wirkung eines Gerätes innerhalb eines kontinuierlichen Nutzungszeitraumes von drei Monaten nicht einstellt.

## **Appendix 2: Formatvorlage eines diagnostischen Berichtes**

### **über individuelle, gerätespezifische Effekte auf die Sprechflüssigkeit**

Diagnostischer Bericht:  
Untersuchung des Redeflusses mit und ohne Einfluss von  
modifiziertem auditivem Feedback

---

Klient: X. Y.	Datum der Untersuchung: XX.XX.20XX
Geburtsdatum: XX.XX.19XX	Alter: XX Jahre
Adresse: Musterstr. 5, XXXXX Musterstadt	Tel./E-mail: XXXXX/XXX XXX X..Y.@gmx.de

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#### **Allgemeine Informationen**

Herr Y. ist ein XX-jähriger Elektrotechnik-Ingenieur, der nach eigenen Angaben seit seinem vierten Lebensjahr stottert. Durch seine aktive Mitgliedschaft in der Stotterselbsthilfe, Landesgruppe Baden-Württemberg, wurde Herr Y. auf das aktuelle Forschungsprojekt der Pädagogischen Hochschule Heidelberg zum Thema Stottern aufmerksam. Er nahm als Studienproband, am XX.XX.20XX an dem Forschungsprojekt „Technisch unterstützte Reduktion des Stotterns (TURS)“ teil.

Ziel des Forschungsprojektes ist die Ermittlung des Einflusses von technischen Sprechhilfen auf die Ausprägung der Stottersymptomatik eines jeden Teilnehmers. Unter technischen Sprechhilfen sind im Rahmen dieses Berichtes die verwendeten Geräte gemeint, welche die auditive Wahrnehmung der eigenen Stimme verändern. Im Rahmen dieses Forschungsprojektes wurde die auditive Rückmeldung des eigenen Sprechens der Teilnehmer einer zeitlichen Verzögerung (delayed auditory feedback, DAF), als auch einer Frequenzverschiebung (frequency altered feedback, FAF) ausgesetzt.

Während der Datenerhebung wurden von Herrn Y. drei verschiedene Sprechbeispiele aufgenommen: Lautes Lesen, ein Monolog und ein Dialog. Diese Sprechbeispiele wurden ohne den Einfluss eines DAF/FAF Gerätes als auch unter dem Einfluss zwei verschiedener Geräte aufgenommen. In der anschließenden Datenauswertung wurden Herrn Y.s Sprechproben auf stottertypische Merkmale untersucht. Die Feinanalyse, die diesem Bericht als Anhang beiliegt, beschreibt die speziellen Kernsymptome die in den verschiedenen Aufnahmen untersucht wurden. Aufgrund der prozentualen Anteile, die die Kernsymptome innerhalb der drei Testphasen einnehmen, wurde Herrn Y.s Stotterschweregrad ohne, als auch unter dem Einfluss verschiedener technischer Sprechhilfen ermittelt.

Im Folgenden werden die in der Feinanalyse aufgezeigten Werte erläutert. Auch soll der vorliegende Bericht versuchen, Antwort auf die Frage zugeben,

inwieweit die Benutzung einer technischen Sprechhilfe während der oben erwähnten Sprechbeispiele einen stottermindernden Effekt hatte. Alle nachstehenden Angaben wurden nur im Rahmen der zweistündigen Datenerhebung an der PH Heidelberg erhoben und können deshalb nur als Momentaufnahme von Herrn Y.s Sprechflüssigkeit gesehen werden.

### **Untersuchung**

#### Hörvermögen

Herr Y. nahm an einem audiologischen Screening zur Ermittlung seiner peripheren Hörfähigkeiten teil. Dieses Screening zeigte, dass Herr Y. zum Zeitpunkt der Studienteilnahme über intaktes Hörvermögen (weniger als 20 dB Hörverlust in den Grundfrequenzen) verfügte.

#### Redefluss & Stotterschweregrad

Der Redefluss von Herrn Y., ohne Einfluss von modifizierter auditiver Rückmeldung, wurde von dem standardisierten Testverfahren SSI:4 (Stuttering Severity Instrument – 4. Ausgabe) zum Zeitpunkt der Aufnahme als von mittelschwerem Stottern gekennzeichnet eingestuft. Herr Y. zeigte während des Lauten Lesens - einer strukturierten Sprechaufgabe - die meisten Stottersymptome. Sowohl in den spontansprachlichen als auch während der strukturierten Sprechaufgaben waren Blockaden im Wort das am häufigsten auftretende Kernsymptom.

Unter Einfluss der ersten in diesem Versuch eingesetzten technischen Sprechhilfe (Model: VA601i, Firma: VoiceAmp) wurde Herr Y. einer Verzögerung von 50ms und einer Frequenzverschiebung - in eine höhere Sprechstimmlage - auf 200Hz ausgesetzt. Dieses erste Gerät wurde mit einem einseitigen Kopfhörer getragen. Verglichen zum Sprechen ohne Gerät, war eine generelle Verbesserung des Redeflusses zu erkennen. Während aller Sprechproben traten die analysierten Kernsymptome gemindert auf. Diese Reduktion der Stotterereignisse war während des lauten Lesens jedoch am deutlichsten. Der flüssige Sprechanteil während des lauten Lesens betrug unter Benutzung dieses Gerätes 100%. Die spontansprachlichen Sprechbeispiele (Monolog und Dialog) waren nach wie vor von Stotterereignissen gekennzeichnet. Jedoch war die Auftretenshäufigkeit der Kernsymptome, vor allem während dem Monolog, wiederum gemindert auf. Blockaden im Wort waren prozentual gesehen unter dem Einfluss dieses DAF/FAF Gerätes das am stärksten reduzierte Kernsymptom. Der Stotterschweregrad änderte sich aufgrund des verflüssigten Sprechens und war der Kategorie „sehr leicht“ zuzuordnen.

Das zweite DAF/FAF Gerät, welches im Rahmen dieses Forschungsprojektes eingesetzt wurde (Model: SmallTalk, Firma: CasaFutura), war ein binaurales, also mit beidseitigen Kopfhörern, angewandtes Gerät. Die zeitliche Verzögerung des auditiven Sprechsignals betrug hier wieder 50ms, wobei die Frequenzverzögerung Herrn Y.s Sprechen in einer tieferen - um 2 Oktaven nach unten verschobenen - Sprechstimmlage wiedergab. Dieses Gerät hatte ebenfalls einen stottermindernden Einfluss auf Herrn Y.s Sprechen. Die Verbesserung des Redeflusses war wie bei dem im vorherigen Absatz

beschriebenen DAF/FAF Gerät, während der strukturierten Sprechaufgabe (lautes Lesen) am deutlichsten. Hier war mit 98,8% flüssigem Sprechanteil eine deutliche Verbesserung zu dem lauten Lesen ohne Gerät zu verzeichnen. Bei den Aufnahmen unter Einfluss dieser zweiten technischen Sprechhilfe waren Blockaden im Wort ebenfalls das am wenigsten häufig auftretende Kernsymptom. Während dem Monolog und Dialog war eine gesteigerte Sprechflüssigkeit, die nochmals leicht deutlicher als unter Einfluss des vorherigen Modells zur Geltung kam, zu vermerken. Das geminderte Stottern während der Sprechproben führte zu einem geminderten Stotterschweregrad. Das gesamte Sprechen, unter Einfluss dieses Gerätes, konnte deshalb ebenfalls dem Stotterschweregrad „sehr leicht“ zugeordnet werden.

### Sprechgeschwindigkeit

Einige Forscher (z.B. Starkweather, C.,W., 1987) gehen davon aus, dass eine mögliche Verbesserung des Redeflusses unter dem Einfluss modifizierter auditiver Rückmeldung auf eine Verlangsamung der Sprechgeschwindigkeit zurückzuführen ist. Diese Hypothese ist jedoch nach aktuellen Erkenntnissen umstritten (MacLeod, Kalinowski, Stuart, & Armson, 1995). Auch im Fall von Herrn Y. kam es im Vergleich zwischen dem Sprechen ohne Gerät und dem Sprechen mit einer technischen Sprechhilfe nicht zu einer deutlichen Verlangsamung der Sprechgeschwindigkeit.

### Zusammenfassung

Herr X. Y., der seit seiner frühen Kindheit an der Redeflussstörung Stottern leidet, nahm am XX.XX.20XX als Studienproband an einem Forschungsprojekt an der PH Heidelberg teil. Im Rahmen der Studie wurden strukturierte und spontansprachliche Sprechproben aufgenommen. Herr Y. hatte im Rahmen des Versuchs die Möglichkeit, den individuellen Einfluss der modifizierten auditiven Rückmeldung in Form von zwei verschiedenen technischen Sprechhilfen, auf seine Sprechflüssigkeit zu erfahren. Die Sprechbeispiele wurden im Anschluss ausgewertet. Die Auswertung soll Auskunft darüber geben, inwieweit eine Minderung von Herrn Y.s Stottern während der Benutzung der Geräte zu verzeichnen war.

Nachdem die aufgenommenen Sprechproben ausgewertet wurden, war festzustellen, dass die Benutzung der technischen Sprechhilfen für Herrn Y. während des lauten Lesens (skriptiertes Sprechen) als auch während der spontansprachlichen Sprechbeispielen (Monolog & Dialog) einen stottermindernden Effekt hatten. Herrn Y.s Stotterschweregrad, welcher zur Zeit der Datenerhebung der Kategorie „mittelschwer“ zuzuordnen war, veränderte sich aufgrund der verbesserten Sprechflüssigkeit unter Benutzung beider Sprechhilfen (Kategorie: „sehr leicht“).

Für Ihre Bereitschaft zur Teilnahme an der TURS Studie, möchten wir uns herzlich bei Ihnen bedanken. Wir hoffen, die Studienteilnahme und der anschließende Bericht werden für Ihr weiteres therapeutisches Vorgehen und Ihre Akten von Nutzen sein. Sollten Sie Fragen bezüglich dieses Berichtes haben, stehen wir Ihnen jederzeit unter der am Seitenende aufgeführten Kontaktinformation zur Verfügung.

## Anhang: Feinanalyse des Redeflusses während der Datenerhebung

	OG <sup>★</sup> (ohne Gerät)			VA <sup>★★</sup> (VoiceAmp Gerät)			CF <sup>★★★</sup> (Casa Futura Gerät)		
	Lautes Lesen	Monolog	Dialog	Lautes Lesen	Monolog	Dialog	Lautes Lesen	Monolog	Dialog
Silben gesamt	360	781	676	1140	767	624	1074	900	593
Nicht-gestotterte Silben	303	746	596	1140	743	572	1072	885	566
Gestotterte Silben	57	35	80	0	24	52	2	15	27
Anzahl Stotterereignisse									
Wiederholungen	21	6	13	0	8	16	2	2	6
Lautwiederholungen	21	5	13	0	8	14	2	2	6
Silbenwiederholungen	0	1	0	0	0	2	0	0	0
Dehnungen	13	18	1	0	14	2	0	7	7
Blockaden	23	11	66	0	2	34	0	6	14
Im Wort	17	11	54	0	2	21	0	3	12
Zwischen Wörtern	6	0	12	0	0	13	0	3	2
Stotterereignisse prozentual									
Wiederholungen	36,8%	17,4%	16,3%	0,0%	33,3%	30,8%	100%	13,3%	22,2%
Lautwiederholungen	36,8%	14,3%	16,3%	0,0%	33,3%	27,0%	100%	13,3%	22,2%
Silbenwiederholungen	0,0%	2,9%	0,0%	0,0%	0,0%	3,8%	0,0%	0,0%	0,0%
Dehnungen	22,8%	51,4%	1,3%	0,0%	58,3%	3,8%	0,0%	46,7%	26,0%
Blockaden	40,3%	31,4%	82,5%	0,0%	8,3%	65,4%	0,0%	40,0%	51,9%
Im Wort	29,8%	31,4%	67,5%	0,0%	8,3%	40,4%	0,0%	20,0%	44,4%
Zwischen Wörtern	10,5%	0,0%	15,0%	0,0%	0,0%	25,0%	0,0%	20,0%	7,4%
Prozentanteile									
Nicht-gestotterte Silben	84,2%	95,5%	88,2%	100%	96,9%	91,7%	99,8%	98,3%	94,4%
Gestotterte Silben	15,8%	4,5%	11,8%	0,05	3,1%	8,3%	0,2%	1,7%	4,6%
Sprechgeschwindigkeit In Silben pro Minute (S/min)									
	74	298	427	296	298	369	271	302	236
Stottereschweregrad ****	OG			VA			CF		
	mittelschweres Stottern			sehr leichtes Stottern			sehr leichtes Stottern		

- ★ Sprechbeispiele ohne Verwendung eines DAF/FAF Gerätes
- ★★ Sprechbeispiele unter Verwendung des DAF/FAF Gerätes: VA601i, VoiceAmp
- ★★★ Sprechbeispiele unter Verwendung des DAF/FAF Gerätes: Small Talk, Casa Futura
- \*\*\*\* Der Stottereschweregrad laut SSI-4 (Stuttering Severity Instrument – 4. Ausgabe) ist in 5 Unterkategorien unterteilt: sehr leicht, leicht, mittelschwer, schwer, sehr schwer.

**Appendix 3: Anamnesebogen zur Identifikation  
personenspezifischer Daten vor der Anwendung von  
modifiziertem auditiven Feedback (MAF)**

Anamnesebogen  
zur Beratung bezüglich technischer Hilfsmittel in der Stottertherapie

Vielen Dank, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen!  
Bitte schicken Sie den ausgefüllten Bogen an [XYZ@Beratungszentrum.de](mailto:XYZ@Beratungszentrum.de)  
zurück. Nach Erhalt des Anamnesebogens werden Sie umgehend zur  
Vereinbarung eines Beratungstermins kontaktiert.

Allgemeine Informationen:

Name:

Geburtsdatum:

Adresse:

E-mail Adresse:

Telefonnummer:

Wie würden Sie am liebsten kontaktiert werden?

☐ per Telefon

☐ per E-mail

☐ per Post

Therapeutische und Medizinische Vorgeschichte:

Seit wann leiden Sie an der Redeflussstörung Stottern?

Wurden Sie von einem ausgebildeten Fachmann (z.B. Sprachtherapeut) mit  
der Redeflussstörung Stottern diagnostiziert? ☐ ja ☐ nein

Wenn „ja“ wer stellte die Diagnose und wann?

Haben Sie jemals „technische Sprechhilfen“ zur Minderung Ihrer  
Redeflussstörungen benutzt? ☐ ja ☐ nein

Wenn ja, welches Gerät wurde von Ihnen benutzt?

Haben Sie sich jemals zur Minderung Ihrer Sprechunflüssigkeiten in  
therapeutische Behandlung begeben? ☐ ja ☐ nein

Art der Therapie (Inhalt)	Behandelnder Therapeut (z.B. Logopäde, Sprachtherapeut, Arzt usw.)	Dauer der Therapie	Rückblickendes Urteil (z.B. minderte stottern/nicht)

Wurden bei Ihnen jemals andere Sprach- oder Sprechstörungen  
diagnostiziert?

Haben Sie sich jemals einer audiometrischen Untersuchung bzw. einem  
Hörtest unterzogen?      ☐ ja    ☐ nein

Wenn „ja“:

Wann?

Von wem durchgeführt?

Ergebnis?

Vielen Dank für die Bereitstellung dieser Informationen!

**Appendix 4: Formatvorlage für einen Fragebogen und ein  
Anwendertagebuch zur kontinuierlichen Erfassung  
klientenspezifischer Eindrücke während einer Gerätenutzung**

**Wöchentlicher Fragebogen zur Erfassung der klientenspezifischen  
Gerätenutzung**

Bitte kreuzen Sie die Antworten an die Ihre persönliche Erfahrung mit dem Gerät am besten widerspiegeln. Bitte ergänzen Sie Ihre Antwort ggf. mit weiteren Informationen.

Name:

Datum:

Nutzungswoche:

Emailadresse:

**Wie oft haben Sie das Gerät diese Woche benutzt?**

- ☐ Mehrere male am Tag
- ☐ Einmal täglich
- ☐ 4-5 mal wöchentlich
- ☐ 2-3 mal wöchentlich
- ☐ Einmal pro Woche
- ☐ Gar nicht

**In welchen Situationen haben Sie das Gerät diese Woche benutzt?**

- ☐ Gruppengespräche mit vertrauten Personen
- ☐ Gruppengespräche mit Fremden
- ☐ Einzelgespräche mit vertrauten Personen
- ☐ Einzelgespräche mit Fremden
- ☐ Telefonate mit vertrauten Personen
- ☐ Telefonate mit Fremden
- ☐ Sonstige. Bitte nennen:

**In welchen Umgebungen haben Sie das Gerät diese Woche eingesetzt?**

- ☐ Zu Hause
- ☐ Am Arbeitsplatz
- ☐ In der Öffentlichkeit
- ☐ Sonstige. Bitte nennen:

**In welcher Situation hat sich das Gerät diese Woche bewährt?**

- ☐ Gruppengespräche mit vertrauten Personen
  - ☐ Gruppengespräche mit Fremden
  - ☐ Einzelgespräche mit vertrauten Personen
  - ☐ Einzelgespräche mit Fremden
  - ☐ Telefonate mit vertrauten Personen
  - ☐ Telefonate mit Fremden
  - ☐ Sonstige. Bitte nennen:
- 

**In welcher Umgebung hat sich das Gerät diese Woche bewährt?**

- ☐ Zu Hause
  - ☐ Am Arbeitsplatz
  - ☐ In der Öffentlichkeit
  - ☐ Sonstige. Bitte nennen:
- 

**In welchen Situationen war es schwer das Gerät zu tragen?**

- ☐ Gruppengespräche mit vertrauten Personen
  - ☐ Gruppengespräche mit Fremden
  - ☐ Einzelgespräche mit vertrauten Personen
  - ☐ Einzelgespräche mit Fremden
  - ☐ Telefonate mit vertrauten Personen
  - ☐ Telefonate mit Fremden
  - ☐ Sonstige. Bitte nennen:
- 

**In welcher Umgebung war es schwer das Gerät zu tragen?**

- ☐ Zu Hause
  - ☐ Am Arbeitsplatz
  - ☐ In der Öffentlichkeit
  - ☐ Sonstige. Bitte nennen:
- 

**Allgemeine Symptomeinschätzung:**

**Traten diese Woche unter Verwendung des Gerätes übliche  
Kernsymptome (z.B. Blocken, Dehnungen, Wiederholungen) gemindert  
auf?**

- ☐ Ja
- ☐ Nein

**Traten diese Woche unter Verwendung des Gerätes übliche  
Kernsymptome (z.B. Blocken, Dehnungen, Wiederholungen) gemindert  
auf?**

- ☐ Ja
- ☐ Nein

**Welches Gerätezubehör haben Sie diese Woche benutzt?**

- ☐ Verkabelte, doppelseitige Kopfhörer

☐ Verkabelte, einseitige Kopfhörer

☐ Kabelloses Ohrteil

☐ Sonstige. Bitte

nennen: \_\_\_\_\_

**Welche Geräteeinstellungen haben Sie diese Woche genutzt?**

☐ DAF/FAF Dualeffekt:

FAF Einstellung: \_\_\_\_\_ Hz/Oct

DAF Einstellung: \_\_\_\_\_ ms

☐ Nur FAF

☐ Nur DAF

☐ Masking

☐ Sonstige. Bitte

nennen: \_\_\_\_\_

**Gab es diese Woche Probleme mit dem Gerät?**

☐ Ja. Bitte Art des Problems

nennen: \_\_\_\_\_

☐ Nein

**Name:** \_\_\_\_\_

**Nutzungswoche:**

Bitte verwenden Sie die folgenden Zeilen, um Ihre persönlichen Erfahrungen mit dem Gerät in dieser Woche mit uns zu teilen. Dabei können Sie gerne auf die verschiedensten Themen eingehen die Ihnen wichtig erscheinen: z.B. Schildern von spezifischen Situationen mit dem Gerät, genauere Erläuterungen von Problemen/Erfolgen unter Verwendung des Gerätes usw.

This image shows a single sheet of white paper with horizontal blue ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## **Appendix 5: Übersicht der elektronischen Anhänge auf den Begleitmedien<sup>4</sup>**

1. Videobeispiele stottertypischer Kernsymptome
  - A. Lautwiederholung
  - B. Silbenwiederholung
  - C. Dehnung
  - D. Blockade im Wort
  - E. Blockade zwischen den Wörtern
2. Videobeispiele für Sprechtechniken der traditionellen sprachtherapeutischen Behandlungsansätze
  - A. Fluency Shaping
    - i. Die Sprechtechnik "Easy Onsets/Weicher Stimmeinsatz" auf Wortebene
    - ii. Die Sprechtechnik "Easy-Onsets/Weicher Stimmeinsatz" in der Spontansprache
  - B. Stottermodifikation
    - iii. Die Sprechtechnik "Cancellations" auf Wortebene
    - iv. Die Sprechtechnik "Cancellations" in der Spontansprache
    - v. Die Sprechtechnik "Pull-outs" auf Wortebene
    - vi. Die Sprechtechnik "Pull-outs" in der Spontansprache
3. Videobeispiele exemplarischer Sprechproben mit und ohne Nutzung eines Gerätes
  - A. Lautes Lesen ohne Gerät
  - B. Lautes Lesen mit Gerät
  - C. Lautes Lesen in der Placebokondition
  - D. Monolog mit Gerät
  - E. Monolog ohne Gerät
  - F. Dialog mit Gerät
  - G. Dialog ohne Gerät
4. Mastertabelle der zusammengefassten quantitativen Datensammlung
  - A. Kodierte Mastertabelle mit allen ausgewerteten Sprechproben der Querschnittstudie
  - B. Kodierte Mastertabelle mit allen ausgewerteten Sprechproben der Längsschnittstudie
5. Mastertabelle der zusammengefassten qualitativen Datensammlung
  - A. Kodierte Mastertabelle mit allen ausgewerteten Fragebögen der Querschnittstudie
  - B. Kodierte Mastertabelle mit allen ausgewerteten Fragebögen der Längsschnittstudie
  - C. Kodierte Mastertabelle mit allen ausgewerteten Anwendertagebüchern der Längsschnittstudie
6. Komplette Dissertation als pdf Datei

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<sup>4</sup> Die elektronischen Begleitmedien sind aus datenschutzrechtlichen Gründen nicht für die Veröffentlichung vorgesehen.