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Interactional effects of introducing the computer into phonological intervention

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ABSTRACT

Phonological intervention is often aimed at resolving problems with the specific speech sounds and phonological processes that cause difficulties for the child. But part from working with these specific targets, the speech and language pathologist (SLP) can also use conscious communicative strategies, e.g. encouraging the child's own communicative initiatives, to strengthen the child as a communicator. Previous research has showed that different intervention approaches have different effects on the interactional balance between the child and the SLP.

Today, a small number of computer programs are used in intervention in children with deviant speech, especially in children with impaired hearing. Direct visual feedback is one of the virtues offered by computer technology that goes beyond what the human SLP alone can offer. Moreover, the introduction of the computer in language intervention may have positive effects on the child's motivation. However, the effects that the introduction of the computer might have on the interaction between the child and the SLP have remained unexplored.

In this study, two child-therapist pairs have been video recorded in two different therapy settings – one traditional, "tabletop", session and one computer-assisted session. The transcribed recordings were then analysed with Initiative-Response analysis (Linell & Gustavsson, 1987). The results suggest that the introduction of a computer into the therapy room actually affects the interaction between child and therapist in some aspects. In the computer-assisted setting, the therapist is less dominant and the child takes more communicative initiatives. Hence, the interactional asymmetry is less pronounced. Moreover, the computer-assisted therapy is characterised by fewer and shorter turns between child and therapist. But even though the children generally talk less, they spend more efforts at pronouncing the targeted phonemes (or syllables/words).

This study demonstrates that the computer can serve a social and educational function in the therapy setting. By directing the user (the child) through the exercises and by providing positive as well as negative feedback, the computer can shoulder the therapist's role as "conductor" and judge in the therapy setting. The therapist is thereby relieved from tasks that are potentially face threatening to the child, and might instead focus on being a facilitator and fellow explorer in the child's phonological progress.

SVENSK SAMMANFATTNING

Det övergripande målet vid fonologisk intervention är att förbättra barnets möjligheter till friktionsfri kommunikation med sin omgivning. Förutom att arbeta direkt med de språkljud och fonologiska processer som orsakar problem för barnet, kan logopeden med hjälp av medvetna kommunikativa strategier stärka barnet i sin roll som kommunikatör. En strategi är t ex att uppmuntra barnets egna kommunikativa initiativ. Tidigare forskning har visat att olika interventionsmetoder har olika effekt på balansen i interaktionen mellan barn och logoped.

Idag finns ett litet antal datorprogram som används vid logopedisk intervention hos barn med uttalssvårigheter, framför allt hos barn med hörselnedsättning. Genom t ex direkt visuell återkoppling kan datorer och ny teknologi bidra med interventionsstrategier utöver dem logopeden kan erbjuda på egen hand. Dessutom kan användandet av dator i logopedisk intervention ha positiva effekter på barnets motivation. Att introducera datorn i behandlingssituationen kan alltså medföra många fördelar, men vilken effekt det har på interaktionen mellan logopeden och barnet är hitintills outforskat.

I denna studie har interaktionen mellan två barn med fonologisk språkstörning och deras respektive terapeuter (logoped resp. talpedagog) studerats. Barnen och terapeuterna har spelats in på video dels i en traditionell, ”datorlös”, behandlingssituation, dels i en behandlingssituation där datorn introducerats. De transkriberade inspelningarna har sedan analyserats med Initiativ-Respons-analys (Linell & Gustavsson, 1987). Resultaten antyder att det datorstödda arbetssättet faktiskt påverkar interaktionen mellan barn och terapeut i vissa avseenden. I den datorstödda behandlingssituationen är interaktionen mindre asymmetrisk; terapeuten är mindre dominerande och barnet tar fler initiativ. Vidare karaktäriseras den datorstödda behandlingen av färre och kortare turer mellan barn och terapeut. Men trots att barnen totalt sett talar mindre i den datorstödda situationen än i den traditionella, uttalar de oftare de fonem (eller stavelser/ord) som fokuseras i behandlingen.

Studien visar att datorn kan fylla en social och pedagogisk funktion i behandlingssituationen. Genom att dirigera användaren (barnet) genom övningarna, samt genom att ge såväl positiv som negativ återkoppling, kan datorn överta terapeutens roll som ”chaufför” och domare i behandlingssituationen. Därigenom befrias terapeuten från uppgifter som kan upplevas som ansiktshotande av barnet. I stället kan terapeuten frigöra resurser till att vara medupptäckare tillsammans med barnet och på så sätt underlätta barnets fonologiska framsteg.

1. INTRODUCTION

Phonological disorders in children are often communicatively impairing. Deviant speech production often leads to decreased intelligibility and communicative breakdowns. Repeated experience of communicative failure may in turn have serious consequences, at its worst leading to communicative avoidance. The overall goal for phonological intervention is to break this trend; to increase speech intelligibility and to strengthen communicative functioning.

The challenges for the speech and language pathologist (SLP) are plentiful. The target of intervention – the language – is also the medium through which intervention is performed. This might be considered a paradoxical hindrance, but it can also offer therapeutic possibilities. By creating an atmosphere where communicative initiatives from the child are encouraged, and thereby strengthen him/her in his/her role as an active learner and communicator, the SLP can intervene on many levels at once.

For many children with speech and language impairment, intervention is lengthy and may stretch over several years. Introducing computers to support phonological intervention might have positive effects on the child's motivation. Moreover, computer technology can provide additional therapeutic strategies than the SLP alone can offer. However, introducing computers in phonological intervention might affect the interaction between the child and the clinician, and these effects remain unexplored.

This study aims at shedding light on the interactional effects of introducing the computer to phonological intervention, through the empirical analysis of video recorded "computer-less" and computer-assisted therapy sessions. An additional purpose is to unravel the terminological confusion that surrounds the use of the term *phonological impairment*, as well as to present a systematic overview over different approaches to phonological intervention.

2. BACKGROUND

2.1 Phonological impairment: definition

In the literature, the term *phonological* is used differently by different authors. Disorders of speech production can be classified either by how they are realised, or by what causes them, i.e. where in the speech production chain the problem is assumed to lie. The term *phonological* is sometimes used when referring to the manifestation of a speech disorder, and sometimes when referring to a cognitive-linguistic level of speech production (as well as perception).

Based on underlying deficits, speech disorders due to either physical/organic or motor restrictions may be classified as *articulatory* speech disorders, and speech deviations that do not fall into this category as *functional* speech disorders (Bishop, 1997; Gierut, 1998). More established, though, is the distinction between articulatory speech disorders and *phonological* disorders, where the latter suggests underlying deficits on a linguistic-cognitive level (Nettelbladt, 1983; Howell & Dean, 1991).

Based on surface manifestation, speech disorders are classified as exhibiting either *phonetic* or *phonemic/phonological* deviations. From a segmental perspective, the difference lies in

whether or not phonemic contrasts between speech sounds are preserved in the distorted speech. In phonetically deviant speech (e.g. interdentalisation of /s/, ”lisping”), phonemic contrasts between speech sounds are still preserved, whereas they are lost in phonologically distorted speech. Stopping of fricatives is an example of a process that results in phonologically deviant speech. (This process may e.g. result in the pronunciation [tu:l] of the Swedish word “sol” (*sun*), where [su:l] is expected.) Speech distortions that are dependent on phonetic or prosodic context are also classified as phonological deviations.

There is often an assumed association between articulatory speech disorders and phonetic speech deviations; the terms *articulatory* and *phonetic* are often used interchangeably (Gierut, 1998). In Table 1, however, we see that this association does not always hold. In cleft palate speech, for example (i.e. an articulatory speech disorder), backing of plosives (i.e. a phonological error pattern), is not a rare phenomenon (Grunwell, 1992). Moreover, we see that phonetically deviant speech is not always explained by articulatory restrictions; interdentalisation of /s/ is an example of a functional speech disorder that results in phonetically deviant speech. Note that Table 1 illustrates a theoretical categorisation; speech disorders cannot always be neatly placed in one of the four categories.

Table 1: The relation between the level of underlying deficit and manifestation (surface error patterns) of speech disorders. Note that the term *phonological* is sometimes used when referring to the underlying deficit and sometimes to the manifestation of a speech disorder.

		Surface error patterns	
		Phonetic	***Phonological***
Level of deficit	*Articulatory*	E.g. dysarthria, resulting in globally distorted articulation	E.g. cleft palate speech, resulting in backing of plosives
	Phonological - functional	E.g. interdentalisation of /s/	E.g. stopping of fricatives, consonant cluster reductions

Clearly, there has been some confusion around the concept of phonological disorder traditionally. Therefore, it is probably not surprising to find confusion also in the clinical use of the terminology. According to the International Classification of Disease (ICD-10), as defined by the World Health Organization (2007), developmental phonological disorder is considered a specific speech articulation disorder. Here, it remains unclear whether phonological refers to the underlying cause or the manifestation of the speech disorder. In clinical practice in Sweden generally, however, a distinction is made between phonological impairment (Swedish: “fonologisk språkstörning/-försening”) on the one hand and articulation disorder (Swedish: “uttals-/artikulationsproblem”) on the other hand. The former is classified as a linguistic-cognitive impairment, while the latter is used to describe problems of articulation specifically (Hansson & Nettelbladt, 2002). Here, it is clear that phonological is referring to the assumed underlying deficit, rather than to the surface manifestation. This is also the sense that is intended when referring to *phonological disorder* henceforth in this work.

Phonological impairment vs. other linguistic skills

In Swedish clinical practice, phonological impairment is a possible – and sufficient – inclusive criterion in a Specific Language Impairment (SLI) diagnosis (Hansson & Nettelbladt, 2002). However, there is not international consensus regarding this terminology. Generally and internationally, when using the term SLI, emphasis is usually on grammatical and lexical deviations. According to some researchers (e.g. Tallal, 2000), there is reason to believe that a phonological processing deficit, caused by an auditory sensory deficit, is a core

deficit for language impairments generally. However, others would dispute this, either advocating another core deficit, e.g. deficient phonological short-term memory (Gathercole & Baddeley, 1990[1]), or assuming a joint effect between reduced speed of processing and language specific grammatical structure (e.g. the Surface Hypothesis, Leonard, 1997).

Hence, the relation between phonological skills and overall linguistic skills is far from resolved. But there is general agreement that, as with many speech and language difficulties, problems are rarely limited to one specific language function, in this case phonology. For example, there is rich evidence of a strong correlation between phonological developmental stage and grammatical level (e.g. Sahlén, Reuterskiöld-Wagner, Nettelbladt & Radeborg, 1999; Hansson & Nettelbladt, 1995). In other words, even though phonological problems might appear as the most salient feature of a child's linguistic skills at first sight, they are often part of broader language difficulties (Bishop, 1997).

A distinction is generally made between, on the one hand, phonological ability in the sense that has been described above, i.e. how the phonological system of a language is structured cognitively, and, on the other hand, ability to reason about structure of speech sounds from a meta-perspective, i.e. *phonological awareness* (or *metaphonology*). Tasks for phonological awareness include e.g. rhyming and reflecting upon word length. Many tasks for phonological awareness tap *phonological processing* skills, such as phoneme deletion (e.g. "What would 'stand' sound like without /t/?") and metatheses (e.g. "What word have I messed up when I say 'pheletone' (telephone)?"). As can be expected, children with phonological impairment often show poor phonological awareness (Bishop, 1997; Leitao, Hogben & Fletcher, 1997; Nauclér & Magnusson, 2000). But as Leitao et al. (1997) showed, there are also poor speakers with good phonological awareness, as well as good speakers with poor phonological awareness. There is a commonly assumed link between phonological awareness and word decoding skills (Catts & Kamhi, 2005), and it might be tempting to assume that phonological impairment in pre-school children predicts poor word decoding skills in later reading development, and subsequent poor overall reading skills. But, as Nauclér and Magnusson (2000) have shown, phonological impairment in pre-school years does not necessarily lead to poor word decoding skills in later reading development.

2.2 Phonological intervention

In the speech of phonologically impaired children (or in any child at an early phonological stage), intelligibility is disturbed by a lack of phonological variation. Not only is the number of phonemes often reduced, but also the combinatorial possibilities. This results in a lot of homonymy, i.e. words that should be pronounced differently actually sound the same. For example, for a child with unresolved dentalisation and cluster reduction, the three words "tack" (*thanks*), "katt" (*cat*) and "stack" (*stack*/*left*) might all be produced [tat]. Homonymy is a source of reduced intelligibility, and is often communicatively impairing for the child. Reducing homonymy, by strengthening of the child's phonological skills is thus a way of approaching the overall goal in all language intervention: improving communicative functioning.

[1] Note that although Gathercole & Baddeley (1990) suggest deficient phonological short-term memory as an underlying cause of SLI, they exclude children with poor phonological discrimination and/or articulatory limitations from their study. Thus, this study reveals little about the relation between poor phonological short-term memory and phonological impairment.

In normal as well as in deviant phonological development, the road towards more adult-like speech production involves revising rules for phonetic realisation of phonemes (Hewlett, 1992). But in order for the child to revise a rule, Hewlett (1992, p. 32) argues that the child must:

1. be aware that the current production is somehow insufficient.
2. be willing to change it.
3. know the relevant crucial articulatory targets.
4. be physiologically able to implement these targets at speed and in a variety of phonetic contexts.

A variety of approaches to phonological intervention has been suggested. Different strategies emphasise different aspects of encouraging speech production modification in phonologically impaired children. On the one side, there is the question of the *form*, of how the intervention should be applied: who is the "intervention agent", where and how often do the intervention agent and the child meet, what pedagogic strategy leads to the most efficient way of facilitating phonological development, etc. On the other side, there is the question of the *contents* of intervention: what skills should be trained (and why), what speech/language structures should be focused, what locus in the speech production chain should be targeted, etc. These issues will be explored in the following sections.

The form of phonological intervention

Theories on how linguistic skills are best learnt obviously influence the role of the clinician and how phonological intervention is performed. Some clinicians apply a *behaviouristic* view on learning to phonological intervention, attempting to modify the child's phonological behaviour by praising correct behaviour and discouraging (possibly by not encouraging) incorrect behaviour. Others approach modified phonological behaviour through *motor learning* – motor exercise and self-correction in response to conflicting feedback. For instance, a computer program that visualises acoustic features can provide immediate, visual feedback to a child, informing the child if his/her speech production was adequate or not. From this feedback, the child can adjust – self-correct – his/her speech production towards the target sound. In contrast to behaviouristic and motor-learning approaches, other clinicians adopt *cognitive* learning theories, focusing the cognitive processes underlying the child's behaviour. Some clinicians apply a *constructivist-cognitive* view to intervention, stressing the child's role as an active learner. By reflecting on his/her own phonological behaviour (metaphonological reasoning) the child is assumed to take an active part in acquiring language, and the clinician's role is more that of a facilitator than a teacher. *Social-cognitive* (or interactionist) views on learning shift focus from the child to the surrounding environment, emphasising the learning that takes place in the interaction with the environment. Through studying, imitating and interacting with people in his/her environment, the child is assumed to learn. Clinicians who apply a social-cognitive view to language intervention concentrate on adapting the communicative style towards the child, focusing more on facilitating communication than "teaching" linguistic skills. (For an overview over the application of different learning theories to language intervention, see Klein & Moses, 1999). Obviously, the clinician's view on learning will have a heavy impact on how intervention is performed. But ideas from different learning theories are not necessarily conflicting; many clinicians have a more eclectic approach to learning, picking elements from different learning theories.

The contents of phonological intervention

Different approaches to the contents of phonological intervention rely on different views on what phonological impairment really *is*. Historically, different explanatory models have been influential in different time periods. Nettelbladt (2007) describes a shift in logopedics/speech pathology in the mid 1900s, from a focus mainly on defects of speech and articulation, to descriptions of deviant speech and language production based on linguistic and phonological theory. This "phonologic revolution" (Crary, 1993) provided taxonomies for describing linguistic data, entailing new ways of interpreting collected data from children with language disorder. These new discoveries also influenced the views on phonological remediation.

Intervention approaches that spring from an articulatory/speech-motor tradition typically target speech movements and articulation of (single) speech sounds, aiming at improved motor programming skills. Phonologically based intervention strategies, on the other hand, target phonological processes and aim for a cognitive re-organisation of the sound system. Crary (1993) suggests a continuum from approaches with *bottom-up* focus to those with *top-down* focus. Bottom-up strategies, he explains, focus on the individual building blocks of speech, emphasising non-speech oral movements and/or production of single consonant or vowel segments. Many articulatory/speech-motor approaches to intervention correspond to these bottom-up features. At the other end of the continuum are the top-down strategies, where the clinical focus is on the *meaningful word* and linguistic contrasts, rather than motor speech execution. Here, the child learns that in order to change the meaning of a word, articulation has to be altered.

"Traditional speech training" (Swedish: "traditionell talträning", see Nettelbladt, 2007; Gierut, 1998) typically starts with perceptual training, where the child listens to the target speech sound in an attempt at promoting awareness of this particular sound. Proceeding to speech production, the child initially attempts to produce the target sound in isolation, before moving on to more complex contexts: syllables, words, phrases and conversational speech. This kind of approach is thus an example of a bottom-up strategy. Inspired by behaviouristic theory, the clinician serves as a speech role model and a teacher; through imitation and explicit reinforcement and corrections, the child is assumed to approach the adult target.

Instead of focusing a specific speech sound as target for intervention, many strategies focus a particular feature contrast as the target for phonological remediation, e.g. the stop/continuant distinction between /t/ and /s/. This phonological generalisation is assumed to result not only in economy of analysis, but also in an increase of therapeutic efficiency (Costello & Onstine, 1976). A phonologically oriented top-down approach where the contrast between phonemes is highlighted is the strategy of using *minimal pairs* (e.g. Blache, Parsons & Humphreys, 1981). Minimal pairs are word pairs which differ only by one phoneme, e.g. *sun* and *fun*. Typically, intervention based on minimal pairs involves both perceptive discrimination between the two words and production of the same distinction. Just like traditional speech training, the phonological approaches suggested by Costello and Onstine (1976) and Blache et al. (1981) display heavy influence from behaviouristic learning theory, and are limited to remediation of phonology as an isolated specific linguistic skill.

Metaphon (Howell & Dean, 1991) is an approach to phonological intervention where phonological skills are not targeted per se, but where the target is phonological function in a communicative context. In order to encourage changes in the child's speech production, Howell and Dean suggest an approach through *communicative awareness*; the child must recognise that there is a mismatch between what s/he means to say and what s/he actually

says, and this will often lead to communicative breakdowns. Another important goal is, obviously, to provide the child with the tools to repair the communicative breakdowns, through altering or repairing his/her speech output. If and when s/he fails to produce or perceive a contrast, it will lead to a communicative breakdown, rather than to the clinician correcting him/her. The clinician and the child will then use this communicative breakdown as a starting point for a discussion on what happened and what can be done to resolve the misunderstanding. The goal is to enable the child to find his/her own ways of making changes in articulation. In promoting the child's role as an active learner and the clinician's role as a facilitator rather than a teacher, Metaphon shows apparent influences from cognitive learning theories.

In both top-down and bottom-up strategies to phonological intervention, *automaticity* is often a final goal. This relates to the fourth of the conditions listed by Hewlett (1992, p. 32, see page 4), that the child must "be physiologically able to implement these targets at speed and in a variety of phonetic contexts". In other words, overlearning of the acquired phonological skills is assumed to make the child's phonological system robust and less fragile in challenging linguistic and communicative contexts.

There is abundant evidence, both scientific and clinical, that children with phonological disorders benefit from speech-language intervention (e.g. Gierut, 1998; Hesketh, Adams, Nightingale & Hall, 2000). However, few studies have been done to support the application of one intervention approach over any other approach (Crary, 1993). According to Dodd and Bradford (2000), there is not *one* single treatment approach that fits *all* children with phonological impairment, since this group is very heterogeneous. For some children, the most appropriate intervention may involve selecting and sequencing different intervention approaches. This concurs with the suggestion made by Hesketh et al. (2000), that speech and language pathologists rarely make a clear distinction between (meta)phonological and articulatory, phonetically, oriented work in clinical practice. Most clinicians are assumed to adopt a more eclectic approach to intervention in their clinical practice.

It is worth noticing that of the few different comparative studies that have been done, most compare different intervention approaches in terms of effect on the directly targeted language skills, i.e. phonology and speech production. Unfortunately, comparative evaluation studies like these have been scarce, and undoubtedly, more evaluative research is needed. However, not only the direct effects on the partial goal – improved phonologic skills – need to be studied, but also the effects on the overall goal – improved communicative functioning. Clinical research focusing the interactional patterns between child and clinician within different intervention approaches can shed light on this aspect.

2.3 Computer-assisted intervention

Computers have been used in educational and special educational settings since the 1980's, and according to Schery and O'Connor (1995), the availability and use of computer technology in this domain has virtually exploded since then.

Computer-assisted intervention vs. tabletop intervention

In some areas, computer technology provides possibilities that go beyond what a human clinician can offer. For example, some programs (e.g. SpeechViewer and Box of Tricks, see Öster, 2006), provide immediate visual feedback on speech production. By modifying his/her speech production, the child manipulates both acoustic features *and* visual features visible on

the screen. Obviously, tasks like this would be impossible without the use of computers. By giving this kind of enhanced feedback, computers can be used to facilitate the child's self-monitoring process (Masterson & Rvachev, 1999). Furthermore, the introduction of computer software into language intervention and education has proved to have positive effects on motivation and attention span, at least for some children (Schery & O'Connor, 1995; Gierut, 1998). Moreover, contrary to what some might fear, introducing computers into an educational setting might lead to *more* social interaction and verbal communication in children, not less (Schery & O'Connor, 1995). Finally, computer technology can be used to facilitate intervention administration; phonotactically sorted picture databases and automatic documentation and analysis of progress are examples of tools that can assist the clinician in planning and evaluating intervention.

Despite several suggested advantages of computer-assisted therapy, there are obvious limitations to how much support a computer can provide in phonological intervention. Before even considering introducing a computer, the first step is always to plan the contents of the intervention. Only then can the clinician determine if using computer technology might enhance the remedial plan. The task of planning the contents of the intervention will continue to rest on the human clinician, although computational tools have been developed to assist this process (see Masterson & Rvachev, 1999 for an overview). Gierut (1998) argues that computerised instruction might be more appropriate in later phases of treatment, while tabletop approaches are still preferred in early stages, or with very young (or distractible) children.

An obvious challenge for intervention in general, but perhaps even more for computer-assisted intervention, is the extent to which skills trained in computational settings are transferred to natural communicative contexts. Depending on how the computer is used in intervention, the transfer of phonological skills trained in a computational context to a functional communicative context is not necessarily straightforward. This is perhaps the most obvious limitation to computer software in language intervention and the main reason why a computer program can never replace the human clinician in strengthening communicative function.

Although a vast range of commercial software has been developed that target language and communication skills in a second language, the selection of computer programs to assist children with atypical linguistic and communicative development is more restricted. In the area of reading and writing difficulties, computer technology can provide important help both in training and in compensating for weak reading and writing skills. Computerised training has also been suggested to relieve symptoms of neuropsychiatric disorders such as Attention-Deficit/Hyperactivity Disorder, ADHD (Klingberg, Forssberg & Westerberg, 2002). Much of the software that has been used in language intervention is based on behaviouristic learning theories of immediate feedback and reinforcement (Schery & O'Connor, 1995). An example of this is the computer program Fast ForWord (Tallal, 2000). Here, the child responds to auditory stimuli, speech as well as non-speech sounds, and through immediate feedback and reinforcement, the child's auditory processing skills are assumed to improve. However, the Fast ForWord method has been questioned, and although results indicate that Fast ForWord training leads to improvements not only in auditory processing, but also in some linguistic skills (Tallal, 2000), the effects on communicative functioning remain to be studied.

Although several computer programs have been designed for phonological and articulatory intervention (see e.g. Masterson & Rvachev, 1999 for an overview), only few are available for Swedish. Of these, two speech training programs are widely used and acknowledged among

Swedish speech and language pathologists, especially for intervention in children with impaired hearing: *IBM SpeechViewer* and *Box of Tricks* (Swedish: Trollerilådan) (Öster, 2006).

IBM SpeechViewer

The IBM SpeechViewer has been used, and is still used, in clinical and educational settings in Sweden for almost 20 years (Öster, 2006). It contains various exercises, where real-time visual feedback is provided in response to the child's productions, in a play-like fashion. For example, in an exercise for pitch control the task is to steer a car by using voice pitch, moving the car up with a higher pitch and down with a lower pitch. Other basic speech attributes that are targeted are voicing, timing, breath control and loudness. The exercises are intended to be used in intervention in young profoundly deaf children, increasing their basic awareness of when they produce sound and when they do not, and – to some extent – what the sounds they produce are like (ibid). Apart from these basic skills exercises, there are also exercises for articulation and prosody. For instance, some tasks target stable phoneme production. Here, an acceptable sample of the child's production of the target phoneme is recorded and used as a model. The aim in these exercises is to make the child's best production his/her most common production (ibid). Of course, this requires that the child is able to produce the target phoneme correctly/acceptably at least sometimes.

Box of Tricks

Just like SpeechViewer, Box of Tricks contains exercises targeting different attributes of speech sounds, ranging from basic features such as loudness, pitch and voicing, to articulation of phonemes in various contexts and intonation (Öster, 2006). Just as in SpeechViewer, the child uses his/her voice and articulation to manipulate figures and shapes and receives real-time feedback. In addition, articulatory feedback is presented in the shape of articulation pictures, showing correct positioning of the vocal organs during articulation. In some exercises, a picture of a spectral target is presented (see Figure 1) and as the child attempts to produce the same speech sound, spectral feedback is given. If the child produces the target speech sound correctly, s/he will "paint" the same picture as the reference spectrum. Through evaluative feedback the child is encouraged if his speech production attempts are approaching the target reference, not only when they are correct. In Box of Tricks, the speech recognition is speaker-independent, as opposed to IBM SpeechViwer where the child's own best production is recorded and used as a reference.

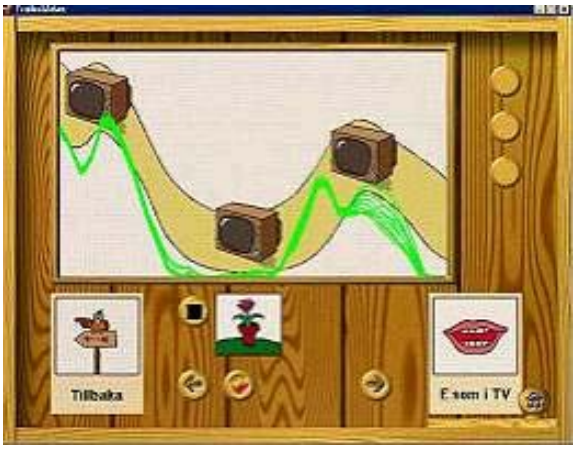

Figure 1: An example of an articulation exercise in Box of Tricks (Trollerilådan). If the child produces the vowel /e:/ (as in the Swedish word for TV) correctly, the spectrum will match the path, and the flower below the path will flourish.

ARTUR – The ARticulation TUtoR

Bälter, Engwall, Öster & Kjellström (2005) report on ARTUR (The ARticulation TUtoR), a process-oriented speech training program prototype developed at KTH, Stockholm. ARTUR is the name of a virtual articulation tutor in the shape of a talking head with internal parts that can be made visible to the user. ARTUR can thus provide feedback on many levels to the user – as a verbal instruction (e.g. "Try to retract the tongue tip and make the contact between the tongue and the palate with the edges, instead of the middle, to get a vibration of the tongue tip", Bälter et al., 2005) or as a audio-visual instruction by showing how he moves his articulators. This visual information is often hard and sometimes impossible to deliver without the use of pictures or simulations. Here, computational simulations can serve as an extension to what can be done in traditional speech therapy. Although ARTUR still only exists as a prototype, it serves as an illustration of what state-of-the-art computer and speech technology can offer.

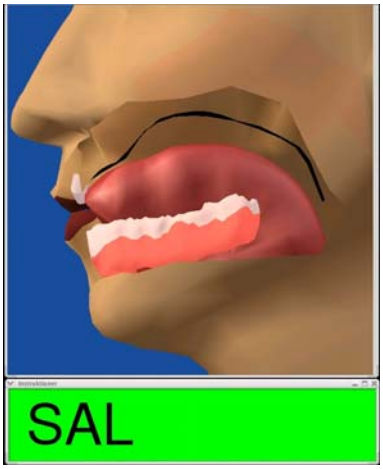

Figure 2: ARTUR's user interface for articulatory feedback (from Bälter et al., 2005: p. 2). Here, the training word is "sal" (*hall*, *room*, *ward*) and the target pronunciation is [sɑ:l]. Intra-oral target articulation is visible in the talking head model.

IBM SpeechViewer, Box of Tricks and ARTUR all largely follow the drill-and-practice style of traditional speech training (see page 5), with the addition of the real-time visual feedback that modern computer technology can provide, to increase awareness of speech production. Although this approach has proven appropriate for speech production in some children (e.g. deaf or hard of hearing, Öster, 2006), common practice in Sweden and Scandinavia generally has shifted from a behavioural tradition to a more cognitive (constructivist and interactionist) view on language learning. In Sweden today, there exist no computer-based strategies to intervention that implement the view of phonological impairment as a linguistic-cognitive deficit, aiming intervention at the level of phonological organisation. And world-wide, no computer-assisted approaches to phonological intervention can be found that incorporate ideas of communicative functionality and constructivist/interactionist learning theory.

2.4 Interactional analysis

Although the *effect* of language intervention obviously needs to be studied and evaluated, many also acknowledge the importance of studying the *interaction* between the clinician and the child in the ongoing therapy session (e.g. Hulterstam & Nettelbladt, 2002; Howell & McCartney, 1992). Considering that the overall goal of phonological intervention is to improve communicative functioning in the everyday life, the communicative context of the child, both in the therapy sessions and outside the therapy room, is of obvious interest.

Moreover, as Howell & McCartney (1992) argue, there is reason to believe that the social context, who the child interacts with and how, will have effects on learning.

Interactional analysis may be applied to different kinds of interactions, both everyday conversations between friends and between members of families, but also institutional conversations, e.g. doctor-patient conversations, classroom interaction and political debates (Linell & Gustavsson, 1987). Descriptions of different types of interactions can reveal different interaction patterns and communicative strategies in different contexts. Although we all might appreciate that there *is* a difference in communicative style in these different contexts, interactional analysis can pinpoint *how* these communicative styles differ.

In some studies, the insight of how communicative styles differ has had clinical implications. For example, Hansson et al. (2000) found that children with language impairment are more active communicators in conversations with peers than with adults. On the other hand, as adults take more communicative control than peers, children produce longer utterances with greater lexical variation in child-adult conversations than in conversations with peers. It seems, the authors speculate, that communicative "scaffolding" (as provided by the adults) enables the children to pay more attention to their language production. Thus, different conversational partners seem to stimulate different linguistic and communicative skills. These results were supported by Bruce, Hansson and Nettelbladt (2007), in their study of interactions between children with SLI in conversation with age-matched and younger children with typical language development. The more communicative support the conversational partner offers, the less communicative control the children with SLI take.

According to Linell and Gustavsson (1987), well-functioning, symmetrical, conversations are characterised by a balance between the speakers; the conversational space is divided equally between the speakers and both contribute with equal amounts of speech. Moreover, the speakers collaborate to control the interactional course; they respond to the other's initiations and their own initiations "point forward", yet they are not forcing. However, Linell and Gustavsson argue, the symmetrical dialogue is a theoretical ideal that is never seen in reality. Furthermore, they continue, certain social contexts actually require a certain asymmetry, e.g. the therapeutic conversation or the educational setting. Within intervention strategies that emphasise the role of the child as an active learner and the clinician as a facilitator rather than a teacher (e.g. Metaphon), interactions can be expected to be more symmetrical than within other approaches. This is also confirmed by Hulterstam and Nettelbladt (2002) in their comparative study of the interactions between children and clinicians in two different settings, traditional speech training and Metaphon therapy. The authors found that within both approaches, the clinician was the dominating party in the interactions. However, as was expected, the asymmetry was less pronounced in Metaphon.

Asking someone for a response, whether it is to perform an action or to answer a question, is potentially *face threatening*, especially if the respondee has difficulties performing the action, or is reluctant to do so, if s/he does not know the answer to the question or suspects that the answer is unsatisfying (Aronsson, 1991). Social distance and difference in social power tend to increase the demands on the respondee even more. Doctor-patient interactions, or child-adult interactions, are therefore situations with great risk of threatening the weaker party's face (Swedish: "social fasad", Aronsson, 1991). However, people often use strategies to make potentially face threatening initiatives less coercive, e.g. use inclusive pronouns ("we"), endearments ("sweetie"), politeness markers ("please") or indirectness ("could you"). But, as Aronsson (1991) found in her study of doctor-parent-child/patient situations, mitigating strategies, especially indirectness, might obscure the underlying message, and the speaker's

intention might be misunderstood. Hence, there is a balance between coerciveness and clarity on the one hand, and mitigation and obscurity on the other hand.

Studies on the interactional effects of introducing a computer into a clinical or educational setting have been scarce. As already mentioned, Schery and O'Connor (1995) report that the presence of computers in classroom settings does not hamper social interaction among children, but can actually have a positive effect on the social and verbal interaction. Clements and Nastasi (1992) support this claim, reporting that children generally prefer the social use of computers, i.e. working in groups with peers, to working alone. The authors mention several successful cases where computers have been used in collaborative learning situations in classrooms, with positive interactional patterns of peer tutoring and encouragement. Although several studies show positive social and educational effects of introducing computers in educational settings, effects on interactional patterns between humans when computers are introduced remain unexplored.

Initiative-Response analysis

Initiative-Response (IR) analysis was suggested by Linell and Gustavsson (1987) as an approach to interactional analysis. Within this framework, conversations are viewed as dynamic collaborative processes between the participants; every turn is assumed to be related both to the preceding and the following context. Each turn is analysed in terms of its initiating and responsive qualities, i.e. how and to what extent it refers backwards and how and to what extent it affects the following interaction. Thus, a turn can never be analysed in isolation, but is always analysed in terms of how it relates to the surrounding context.

The categorisation of turns in terms of initiating and responsive features takes several dimensions into account. Initiating features are classified as either soliciting or non-soliciting. Through soliciting initiations, a speaker explicitly requests his/her conversation partner for a response. Non-soliciting initiations are "weaker" in that they do not require a response from the partner. Responsive features are classified by several different dimensions:

- *Scope*: whether a response links to the immediately preceding turn or to a more distant turn
- *Focality*: whether a response links to focal or peripheral aspects of the present topic
- *Alter- vs. self-linkage*: whether a response links to the speaker's own or to the interlocutor's preceding turn
- *Expansion*: whether a response contains more information than requested or not
- *Adequacy*: whether a response is accepted by the conversation partner or not

The combinatorial possibilities of initiating and responsive features yield a total of 21 different categories. (For an overview, see Appendix A.) Following the IR coding scheme (Linell & Gustavsson, 1987; Linell, Gustavsson & Juvonen, 1988), each turn is assigned a score, i.e. a numeric measure of its initiating/responsive qualities. Based on these utterance scores, quantitative computation on the analysed interactions is performed, yielding measures of interactional balance between the participants and coherence within the interaction.

IR-analysis has been used in the description of different types of conversations, not least in studies of interactions between children with phonological impairment and SLPs (Hulterstam & Nettelbladt, 2002), and between children and different types of conversation partners (Hansson et al., 2000; Bruce et al., 2007). These studies (previously discussed on page 10)

constitute examples of contributions of IR-analysis in describing and evaluating communication strategies in intervention with children with language impairment.

3. PURPOSE

This study has two main purposes. One is to present a comprehensive theoretical overview over different views on the definition of phonological disorder and of different approaches to phonological intervention. The other purpose is to compare two different therapy settings in terms of interactional dominance; one tabletop setting, where the child and the clinician centre in activities around physical objects like e.g. picture cards, and one where a computer program for speech training is introduced into therapy. The purpose in the empirical part of the study is to reveal *if* the introduction of a computer into phonological intervention affects the interactional balance between child and clinician and – if so – *how* this balance is affected. The results are assumed to give clinical implications as guidelines on using computer-assistance in phonological intervention.

4. HYPOTHESIS

It is hypothesised that introducing a computer into phonological intervention *does* affect the interactional patterns between the child and the clinician. On the one hand, the introduction of a third party – the computer – into the interaction is assumed to lead to reduced overall verbal communication between clinician and child. On the other hand, the expected asymmetry in the interaction between clinician and child is assumed to be reduced; as both the clinician and child focus their attention on exercises suggested and controlled by the computer, rather than exercises suggested and controlled by the clinician, the clinician is assumed to be less dominant in the computer-assisted setting than in the “tabletop” setting.

5. METHOD

Four sessions of phonological intervention were video recorded, transcribed and analysed. The participating children were first recorded in a tabletop (“computer-less”) session with their respective therapists. Then, three months later, the same child-therapist pairs were recorded again, now in a computer-assisted setting. The recordings were transcribed and analysed along the procedure described below.

5.1 Participants

Two children were recommended for participation by their respective therapists. The therapists were informed that the purpose of the study was to explore the interaction between child and therapist. The children’s parents were also informed of the purpose of the study (Appendix B) and signed a letter of agreement of participation (Appendix C). The children had both been diagnosed with moderate specific phonological disorders. Assessment of phonology was performed using Fonemtestet (Hellquist, 1991) and assessment of language comprehension using the Swedish version of TROG (The Test of Reception of Grammar, Bishop, 1983; adapted to Swedish by Holmberg & Lundälv, 1998).

The girl, Anna (a fictive name), was 5;0 years at the time of the first recording. She had been referred to an SLP from a child health care screening one year earlier, and she was then

diagnosed with specific phonological disorder. Today, she attends a language preschool where she meets her SLP for phonological therapy about three times a week. Anna's speech production is characterised by consistent dentalisation and traces of stopping; simplification of consonant clusters is frequent, and traces of assimilations and metatheses are also found. /r/ is consistently produced as [j]. Anna's language comprehension skills, as assessed by TROG, are within (and even slightly above) age norms. According to her SLP, Anna has some attentional difficulties; she often seems to answer without thinking. The SLP consciously tries to scaffold Anna to focus on the task at hand, to think before answering and to listen closely. Because of her attentional difficulties, the SLP thought introducing the computer into therapy could be beneficial for Anna.

The boy, Tom (a fictive name), was 7;5 years at the time of the first recording. He was first referred to an SLP in 2003 (at the age of 4) after a child health care screening, and was diagnosed with specific phonological disorder. After his first referral, Tom regularly saw an SLP for phonological therapy, individually as well as in group, in recurring periods of four to five weeks. Following common practice in Sweden, Tom's SLP within the health care system informed the school about his difficulties, and special education resources were prepared for him by the time he started school. He is now in his first year in a public school and meets with his special education teacher (Swedish: "speciallärare") about three times a week for phonological therapy and extra support for literacy development. As for Anna, dentalisation is also a salient deviation in Tom's speech production, although for Tom the pattern is not consistent. However, he consistently produces /r/ as [j] and shows frequent weakening of /l/. /ʃ/ and /ç/ are consistently produced as [s]. Cluster reduction and traces of assimilations occur occasionally. Tom's language comprehension skills, as assessed by TROG, are slightly below average for his age.

The therapists[2] in the recordings are, for Anna, the SLP who is responsible for her phonological intervention, and for Tom, his special education teacher who administers his phonological intervention under the supervision of Tom's former SLP.

5.2 Procedure

Recordings

For each of the two children, two therapy sessions were video recorded. In the first recorded therapy session – the tabletop session – the therapist and the child work on phonological tasks using pictures and physical objects in game-like settings. Such tasks are e.g. picking a card from a pile, pronouncing the name of the object (or event) on the card and deciding if it is pronounced "in the back" (i.e. if it is a velar sound) or "in the front" (i.e. if it is a dental sound). No explicit instructions were given to the therapists on the form or contents of phonological therapy. The second video recording was from a therapy session three months later. Here, the children work with exercises on the computer under the supervision of their respective therapist. The exercises include tasks of discrimination (hearing a word and placing it in the correct category, e.g. by dragging pictures of apples into the correct basket), speech production (e.g. "kicking" a football into a goal on the screen, by producing the target word repeatedly) and self-monitoring (imitating a target word played in the program, recording it, hearing it re-played and comparing it to the original).

[2] In the literature, SLPs are often referred to as *clinicians* and special education as *teachers*. In this study, however, the term *therapists* will be used to include both Anna's SLP and Tom's special education teacher.

The computer program used here is Pratvis, a program for interactive speech training still under development. Pratvis includes exercises focusing different levels of speech – isolated speech sounds, syllables, words and phrases. Tasks vary from identification, discrimination, pronunciation and concatenation of the different speech segments. The program contains recordings of different speech segments, both as sounds and video sequences. Pratvis also includes a recording function, enabling self-monitoring. Feedback is presented to the user both auditively and visually.

Transcriptions

The recordings were transcribed in the CHAT (Codes for the Human Analysis of Language) transcription and coding format (MacWhinney, 2000). CHAT is the standard format used in CHILDES, Child Language Data Exchange System (ibid). This environment offers means of linking video recorded data with transcriptions, as well as tools for analysing the data.

Example 1: Sample from the first recording with Anna, illustrating treatment of incorrect speech production (2 and 5). (ANN = Anna, SLP = Anna's SLP)

(1)	*SLP:	# och det där var att man skulle klättra upp på bergets +..?	*# and this was that you were climbing all the way up to the mountain +..?*
(2)	*ANN:	## k kopp [: topp].	*## c cop [: top].*
(3)	*SLP:	# tänk efter nu!	*# think carefully now!*
(4)	*SLP:	bergets +..?	*the mountain +..?*
(5)	*ANN:	## <u>kopp</u> [: topp].	*## <u>cop</u> [: top].*
(6)	*SLP:	t.	*t.*
(7)	*ANN:	# topp.	*# top.*

Since the focus of this study is the communicative *function* of each utterance, more than the phonological *form* of the utterance, the transcriptions were coarse and closer to written language than to spoken. However, as speech production is the focus of the therapy sessions, incorrect speech production will quite often be of interest. Consequently, this information is retained in the transcriptions, as illustrated in Example 1 above.

Not only verbal interaction was transcribed, but also some non-verbal activities, following CHAT conventions. Only such non-verbal activity that was judged as contributing to the interaction has been coded, e.g. nodding, pointing, picking up cards etc. An illustration is presented in Example 2 below.

Example 2: Sample from the first recording with Anna, illustrating coding of non-verbal activity (line 2). (ANN = Anna, SLP = Anna's SLP)

(1)	*SLP:	vem ska ha det?	*Who should have that?*
(2)	*ANN:	## 0 [%act: lägger bilden på gubben bak].	*## 0 [%act: puts the picture on mr back].*
(3)	*SLP:	ja precis	*yes, that's right.*

Whereas the basic unit according to the CHAT transcribing conventions (MacWhinney, 2000) is the *utterance*, the basic unit within the IR framework is the *turn*. Linell and Gustavsson (1987, p. 14) defines turn as a continuous period where one speaker "has the floor", where s/he is "in charge of" the conversational space. Thus, a turn can comprise several utterances (as MacWhinney defines them). For instance, in Example 1 above, lines 3 and 4 would be treated as two utterances in CHAT, but as one single turn within the IR framework.

Table 2: Number of turns (as defined by Linell & Gustavsson, 1987) in the recordings. Number of utterances (as defined by MacWhinney, 2000) is given in parentheses.

	Therapist	***Child***	***Total***	***Duration (mm:ss)***
Tabletop therapy				
Tom	249 (481)	231 (241)	480 (722)	23:28
Anna	282 (573)	274 (214)	556 (787)	26:06
Comp. therapy				
Tom	219 (411)	219 (333)	438 (744)	31:40
Anna	149 (295)	145 (121)	294 (416)	18:50

In order to transform the CHAT transcriptions to a format more appropriate for IR-analysis, an automatic conversion was performed. In this procedure, all consecutive utterances by one speaker were collapsed into one single turn. Moreover, all CHAT specific notation was converted to a notation that was more easily read. Some manual post-processing was done to ensure that each line consisted of one and only one turn. Table 2 displays the absolute number of turns and utterances in all recordings. Given that the recordings have different duration, the estimated number of turns (and utterances) during 15 minutes are given in Table 3.

Table 3: Estimated number of turns (as defined by Linell & Gustavsson, 1987) per 15 minutes in the recordings. Number of utterances per 15 minutes (as defined by MacWhinney, 2000) is given in parentheses.

	Therapist turns/15 min	***Child turns/15 min***	***Total turns/15 min***
Tabletop therapy			
Tom	159 (307)	148 (154)	307 (461)
Anna	162 (329)	157 (123)	319 (452)
Comp. therapy			
Tom	104 (195)	104 (158)	208 (353)
Anna	119 (235)	115 (96)	234 (331)

MLU analysis

Mean Length of Utterance (MLU) as measured in words was calculated by the tool MLU (MacWhinney, 2000), for both children and adults in all recordings.

Initiative-response analysis

Initiative-Response analysis was performed manually on the transcribed data, after conversion from CHAT format (see description above). Although verbal data produced by the computer was also transcribed, only turns uttered by the child and the therapist were assigned one of 21 possible labels, based on their initiating and responsive characteristics (see Section 2.4). According to the IR coding scheme (Linell & Gustavsson, 1987; Linell et al., 1988), the weakest interactive contributions (minimal inadequate responses) receive a score of 1, while the strongest (independent soliciting initiatives) receive a score of 6. Other categories are distributed in between. Three utterance categories do not receive any score at all. (For a complete overview over the different categories, see Appendix A.)

Table 4: Description and explanation of the different IR measures (Hulterstam & Nettelbladt, 2002; from Linell et al., 1988 and Linell & Gustavsson, 1987).

Measure	*Description*
IR-index	The mean strength of the conversational contributions. A measure of the dynamics of the dialogue.
IR-difference	The difference between the two speakers' IR-index. A measure of the dominance relation in the dialogue.
S-coefficient	Solicitation. Percentage of turns containing a soliciting initiation, that is question or directive.
O-coefficient	Obliqueness. The percentage of turns with non-focal linking or self linking. A measure of the 'smoothness' of the dialogue. High obliqueness implies a dialogue where the participants do not take into account the partner's contributions or where they are talking at cross-purposes.
B-coefficient	Balance. Percentage of turns with local, focal, alter-linking and non-soliciting initiatives (so called expanded responses). A high B-coefficient implies a very coherent and smooth dialogue where both participants contribute equally.
F-coefficient	Fragmentation. The percentage of turns that are non-locally or not at all linked to preceding turns. A measure of the frequency of topic change.
R-coefficient	Repairs. The percentage of turns consisting of a request for clarification. Like obliqueness, this can also be considered as a measure of how smoothly the dialogue progresses.

By counting all instances of the different utterance categories for a speaker, this speaker's *IR-profile* is drawn. From this profile, an *IR-index* is computed, representing the speaker's tendency of controlling the interaction or of being controlled. The IR-index for a speaker is defined as the median value of this speaker's scores on the ordinal scale (Linell et al., 1988). An IR-index above 3.0 reveals a tendency towards a more controlling interactive style, while an IR-index below 3.0 suggests a tendency of being controlled by the conversation partner. The difference between the IR-indices of two conversation partners, the *IR-difference*, is a measure of the degree of dominance in the dialogue. An overview over these and other measures are presented in Table 4 above.

5.3 Reliability

Manual IR-analysis was performed by the author on all recorded and transcribed data. A subset (about 20%) of the IR-coded dialogues was then re-annotated by the supervisor. Table 5 displays the inter-coder reliability as measured in agreement (mismatching codes / all compared codes) and in Kappa statistics (Siegel & Castellan, 1988).

Table 5: Inter-coder reliability of IR-coding, as measured in percentage of agreement and in Kappa statistics (Siegel & Castellan, 1988).

Checked turns	*Mismatching codes*	*Agreement*	*Kappa score*
519	33	94%	0.96

According to Linell and Gustavsson (1987, p. 205), inter-judge reliability of 75% is realistic in IR-coding, considering the interactional status of a turn is often obscured by vagueness and ambiguity. Carletta (1996) recommends the use of the Kappa statistics (Siegel & Castellan, 1988) as a standard for discourse and dialogue annotation work. A kappa value of 1 represents total agreement between coders, while a kappa value of 0 represents no agreement other than would be expected by chance. According to Carletta, annotation schemes are generally considered reliable only when $K > 0.8$, while K-values < 0.67 indicate that the annotations are

not reliable enough to draw conclusions from. The Kappa score displayed in Table 5 thus suggests that the IR-coding is reliable.

6. RESULTS

6.1 MLU analysis

Table 6 displays the mean length of utterance (MLU) as measured in words for all speakers in all recordings, and shows that the therapists' utterances are longer than those of the children. This pattern is consistent across the different modes of intervention (tabletop vs. computer-assisted).

Table 6: Results from the MLU analysis

	MLU, therapist	***MLU, child***
Tabletop therapy		
Tom	4.39	1.89
Anna	3.94	1.70
Comp. therapy		
Tom	3.63	1.86
Anna	4.45	2.25

6.2 Initiative-response analysis

Interactional balance

As illustrated in Table 7, IR-indices for both children in all recordings are below 3.0, while IR-indices for both therapists in all recordings are above 3.0. This suggests that the adults are the dominant parties in the interactions. For both child-therapist pairs, the children's IR-indices are higher in the computer-assisted sessions than in the tabletop sessions, while the therapists' IR-indices are slightly lower. Hence, the IR-difference is smaller in the computer-assisted sessions than in the tabletop sessions, suggesting a tendency of reduced interactional asymmetry.

Table 7: Results from the IR-analysis: IR-index.

	IR-index, therapist	***IR-index, child***	***IR-difference***
Tabletop therapy			
Tom	3.24	2.30	0.94
Anna	3.62	2.04	1.58
Mean			*1.26*
Comp. therapy			
Tom	3.10	2.86	0.24
Anna	3.51	2.52	0.99
Mean			*0.62*

Interactional asymmetry is also inherent in the adults' and children's values for the Solicitation coefficient (S-coefficient), displayed in Table 8. In all recordings, the therapists' S-coefficient values are considerably higher than those of the children, as a consequence of a higher degree of soliciting initiatives. However, there is a tendency in the therapists to use fewer soliciting initiatives in the computer-assisted setting than in the tabletop setting.

Table 8: Results from the IR-analysis: IR-coefficients, therapists. IR-coefficients for the children are given within parentheses.

	Solicitation	***Obliqueness***	***Balance***	***Fragmentation***	***Repairs***
Tabletop therapy					
Tom	40 (0)	13 (4)	38 (32)	6 (5)	5 (0)
Anna	54 (1)	28 (4)	25 (19)	4 (5)	1 (0)
Mean	*47 (1)*	*21 (4)*	*32 (26)*	*5 (5)*	*3 (0)*
Comp. therapy					
Tom	28 (2)	12 (29)	33 (30)	7 (11)	1 (0)
Anna	46 (2)	15 (14)	28 (24)	6 (12)	1 (1)
Mean	*37 (2)*	*14 (22)*	*31 (26)*	*7 (12)*	*1 (1)*

Responsiveness

A high degree of responsiveness implies a coherent and smooth dialogue, with a high degree of linking up with, and expanding, the interlocutor's immediately preceding turn. Responsiveness is measured by means of the Balance coefficient (the B-coefficient). As displayed in Table 8, the B-coefficient valutes for Tom and his therapist are higher than for Anna and her therapist, regardless of intervention mode.

The Obliqueness coefficient is also related to responsiveness, revealing the extent to which the participants follow up their partner's contributions. A low value implies that they do follow up, while a high value suggests that the speakers are talking at cross-purposes. In the computer-assisted setting, the Obliqueness values for both children are higher than in the tabletop sessions, while the therapists' values are lower or slightly lower compared to the tabletop sessions. Thus, the figures indicate that the children are less responsive (i.e. make self-linkings, non-focal responses or do not accept the partner's contributions) when the computer is introduced. For the therapists, the figures suggest that responsiveness is increased or slightly increased by the introduction of the computer into the intervention session.

7. DISCUSSION

This study is based on the analysis of a small amount of data, and one particular computer program, and one might question to what extent these results predict general interactional differences between tabletop and computer-assisted intervention. Moreover, the fact that the therapists have different backgrounds, and that the children are of different ages might contribute to the results being difficult to generalise to other children and therapists. However that may be, the careful study of samples of tabletop and computer-assisted phonological intervention is indeed valuable. The results here show that interactional patterns between children and therapists *can* be affected by the introduction of the computer. Moreover, this study also reveals something of how these differences can present themselves.

The design and purpose in this study have been revised during the course of this work. The initial idea – to evaluate treatment efficacy in the computer-assisted setting – was abandoned when the developers of the computer software realised they would not have a finished product in time for the computer-assisted therapy period. Therefore, they explained, they would not be involved in any larger scale efficacy study where their unfinished software might be scrutinised. But at this stage, after about two months of work and after an initiated recruitment process, the author was reluctant to discard the idea of cooperating with the developers of Pratvis. Instead, an alternative idea was suggested, and accepted by the developers. The number of participating children was reduced from eight to two, and the focus was shifted

from the specific software to how it affected the interaction between child and therapist. Clearly, a larger number of participants would have been preferred to yield more generalisable results, but, as argued above, the results in this study are still considered valuable.

Obviously, informing the participants about the purpose of the study – to explore the interaction between the child and therapist with and without the computer – might have unwanted and uncontrollable effects on their interactional behaviour. However, *not* informing the participants of the purpose of the study would be questionable from an ethical point of view, and was thus not considered an option. In an effort to minimise unwanted side-effects, information was brief and did not reveal what aspects of interaction would be explored. Recording a therapy session, whether it is with a tape recorder or a video camera, might also influence the participants' behaviour. However, *not* recording the therapy sessions was considered impossible for practical reasons.

Applying the dialogistic IR-analysis framework to interaction with three parties involved might seem controversial, but proved to be less challenging than one might have feared. All verbal interaction (and some non-verbal) was transcribed, also when produced by the computer, though only interaction between child and therapist was coded with IR-labels. As a consequence, turns that could be viewed as local, adequate responses to initiatives from the computer were not coded in relation to the computer's initiative, but instead to the preceding interaction between child and therapist. However, since the interaction between child and therapist was indeed the focus of this study, this was not considered a problem. The high level of coding reliability supports the consistency in the IR-coding.

Tom's results in the assessment of receptive language skills were slightly low, and somewhat surprising to both his former SLP and his special education teacher. Although phonological skills often correlate with other linguistic skills (see page 3), this had not been the case for Tom as found in earlier assessment. However, the unexpected results might be explained by a suboptimal test situation; TROG was done in the same session as the phonological assessment, only after a short break. Therefore, Tom's attention might have been disturbed. However, even if Tom really *has* slightly weak receptive skills, this has not been judged as having any significant bearing upon the results in this study.

The results confirmed the hypothesis that the introduction of a computer into phonological intervention would affect the interactional patterns between child and therapist. As to the nature of the interactional differences between tabletop and computer-assisted intervention, the hypothesis predicted reduced overall verbal communication between child and therapist in the computer-assisted setting, as well as reduced dominance on the therapists' part. Both these hypotheses were confirmed by the data.

The following aspects of interaction between the child and the therapist proved to be affected by the introduction of a computer into the therapy room:

- Reduced number of turns (and utterances) for both child and therapist (See Table 3.)
- Reduced interactional asymmetry (IR-difference). The children are more active communicators when the computer is introduced, while the therapists are slightly more passive. The following two findings contribute to the reduced interactional asymmetry:
    - Therapists take fewer soliciting initiatives in the computer-assisted setting.

- Reversed roles of responsiveness (as measured by the Obliqueness coefficient). By the introduction of the computer, the children seem less responsive to the therapists, while the therapists are actually more responsive to the children.

The first finding supports the prediction that introducing the computer leads to reduced verbal interaction between the child and therapist. This should, however, not be surprising. As the therapist and child invite any third party – in this case the computer – into the interaction, they also give away a part of the interactional space that was originally shared by only the two of them. Reduced interactional asymmetry was a finding that was partly predicted by the hypothesis. Recall that "communicative strength" is characterised by a large amount of strong initiatives. The finding that the therapists use a reduced number of strong initiatives in the computer-assisted setting obviously contributes to a reduced IR-index value for the therapists, while the finding that children are less responsive (as measured by the Obliqueness coefficient), contributes to an increased IR-index value for the children.

An explaining factor to the therapists' reduced number of soliciting initiatives in the computer-assisted setting could be found in the observation that the computer very often produces command-like utterances like "Click on the right arrow", "Spin the bottle" etc. If these turns had been assigned IR-lables, they would have been coded as strong initiatives. Thus, it seems that the computer takes on the role of pushing the interaction forward through soliciting initiatives, thereby relieving the therapist from this task. Consequently, the therapists produce fewer soliciting initiatives in the computer-assisted setting.

As the computer takes on the role, or a part of the role, as "conductor" of the interaction, the child will often respond to the computer's initiatives and ignore the therapist's utterances. Quite often, the following pattern was observed in the recordings:

Example 3: Excerpt from the second recording with Tom. (CMP = computer, SET = special education teacher.)

(1)	*CMP:	klättja [: klättra] [%act: spelar upp det TOM sagt]. klöver.	*cjimb [: climb] [%act: replays what TOM has said]. clover.*
(2)	*TOM:	klövej [: klöver].	*clovej [: clover].*
(3)	*SET:	snyggt!	*nice!*
(4)	*CMP:	klövej [: klöver]. [%act: spelar upp det TOM sagt]. kläder.	*clovej [: clover]. [%act: replays what TOM has said]. clothes.*
(5)	*TOM:	klädej [: kläder].	*clodes [: clothes].*

Here, Tom ignores the therapist's utterance (3), and focuses on the initiative taken by the computer (4). This is a recurring pattern in the recordings in the computer-assisted setting, and it might serve as an explanation of the increased value of the Obliqueness coefficient for the children. By following instructions given by the computer the children are less responsive to the therapists than in the tabletop setting.

Although the focus of this study is the *interaction* between the child and the therapist and how it is affected by the introduction of a computer in the phonological intervention, some observations were also made of how the *content* of the therapy session was affected by the introduction of a computer:

- Both children spend more effort at pronouncing the target sounds (or words/syllables).

- One of the therapists produces considerably more supportive comments (e.g. "nice!", "good!" etc.) and considerably less instruction in the computer-assisted setting. The

other therapist actually produces *more* instruction (e.g. “let’s go here”, “let’s try this”) in the computer-assisted setting, as well as “meta-instructional” comments (e.g. “think carefully”, “slow down” etc.)

The finding that both children actually spend more effort at pronouncing the target segments is interesting. The kind of exercises used in the computer-assisted setting might explain this difference, at least partly. In one exercise, for example, the task is to repeat the target segment several times, by each repetition kicking a football closer to a goal on the screen. In another exercise, the rolling of a dice decides the number of repetitions needed. Especially Tom seems to enjoy this; he even makes a sport out of producing as many repetitions as he can in a short time! In the tabletop setting, no corresponding exercises of multiple repetitions are used. Obviously, the task of producing as many efforts at the target segment as a dice decides would be possible to perform also without a computer. But would the children be as motivated to complete a task of this kind in a tabletop setting? Some might question the use of this kind of segment repetition task. The step between multiple repetitions of specific speech segments to the functional use of these segments in communicative speech may seem far. However, one path to automaticity in speech production is through repeated successful efforts at targeted speech sounds (Hewlett, 1992). Therefore, the finding that a computer-assisted setting might be motivating for the child to make more efforts at targeted segments is important.

The other finding, that the two different therapists use different instructional strategies in the two different settings, seems contradictory. Here, one might speculate if the personal traits of the therapists and the children influence the results more than having or not having a computer in the therapy room. The fact that one of the therapists produces more supportive comments and less instruction suggests that she is comfortable with the way the child works with the computer, and that the child is more “self-propelled”. Perhaps not surprisingly, this is Tom, the older one of the two children. Anna’s therapist, on the other hand, does not seem as comfortable with Anna working independently with the computer; the fact that she gives more instruction and reminds Anna to “think carefully” and “slow down” suggests the opposite. Again, more participants, or more recordings with the same therapists, could be a way of neutralising the effect of different personal traits between the therapists.

The introduction of the computer as a third party in the intervention setting has the potential of breeding meta-phonological and meta-communicational discussions between the child and therapist, thus conforming to a cognitive constructivist view on learning. Example 4, from the second recording with Anna, might serve as an illustration of the possibilities to meta-phonological and/or meta-communicational discussions that technology can offer. Here, in row (6), Anna shows awareness that what she said does not sound correct and that it, in fact, sounded like another existing word. In Hewlett’s (1992) words, she recognises that her current speech production “is somehow insufficient” (see page 4). In this case, this does not lead to a meta-phonological discussion on the difference between the two words, but it serves to illustrate how the computer – as an objective third party – can create new opportunities for such reasoning. (Obviously, in this case, a simple tape recorder could have served the same purpose).

Example 4: Sample from the second recording with Anna, illustrating potential starting point for meta-phonological and/or meta-communicational discussion. (CMP = computer.)

(1)	*CMP:	diska.	*"diska" (wash up).*
(2)	*ANN:	ditta [: diska] [%act: försöker upprepa det datorn sagt].	*"ditta" [%act: tries to repeat what the computer said].*
(3)	*SLP:	mm.	*mm.*
(4)	*SLP:	lät det bra?	*did that sound good?*
(5)	*CMP:	ditta [%act: spelar upp det ANN sagt].	*"ditta" [%act: replays what ANN said].*
(6)	*ANN:	## TITTA sa jag.	*## I said "TITTA"(look).*
(7)	*SLP:	ja det LÄT nästan som TITTA när du sa det.	*yes it almost SOUNDED like "TITTA" when you said it.*
(8)	*SLP:	## diska.	*"diska".*
(9)	*ANN:	titta [: diska].	*"titta".*
(10)	*SLP:	diska.	*"diska".*

The use of the computer as an objective third party, and as a conductor of the interaction in the therapy setting has excellent potential for new intervention strategies. As the computer relieves the therapist of the controlling and correcting role, the therapist could instead focus on collaborating with the child, against the computer as a "common enemy". Negative feedback from the computer could serve as a starting point for discussions on what was wrong and what to do to change it. In such meta-phonological and meta-communicative discussions, the child and therapist would collaborate in the task of "making the stupid computer happy". Such reasoning is in line with cognitive-interactionist and cognitive-constructivist learning theories (and Metaphon).

The difference in social power between the child and the computer can be assumed to be smaller than – or even the opposite to – that between the child and the therapist. For example, while the child has little or no influence over the therapist's actions, s/he can easily control the computer's actions by mouse clicks and keyboard strokes. Moreover, the consequences of not responding to the computer's initiatives are assumably less severe than not responding to the therapist. Thus, to the child, the computer does not have as much social power as the therapist. Therefore, the potential face threat that negative feedback or soliciting demands might pose on the child would be much smaller when coming from the computer, than when coming from the therapist. And, notably, the computer does not use mitigating strategies when giving negative feedback or commanding the user to perform an action, and clarity is thus preserved. In other words, the introduction of the computer has the potential of resolving the difficult balance between clarity/coerciveness and obscurity/mitigation (see Section 2.4).

To summarise, the results in this study show that although the introduction of the computer into phonological intervention may lead to less verbal interaction between the child and the therapist, the child may actually become more active as a communicator, with more interactional control than in a tabletop setting. Moreover, as the computer shoulders the role as a judge and a conductor of the therapeutic course, the therapist is relieved from these potentially face threatening tasks. The therapist can instead focus on facilitating the child's learning process. Another important finding is that the introduction of the computer might encourage the child to make more efforts at the targeted sounds/syllables/words than s/he would have in a tabletop session.

In order to draw general conclusions on the use of the computer in phonological intervention, more research is needed. Not only is there a need for larger scale studies with more participants, but the effects of introducing different computer software should also be

investigated. Moreover, advances within speech technology research could generate new ways of enhancing phonological intervention with computer-assistance. And although the importance of interactional studies cannot be stressed too greatly, there is still an acute need for more studies on therapeutic efficacy. Even though the introduction of the computer might have positive effects on the interaction between the child and therapist, the therapeutic efficacy of computer-assisted phonological intervention needs to be evaluated and compared to different approaches to tabletop intervention, not only in terms of effects on the direct target (the specific phonological processes), but also in terms of generalisation to everyday communicative functioning.

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APPENDIX A: Definitions and scores of IR-categories

(Freely from Linell et al, 1988 and Linell & Gustavsson, 1987.)

Code	Definition	Score
>	Free, non-retroactive, soliciting initiative.	6
..>	Non-locally linked, soliciting initiative, the retroactive part being linked to a specific nonadjacent turn further back in the preceding dialogue.	5
:>	Non-focally linked, soliciting initiative. A *non-focal* link usually involves remarking on, or challenging, the form and/or function of the interlocutor's preceding turn.	5
<=>	Turn with clear properties of both response and initiative, the retroactive part being linked to the speaker's own preceding turn and *clearly ignoring an interjacent initiative* by the interlocutor. Initiating features are soliciting.	5
^	Free, non-retroactive, non-soliciting initiative.	5
..^	Non-locally linked, non-soliciting initiative, the retroactive part being linked to a specific nonadjacent turn further back in the preceding dialogue.	4
:^	Non-focally linked, non-soliciting initiative. A *non-focal* link usually involves remarking on, or challenging, the form and/or function of the interlocutor's preceding turn.	4
<=^	Turn with clear properties of both response and initiative, the retroactive part being linked to the speaker's own preceding turn and *clearly ignoring an interjacent initiative* by the interlocutor. Initiating features are non-soliciting.	4
=>	Turn linked to the speaker's own preceding turn (rather than the interlocutor's turn). The turn is either merely a repetition or simple reformulation of the speaker's preceding initiative or (in case the interlocutor has only given or tried to give a minimal response) a continuation of this preceding turn. Typically occurs when the interlocutor's interjacent utterance is not accepted as an adequate response.	4
<>	Turn with clear properties of both response and initiative, the retroactive part being linked to the main content of the interlocutor's preceding (adjacent) turn and the proactive part (initiating aspect) involving a strong initiative.	4
..<	Turn linked to, and treated as satisfying the demands of, a nonadjacent initiative and involving no initiating properties. A nonlocal minimal response to a nonadjacent initiative.	3
=^	Turn linked to the speaker's own preceding turn (rather than the interlocutor's turn). The turn is either merely a repetition or simple reformulation of the speaker's preceding initiative or (in case the interlocutor has only given or tried to give a minimal response) a continuation of this preceding turn. Initiating features are non-soliciting.	3
<^	The *prototypical expanded response*, in which the speaker gives something more than is minimally required or requested by the interlocutor's preceding initiative. Initiating properties are non-soliciting.	3
<)	Turn closing, or proposing to close, the current topic or subgame, and involving no further new initiatives.	3
(>	Turn lacking substantial content but involving an initiative (such as a proposal) to open a new topic or subgame (the topic to be introduced in the speaker's next turn). Preparatory initiative or *preinitiative*.	3
<	Turn linked to the interlocutor's adjacent turn and involving no initiating properties (*minimal response*). The turn is treated by the interlocutor as satisfying the demands of (being conditionally relevant to) his own preceding initiative (*adequate response*).	2
->	Turn linked to the interlocutor's preceding turn but deferring rather in itself providing the adequate response to that turn. This type of contribution involves a very weak initiative, subordinated to the interlocutor's preceding turn, and has no further initiating properties of its own. A *deferring question* asking for repetition, confirmation, or simple clarification of something contained in the interlocutor's preceding turn.	2
-	Turn linked to, or at least possibly linked to, the interlocutor's adjacent turn and involving no initiating properties. Treated by the interlocutor as NOT satisfying the demands of, or as not even conditionally relevant to, his own preceding initiative. A (minimal and) *inadequate response*.	1
?	Inaudible utterances.	0
X	Turns that are aborted before they add something to the dialogue.	0
b	Back-channeling.	0

APPENDIX B: Request for participation

Lund, 2007-01-22

Bästa föräldrar!

I det här brevet vänder vi oss till er föräldrar till normalhörande barn med fonologisk språkförsening, respektive barn med Cochlea Implantat (CI) och uttalssvårigheter, och inbjuder er och ert barn att medverka i en studie. Innan ni tar ställning till en eventuell medverkan är det viktigt att ni läser informationen nedan.

Det finns flera olika metoder för logopedisk behandling av barn med fonologisk språkförsening och uttalssvårigheter. När nya behandlingsmetoder introduceras är det viktigt att de utvärderas och jämförs med existerande metoder på ett systematiskt sätt. Utvärderingar kan ske på många olika sätt och fokusera på olika aspekter; tyvärr har det över huvud taget gjorts få utvärderingar och jämförelser tidigare inom detta område.

Att använda datorn som stöd i behandling är något som blir allt vanligare inom många områden. Datorn kan i många fall utgöra ett bra stöd i inlärningssituationer där nya mönster ska läras in. *Pratvis – datorbaserad uttalsträning* är ett datorprogram som är tänkt att användas som stöd vid behandling av fonologisk språkförsening och uttalssvårigheter, både för normalhörande barn och för barn med CI. Programmet är ännu under utveckling, och en viktig del i utvecklingsprocessen är utprovning och utvärdering av programmet. Utvärderingen kommer förhoppningsvis ge oss svar på framför allt två frågor:

- Hur påverkas interaktionen mellan barnet och behandlaren (logopeden/talpedagogen) av att datorn introduceras i behandlingssituationen?
- Hur upplevs den datorstödda behandlingen av användarna, jämfört med traditionell behandling?

Denna studie omfattar barn i åldern 4-7 år med måttliga till grava fonologiska svårigheter/uttalssvårigheter, med eller utan CI. Barnen kommer att medverka både i traditionell fonologisk behandling och i datorstödd behandling där *Pratvis* kommer att användas. Ett traditionellt och ett datorstött behandlingstillfälle kommer att videoinspelas och analyseras utifrån hur interaktionen mellan barnet och logopeden/talpedagogen ser ut. (Analysen ger t ex svar på frågor om vem som tar flest initiativ, vem som oftast byter samtalsämne, vem som talar mest etc.) Resultaten från analysen av det traditionella behandlingstillfället kommer sedan att jämföras med resultaten från analysen av det datorstödda behandlingstillfället. Vi kommer också att be ert barn att tillsammans med sin logoped/talpedagog fylla i en enkät om hur han/hon själv upplever de båda olika behandlingstyperna.

<u>Tidsplanering</u>
Vi genomför den första videoinspelningen, av ett traditionellt behandlingstillfälle, under februari. I anslutning till detta ber vi ert barn att tillsammans med sin logoped/talpedagog fylla i en enkät om hur han/hon själv upplever behandlingen.

Den datorstödda behandlingen kommer att inledas i maj. Efter ca 4 behandlingstillfällen, då barnet hunnit bekanta sig med programmet, kommer den andra videoinspelningen genomföras. I anslutning till detta kommer vi att be ert barn att tillsammans med sin logoped/talpedagog fylla i en liknande enkät som tidigare, men som denna gång behandlar den datorstödda behandlingen.

<u>Behandling av material</u>
De enda som kommer att ha tillgång till personuppgifter och relevanta journalhandlingar är undertecknade (samt ordinarie logoped), och vi omfattas alla av sjukvårdssekretess. Vi kommer att behandla alla personuppgifter konfidentiellt. Videoinspelat material kommer att behandlas som journalhandlingar. Deltagande i studien är frivilligt och kan när som helst avbrytas.

Vi svarar gärna på era frågor och funderingar!

Sofia Strömbergsson	Ulrika Nettelbladt	Cecilia von Mentzer
Logopedstudent	Leg log, professor, handledare	Leg log, ansv. för Pratvis

APPENDIX C: Letter of agreement

Svarsblankett

Vi lämnar härmed vårt tillstånd till att vårt barn deltar i denna studie, där traditionell och datorstödd fonologisk behandling jämförs utifrån användarnas upplevelser och eventuella effekter på interaktionen i behandlingssituationen.

Vi har läst igenom informationen och projektledarna har förklarat målsättningen med undersökningen. Vi är medvetna om att vi när som helst kan avbryta deltagandet.

Förälders namn:.....

Barnets namn:.....

Banets födelsedatum:.....

....

Förälders namnteckning Ort och datum

Tack för din hjälp!