

Using NLG and Sensors to Support Personal Narrative for Children with Complex Communication Needs

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Abstract

We are building a tool that helps children with Complex Communication Needs¹ (CCN) to create stories about their day at school. The tool uses Natural Language Generation (NLG) technology to create a draft story based on sensor data of the child's activities, which the child can edit. This work is still in its early stages, but we believe it has great potential to support interactive personal narrative which is not well supported by current Augmentative and Alternative Communication (AAC) tools.

1 Introduction

Many tools have been developed to help children and adults who cannot speak (or who have limited speech) communicate better. However, most of these tools have focused on supporting communication for practical goals, such as “*I am thirsty.*” But human communication is also used for social goals; we develop friendships and other inter-personal relationships via social interaction and communication. The bulk of conversation is characterized by free narrative (Cheepen 1988). One of the most important types of conversational narrative is personal narrative: someone telling a story about what happened to him or her.

People with limited or no functional speech do tell stories, but these tend to be in monologue form, or in a sequence of pre-stored utterances on voice output communication aids (Waller 2006). Individuals who use

¹ The term Complex Communication Needs (CCN) describes individuals who, due to motor, language, cognitive, and/or sensory perceptual impairments (e.g., as a result of cerebral palsy), do not develop speech and language skills as expected. This heterogeneous group typically experiences restricted access to the environment, limited interactions with their communication partners, and few opportunities for communication (Light and Drager 2007).

Augmentative and Alternative Communication (AAC) tools tend to be passive, responding to questions with single words or short sentences (e.g. Soto, Hartmann et al. 2006) and if able to initiate and maintain extended conversations tend to relate experience word for word each time they tell a story, even though much of conversation is reused (Clarke and Clarke 1977). This is time consuming and physically exhausting – typical rates range from 8 to 10 words per minute up to 12 to 15 per minute when techniques such as word prediction are used (Higginbotham, Shane et al. 2007), with the result that people seldom engage in storytelling. Despite the importance of narrative, little work has been done on specific tools to help language-impaired individuals engage in personal storytelling. In this paper, we describe our work in progress on building a tool that uses Natural Language Generation (NLG) technology to help children tell stories about their day at school, describing both the work we have done to date, and the challenges that we face in further developing this concept.

2 Background

2.1 AAC

Technology underpins much of Augmentative and Alternative Communication (AAC), a field that attempts to augment natural speech and provides alternative ways to communicate for people with limited or no speech. At the simplest level, people with Complex Communication Needs (CCN) can cause a pre-stored message to be spoken by activating a single switch. At the most sophisticated level, literate users can generate novel text using input methods ranging from a single switch to a full keyboard.

Despite advances in AAC, there are still many individuals for whom communication remains problematic. Although some individuals with CCN become effective communicators, most do not – they tend to be passive communicators, responding mainly to questions or prompts at a one or two word level. Conversational

skills such as initiation, elaboration and storytelling are seldom observed (Waller 2006).

One reason for the reduced levels of communicative ability is the cognitive demands of AAC interfaces. Current AAC technology provides the user with a purely physical link to speech output. The user is required to have sufficient cognitive abilities and physical stamina to translate what they want to say into the sequence of operations needed to produce the desired output. Mnemonic codes and dynamic displays (Beukelman and Mirenda 2005) provide some help in the retrieval process, but users still have to master complex retrieval and production strategies.

A second reason for the impoverished quality of conversation is the focus of AAC devices on transactional communication; conversation which expresses needs wants and information transfer, for example, “*I am thirsty*”, “*I use a straw for drinking*”. Instead, interactive conversation is characterized by free narrative and phatic conversation, for example, “*Guess what happened this morning...*”, “*Hello*”, and “*How are you?*” Without easy access to extended interactive communication, it is difficult to develop the skills needed to initiate new topics and engage in storytelling.

2.2 Importance of Narrative

Conversational narratives (oral stories told during interactive conversations) are crucial to social engagement. Narratives provide a means for people to relate and share experiences, develop organizational skills, work through problems, develop self image, express personality, give form and meaning to life, and allow people to be interesting entertainers (Waller 2006).

Narrative skills develop experientially with children being able to engage in storytelling even before they are verbal (Bruner 1975). Early personal experience stories consist of a high point, for example, “*Mummy fall!*” with adults scaffolding the full story, eliciting the ‘who’, ‘what’, ‘when’ and ‘where’. However, not all experiences make good stories. An experience becomes a story if the storyteller has an emotional connection to the event (Labov, 1972), or if the event is unusual (Quasthoff & Nikolaus, 1982).

Parents of typically developing children encourage development of narrative skills by eliciting stories from their children (Peterson and McCabe 1983), but the development of narrative skills is problematic for people with CCN. We recall a study where disabled children were told different stories more often than typically developing peers who were read the same story night after night (Light, Binger et al. 1994). In doing so, the disabled children did not have the chance to learn the sequence of stories, or the structure commonly used in narrative such as beginning, middle and end. As such, initially children should use the same story template

consistently until they are ready to progress to another one.

It is difficult to provide access to event information which may become a story, and few AAC systems provide support for interactive story narration. However NLG gives us a possibility to change the underlying paradigm of AAC. Instead of placing the entire cognitive load on the user, AAC devices can be designed to support the retrieval of story events and the scaffolding of story narration for individuals with CCN.

2.3 NLG, Data-to-text

NLG systems generate texts in English (or other human languages) from non-linguistic data (Reiter and Dale 2000). Our vision is to use an NLG system to generate a draft story, which the child can edit. The non-linguistic input to our story-generator is sensor data about the child’s activities, including location data (where the child was) and interaction data (what people and objects the child interacted with). We also want to allow teachers and school staff to enter information about the child’s activities (such as voice messages).

A number of data-to-text systems (Reiter 2007) have been developed in recent years, which generate English summaries of sensor and other numerical data. The most popular application area has been weather forecasting (generating textual weather forecasts from the results of a numerical atmosphere simulation model), and indeed several weather forecast generators have been fielded and used operationally (Goldberg, Driedger et al. 1994; Reiter, Sripada et al. 2005). A number of data-to-text systems have also been developed in the medical community, such as BabyTalk (Gatt, Portet et al. 2009), which generates summaries of clinical data from a neonatal intensive care unit, and the commercial Narrative Engine (Harris 2008) which summarizes data acquired during a doctor/patient encounter.

Most previous research in data-to-text has focused on summarizing technical data for expert users, with the goal of effectively communicating key information. In our work, in contrast, the focus is on summarizing data about everyday events, with the goal of having something interesting to talk about. There has been considerable work in the computational creativity community on generating interesting stories (Pérez and Sharples 2004), but it has focused on fictional written stories, where the computer system can say whatever it wishes, without the constraint of describing real events.

Most previous work in NLG has focused on computer systems which generate texts without human input. However, in our case we want children to be able to annotate (evaluate) and edit stories, as far as their abilities permit. There has been some research on human post-editing of NLG texts (Sripada, Reiter et al. 2005), but this has focused on editing at the text level.

Since editing at the text level is very laborious for AAC users, we need a higher-level interface that lets children edit content and structure without needing to type words. We also want children to be able to control how a story is narrated, perhaps in response to a listener’s questions or body language. For example children may wish to add comments such as “*It was awesome!*”, or tell events out of sequence.

In short, we need to develop interfaces and interaction techniques that allow our users to control the NLG system. Unfortunately there has been very little previous work on this topic, indeed almost nothing is known about Human-Computer Interaction aspects of NLG systems. Developing a better understanding of these aspects is one of the main research challenges we face from an NLG perspective.

3 Current and ongoing work

3.1 “How was School today...?”

We developed an initial version of “*How was School today...?*” in 2009; see Reiter et al (2009) for more details about this system.

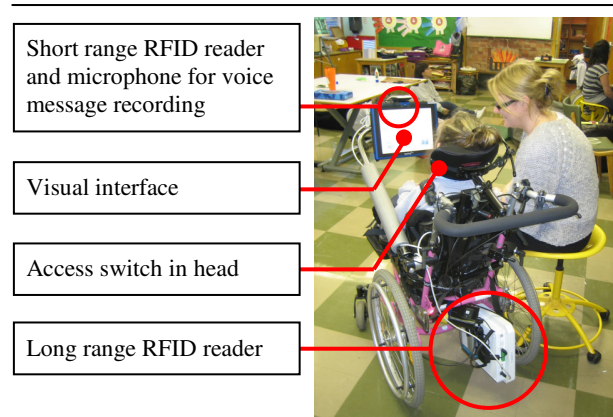


Fig. 1: Participating pupil with support worker: The prototype system is mounted on the wheelchair, and the pupil has access to the system via head switch controlled row/column scanning.

This system used Radio Frequency Identification (RFID), an emerging application in AAC to identify or give access to relevant vocabulary (Bart, Riny et al. 2008; DeRuyter and Fried-Oken 2010). Sensors were used to track both location (by putting tags on doors, which were automatically sensed by a long-range RFID reader) and interaction (by asking staff to manually swipe RFID cards in a short-range reader when the child interacted with a person or object). Staff could also record spoken messages about interesting events during the day (see Fig. 1).

The software analyzed this data to remove sensor noise, and then compared it to a timetable which specified where children were supposed to be, what they were supposed to be doing and which teacher was supposed to be taking the class throughout the day. This allowed the software to both fill in missing information, and to identify divergences from the schedule. The result of this process was a series of events (which corresponded to classes, for example, maths class), each of which had a set of associated messages (interactions during the event, divergence from schedule, etc.).

After the data analysis was completed, an NLG system identified the events most interesting (to the child), using a heuristic that took into consideration both how inherently interesting an event was (for example, lunch was regarded as an inherently interesting event that children were likely to want to talk about) and also whether an event was unusual or not. The latter is based on the observation that most personal narratives focus on unexpected or unusual events. Unusual events were identified by the presence of recorded voice messages and by divergence from the timetable, e.g. a different teacher present or a different location. The system selected the five most ‘interesting’ events and displayed them to the child in a simple visual editing interface. In this interface the child could delete events he/she did not wish to talk about, and also annotate events with simple opinions (evaluations), such as *I liked it*, using the evaluation buttons on the interface, generating appropriate utterances according to the last narrated event or message.(see Fig. 2).

When editing was finished, the NLG system generated texts describing the events and messages, which the child communicated using a simple narration interface (which was similar to the editing interface). Emphasis was placed on providing quick access to messages to minimize the length of pauses between utterances due to the physical accessing difficulties of the users. The narrative model is based on the Labov social narrative model (Labov 1972) which emphasizes the highpoint and evaluation. The dialogue model from beginning through to highpoint to the end with the user being able to add evaluations at any point of the narration. Stories are initially chronological order but interactively under the control of the user. This control of narration differs significantly from current AAC interventions where narrative tends to be output in a monologue format.

From an NLG perspective, the system was fairly straightforward. The most challenging microplanning tasks were choosing connectives, time phrases, lexical variety in embellishments, and pronouns based on discourse context. Connectives and time phrases were necessary since children could narrate events in different orders (for example, “*I went to maths. Then I went to lunch*” versus “*I went to lunch. Before lunch, I went to maths*”). Document structuring was simple because we

assumed that the children would choose their own order in which to narrate events. In fact some children are not able to do this; such children would need to be supported by a more sophisticated document planner that had a model of appropriate text structures in this domain.

We asked two children to use the system for one week for a qualitative formative evaluation. Researchers supplied ongoing support during this, primarily trial observing how the children used the system, and discussing it with teachers, therapists and parents. Generally it worked well for one child, Julie², who had severe motor impairment (no independent means of mobility and interacted with a computer using a head switch with row/column scanning, see Fig. 1). Her expressive abilities were limited but her comprehension skills were comparable to her non-disabled peers with some developmental delay. The other child, Jessica, had more cognitive impairment, and found the interface too difficult.

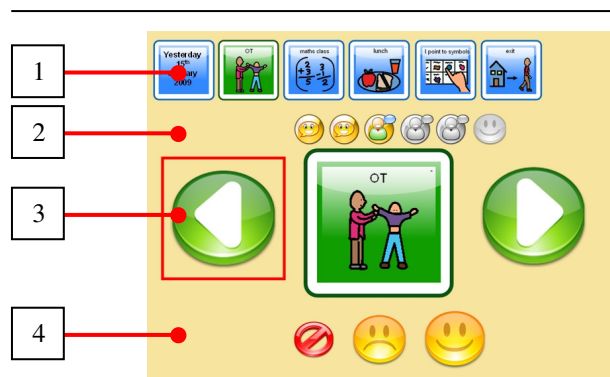


Fig. 2: Example screenshot from interface
 1: Navigation: Day and date of story, maximum of five story events, exit; 2: Event messages, numbers vary for each event. Here: 2 computer-generated messages, 3 recorded messages, 1 user added evaluation; 3: Sequential message navigation: previous, repeat, next; 4: Evaluation: delete event, negative evaluation, positive evaluation;

In a second evaluation, a third child, Eric, joined and all three children used the system over two weeks each. In this evaluation, we asked teachers and other staff to use the system without on-site support from the researchers. This highlighted many practical usability issues, such as delays caused by starting the system in the morning, and problems caused by limited battery life. We eliminated the long-range RFID sensor because of its difficult setup; instead we asked staff to swipe

² The names of the children mentioned in this paper are changed to ensure anonymity.

door cards when children entered rooms. However, this strategy was not successful, as it was difficult for staff to remember to swipe both interactions and location changes.

The participants took the system home for use with their parents who gave positive feedback but also reported issues with system usability (e.g. lack of access to stories from previous days) or suitability (too complicated interface for Jessica).

Eric’s timetable was different from Julie and Jessica’s, because he visited college one morning a day, and we could not collect data during this period. Since some of the most exciting events in a school day happen outside the school building (sports and school trips as well as college), in the long term we do need to see if we can collect data outside as well as inside the school.

3.2 HWST example

Julie used the system on her DynaVox™ Vmax™ Voice Output Communication Aid (VOCA) via head switch using row/column scanning. The above transcript shows an extract of a conversation Julie had with her Speech and Language Therapist (SLT) on day three about her experiences during day two. The researcher (RA) had been present all day for technical support. The conversation extract starts with Julie reporting about her morning break.

In this example Julie is able to quickly reply to context related questions from her communication partner using the evaluations (“So what happened?” – “It was fun!”). Compared to conversations usually observed between aided and unaided partners Julie is able to control the conversation when starting a new topic after talking about the morning break, inviting her communication partner to prompt for more detailed information. Julie provides this with her next generated phrase. When she is asked about the event she replies with an evaluation the system has generated in relation to its previously generated message “A visitor was there.”. We note that the system is able to refer to the correct gender of the visitor.

- | | | |
|----|--------|--|
| 1 | Julie | {next} [I had break.] |
| 2 | Julie | {next} [Lesley was there.] |
| 3 | SLT | Lesley was there? |
| 4 | Julie | ((Opens mouth in agreement, then turns back to screen)) |
| 5 | SLT | Ok mhmh. So what happened? |
| 6 | Julie | {positive evaluation} [It was fun.] |
| 7 | SLT | Oh good! ((laughs)) I’m glad to hear it! |
| 8 | RA | We like Lesley. |
| 9 | SLT | ((nods in direction of RA)) |
| 10 | Julie | ((smiles)) |
| 11 | Julie: | {next} [Then I went to Junior Primary instead of Reading Class.] |

- 12 SLT: Right, you went to Junior Primary? I wonder why that was?
- 13 Julie: {next} [A visitor was there.]
- 14 SLT: Oh, a visitor, right. Wonder what the visitor was doing?
- 15 Julie: {next} ["The dental hygienist came to give a talk."]
- 16 SLT: Oh, dental hygienist.
- 17 Julie: {previous} [A visitor was there.]
- 18 SLT: That was the visitor, okay. That's why you went to junior primary, uhm, what did you think of the talk?
- 19 Julie: {positive evaluation} [She was nice.]
- 20 SLT: She was nice, that was good! ((laughs))

Notation:

- Switch selected button by Julie: {curly brackets}
 - Natural speech: standard text.
 - Computer generated language accessed using one button: [standard text in square brackets].
 - Recorded messages accessed using one button: ["quoted standard text in square brackets"].
 - Paralinguistic behaviors: ((standard text in double brackets)).
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3.3 "How was School Today" – in the Wild

We have now started a new project to further develop our work, called "*How was School today...?*" – *in the Wild* (*'in the wild'* indicates that the focus is on how the technology works in a real school environment). The basic goal is to improve the system sufficiently so that it can be tried out over a period of several months, with children with varying levels and types of impairments; we will also work with several schools in the initial phase, although for practical reasons the evaluations may be at just one school.

During this project we will do some work on the issues described in Section 4; in particular we will try to make the system usable by children with different impairments and ability levels (Section 4.1). This means having a very simple interface for children with considerable cognitive impairments (such as Jessica); but also giving children with more cognitive abilities the opportunity to exert more control over the story (during both editing and narration), for example by supporting a richer range of annotations, and by making it easier to describe events and messages in any order.

Another intermediate goal is to improve the integration of voice messages entered by staff with the computer-generated messages. This could be done by some combination of training staff to enter messages in a specific way (referring to the child in the first person); asking staff to annotate the messages so the computer knows something about their content; and/or using

speech recognition to analyze the voice messages. In general there is a lot of interesting information that can only come from staff, and we need to think about the best way to help staff enter information in a way that is easy for them and useful for our system.

Now that a complete system is built, we are also able to thoroughly and formally evaluate the system. Multiple baseline single case study methodology will be used (Schlosser 2003) to evaluate the use and impact of our system. We intend to have up to four children (with varying ability levels) use the system for a period of 3 months. This will give us a chance to observe the impact of the system on the users and their environment such as the children's interaction with the system and how staff at the school envisage using this new tool. The observations will be supported by semi-structured interviews with the children, their classroom teacher, their speech and language therapist and a parent.

We will look at the children's conversations (with and without using our system) about interesting, staged events with different partners, analyzing them conversational characteristics such as narrative initiation, structure, length and evaluation. Analysis methods will include the Revised Edinburgh Functional Communication Profile (REFCP) (Wirz, Skinner et al. 1990).

However, much of our focus will be on addressing the practical issues that make it difficult to use our current research prototype over a period of months. We have identified many such issues, both from our previous evaluations (Section 3.1) and also from a questionnaire that was distributed to school staff during an in-service day.

Location tracking – There are problems with both of the techniques we have tried to date (automatically reading RFID tags on doors, and asking staff to swipe location information). In this project we intend to try tracking the location of a child using Wi-Fi location tracking, which seems to be rapidly gaining popularity in the commercial world (Liu, Sen et al. 2008).

Data entry, 2D bar codes – We need to allow staff to easily enter and update information about the children (for example, their timetables) and sensor tags (e.g., if a new tag is given to a visitor). For the latter, we want to investigate 2D bar codes, which could allow encoding of alphanumeric input data without reference to a central database.

Portability, battery life – The current system runs on a tablet PC (8"-12" touch screen, generic or VOCA hardware). During the evaluation, late powering up, run-down batteries or simply forgetting a component caused significant data loss and usability issues. A future prototype should favor an 'always-on' system, such as a mobile phone, allowing for easy portability and extended battery life.

Story generation – The prototype system was only able to create a story towards the end of a day and gave

only access to stories generated on that day. However, often the user desired to tell stories that had occurred on previous days, or to, say, tell a story at lunch that occurred in the morning. When data was insufficient for the system to create a story, the only output was an error message “*Can’t generate story right now.*” This frustrated users, so future systems should be able to deliver a story with incomplete data.

Voice messages – as mentioned above, we want to handle these in a more sophisticated way. From a more practical perspective, we also want to make it easier for staff to listen to and change previously recorded messages. We also want to allow parents to record messages about events at home.

4 Long-term vision and issues

4.1 Supporting children with different levels and types of impairment

A key issue in AAC is of course the diversity of AAC users. Children with CCN differ enormously in terms of cognitive ability, motor ability, and social ability. This was clear even in our initial evaluation where we worked just with two children, and discovered that our interface worked well for Julie but not Jessica.

Julie has little functional speech and severe physical impairments, and accesses her VOCA using a head switch through the slow process of scanning the interface. Her VOCA interface consists of a grid of 15 to 30 buttons per page, with more than 20 pages of vocabulary. However, her cognitive skills were sufficient for her to master the interface on the second day. She used the system quite successfully, as shown in the example in Section 3.2.

Jessica also has severe physical impairments but does not use technology to support her communication (she has functional speech). She has cognitive impairments, which (amongst other things) affect her ability to remember and place events correctly in time. She had more difficulty mastering the interface than Julie. We simplified the interface for her (no editing, minimal control of narration), and then she displayed pragmatics known from typical language development in children, by telling her story with no room for interaction of her communication partner.

We also need to keep in mind that abilities are not static, but are likely to progress with age (see also Section 4.2) and (hopefully) with the assistance of communication aids. For example, the WriteTalk project showed how pupils were both able to initiate and control communication more effectively with Talk:About™ and how their formal writing skills improved over time (Waller et al., 1999).

In summary, some children may need a very simple interface because of cognitive impairments, but this should grow with them. For example, the best narration tool for Jessica at her current stage of development is probably a single button that advances sequentially through the computer-generated story. The challenge is to provide an interface that Jessica can initially use via repeatedly pressing an ‘Advance’ button, but which gives her the possibility of exerting more control as her skills and abilities develop.

Other children (such as Julie) may have motor difficulties that restrict the way in which they can interact with computer systems, and thus may require simple controls although they have reasonable cognitive skills. Restricted motor skills make certain tasks, such as entering an arbitrary word, quite difficult and time consuming; hence the interface must avoid such tasks, and instead endeavor to give the child as much control as possible with a minimum amount of data entry. Once these users master a basic story telling structure, it may help them develop their conversation skills if they use a wide variety of conversation patterns. For this purpose, it may be worthwhile for the system to randomly vary the structure and language used in the narratives.

Still other children, for example on the autistic spectrum, may have good cognitive and motor abilities, but not have the experience of expressive communication necessary to develop interactive skills. These children are more likely to benefit from a system that supports the pragmatics of language in general and personal narrative in particular. For example, children on the high functioning end of autism may be comfortable with rather advanced software, which can help them adapt their storytelling according to the intended listener. Indeed, giving these children more complex controls, if done correctly, can make the software fun and challenging in a positive way.

In the long term, as we broaden the range of children we work with, there may be overlaps between our work and research on tools to help typically developing children create stories, such as Robertson and Good (2005), and also between our work and research on tools to help adults with CCN tell personal narratives, such as Dempster (2008). Ideally it would be very nice to combine these efforts and create a story telling tool that could be used across the age and impairment spectrum.

4.2 Narrative across the lifespan

We would like our tool to be able to support children over time, as their abilities grow and as their experiences accumulate. From the perspective of changing abilities, the challenge is to offer children an interface which is not only appropriate for their current stage of development (Sect 4.1), but also allows and indeed en-

courages them to exert more control over story content, language, and narration as their abilities grow.

We would also like our tool to become a repository of a child's personal stories. The ability to relate relevant stories can influence the quality of life, as well as social development and successful transitions. The life stories of people who use AAC are often held by parents and siblings (e.g., stories relating to health care (Hemsley, Balandin et al. 2007)), and there is the inevitable concern that these stories and others are lost as parents age and siblings move away.

Technology has the potential both to support the acquisition of conversational skills for people who use AAC and to provide a repository for life stories. In the context of our work, it is essential that we provide ways of enabling children to develop their narrative skills so that they are more able to manage their own story repository. In terms of development, young children will narrate recent stories regardless of conversational context. By enabling the child to develop story structure by scaffolding interaction and enabling children to easily annotate stories, the child will begin to anticipate and control conversation.

Conversational narratives have traditionally not been supported by AAC tools partly due to the fact that they are so nebulous; they emerge during interactive conversation (to date, events have to be manually input into a system and it is difficult to predict what events will become a story); 'new' stories are repeated often (to date it is difficult to save conversation online); as stories age they are repeated in context (retrieval is often contextual e.g. topic based) and they grow longer having more embellishments added to them. The technology we are developing provides an opportunity for children to access information about personal events over time, which they can communicate and narrate during a conversation. They can also evaluate (annotate) their stories, thereby embellishing and lengthening the stories. However this will only be possible if the children can easily access previously experienced, generated and saved stories.

We can provide fast access to recent stories while anticipating the use of older stories such as for example those which closely match the current conversation topic. In a research prototype called PROSE (Waller and Newell 1997), stories had to be physically tagged; there is now the potential to automate topic matching by recognizing topic words spoken by a listener and parsing stored information for appropriate stories. Over a lifetime, some stories may fall into disuse, while others will be weighted more strongly depending on frequency of use and relevance.

4.3 True dialogue in narration

The ultimate goal of our research is to enable children to tell stories in the context of a social dialogue; for exam-

ple, we want children to be able to chat to their parents and other interested parties about what they did during the day.

Our current system incorporates a simple model of a conversation, where children are restricted at any point to choosing from a small number of options. The child chooses an event to talk about, and then goes through the sequence of messages associated with that event. The child has the freedom to switch to a different event, hence controlling the conversation, and to add annotations/evaluations (for example "*it was fun!*").

This is adequate in many cases, but in the long term we would like to support more complex conversations; for example interrupting a discussion about today's events to talk about what happened yesterday, or to discuss a particular teacher instead of an event. We would also like children to easily be able to add conversational phrases, such as "*Guess what happened today at school*".

Because our children have motor and cognitive impairments, we cannot present them with a large number of options for conversational moves. Ideally, the system would detect what the conversational partner wishes to talk about, and from this present the child with a small number of appropriate choices. For example, if the conversational partner asks the child what happened over the past week, our system would detect this and then give the child the option of talking about any individual weekday or the week in general.

One way of detecting what the conversational partner intends is to use speech recognition and Natural Language Processing (NLP) technology to analyze what he or she says. Speech and NLP technology tend to work best when it is possible to train the system to the user's voice, and also (in essence) train the user to understand what the speech/NLP system can and cannot do. This should be possible in our context, at least for people (such as parents) with whom the child regularly interacts.

Another possibility is to create a graphical user interface for the conversational partner, perhaps on the same device that the child uses, which the partner could use to indicate what he/she wants to talk about. This is probably technically easier, but does move away from the goal of having as natural a dialogue as possible.

4.4 Pragmatics of interacting with others

Currently, "*How was School today...?*" supports storytelling between language-impaired children and adults who are the children's parents, carers, teachers, and therapists. But of course for normally developing children, many of their most important social interactions are with other children.

An interesting example here is the STANDUP system, which was developed to help children who use

AAC create and tell novel punning riddles. The study results suggested that children saved the jokes so that they could retell them to friends and family (Waller, Black et al. 2009). Whilst the evidence is anecdotal, there did also appear to be a marked increase in joke telling by participants, both amongst their peers and with adults in the home environment. Hence STANDUP succeeded in supporting interaction with other children as well as with adults.

One of the key challenges in interacting with other children, and indeed with adults who are not formally involved in the care or teaching of the child, is to adapt the story to the interests of the recipients. In other words, a child's parents and teachers will not insist on stories that are interesting to them, but other conversational partners will. These conversational partners will also need additional information. For example "*Jane came to take me to the OT room*" makes more sense if the recipient knows that Jane is the occupational therapist; parents and teachers already know this, but other people may need to be told this. Also if the conversational partner was present at an event, this should be acknowledged and indeed used in the story. For example, "*Did you really enjoy maths? I thought it was boring!*"

In short, telling stories to peers and adults who do not know the child well requires adapting the story to the interests, knowledge, and involvement of the partner; this is part of learning pragmatics. This is not something we are looking at currently, but it is something that we hope to look at in the future.

4.5 Security and privacy issues

We need to ensure that data about the children is private and secure. Taken to its logical conclusion, our project would result in an intimate record of the child's life at school, home and beyond. It is important that both the raw data and the generated content are under the control of the child and his/her guardians, with the child exercising as much control as possible. This is especially important since children with learning difficulties are very vulnerable; there is potential for great harm if data about a child's activities got into the hands of a malicious outsider.

In a study on the software tool TalksBac, which supports personal narrative (Waller, Dennis et al. 1997), privacy issues were coded along with stories. This allowed the NLG process to decide the appropriateness of telling a story to a specific communication partner. Children in general do not care who they tell their stories to. Only when older children learn to distinguish which story is appropriate for a conversation partner. This process could be embedded into the prediction algorithm that presents stories for narration. Currently

prediction on AAC devices only support character, word or phrase selection.

Another concern is information that is embarrassing or otherwise puts the child in a negative light; for example, imagine a staff member entered the voice message "*I refused to eat my lunch today*". We believe that the child should be free to delete such messages; she should never be forced to include material in a story that she does not want to include.

A related issue is whether we should allow stories generated for one child to use information acquired about another child. In principle this is very valuable, for example it allows messages such as "*Jane didn't eat her lunch today*". But is this acceptable from the perspective of ensuring the privacy of data about Jane's activities? On the other hand, this is exactly the sort of thing that a normally developed child would say about a classmate.

5 Conclusion

In addition to having difficulty in communicating desires and needs, language-impaired children also find it hard to participate in social linguistic interaction that would help create and build up friendships and other interpersonal relationships. We believe that we can help these children participate in such interactions by giving them a tool that helps them tell a story about their day at school, by using an NLG system that has access to sensor and other data about the child's activities. We are still at an early stage in this work, but our initial prototype system has shown great potential to improve the quality of life of children with limited speech. Our current work plans to explore this potential further while evaluating the efficacy of the system for four children with varying ability levels.

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