Potentials and challenges in interactive and musical collaborations involving children with disparate disabilities

A comparison study of how Petronella, with Down syndrome, and Dylan, with autism, interact with the musical and interactive tangible 'WAVE'

Karette Stensæth

Vignette 1:
When Petronella and her 'close other'¹ enter the semi lit room, the only thing they see is the big octopus-like pillow known as the WAVE carpet, which is interactive and musical and has a built-in camera and microphone as well as capacities for vibration and audio. Petronella lies down on the WAVE carpet while her close other sits beside it, next to her. Soon, Petronella finds the particular arm of the WAVE carpet that houses the microphone. She picks it up and says 'Say Europe' into it. When her close other bends the sensor of another arm of the WAVE, they both hear the carpet say 'Europe!' in a voice that is similar to Petronella's but somewhat distorted and differ-ent as well. Petronella finds this amusing and says other words into the microphone, all of which the WAVE carpet repeats back to her. However, when Petronella eventu-ally says 'Say Taco!' into the microphone, the WAVE says 'Europe!' instead. Petronella is surprised, then laughs. Her close other laughs too.

Vignette 2:
Another time, in the same room with the same WAVE carpet, Dylan arrives with his close other. They both sit down next to the WAVE carpet. The close other shows Dylan the camera that is built into one of the WAVE carpet's arms. She knows that he loves cameras and hopes that this will encourage him to play and collaborate. With guidance from his close other, Dylan picks up the arm where the camera is placed and projects his own face on the nearby white wall. He keeps the camera still and sits like

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1   This term generally refers to family members or others who the child with disabilities views as close or even family-like. Aides who assist the children to the RHYME action know the children well and are also close others. The role of the close other in the RHYME project is discussed thoroughly in Eide (2014) or elsewhere in this anthology.

this for a long time. Because the camera is not being moved, its function pauses and screensaver graphics appear on the wall. The graphics create colourful patterns that move slowly across the wall. Dylan stares at the patterns and seems to withdraw or lose contact with himself, his close other, and the whole room.

Introduction

The vignettes above, small narratives derived from the video analysis presented later on in this article, illustrate the potential differences in reactions of two children with disabilities as they are introduced to the musical and interactive tangible known as the 'WAVE', which was developed for the on-going qualitative interdisciplinary research project known as 'RHYME' (www.rhyme.no). RHYME addresses the lack of health-promoting and musical interactive communication technology (ICT) for families with severely disabled children, and the present article presents a comparison study of two of the participating children. The children are the rather active girl named Petronella, with Down syndrome, and the more passive boy named Dylan, with autism. Through an examination of the manner in which these two children approached the WAVE, this article will present some of the possibilities and challenges associated with the development of such health-promoting media for children with disabilities.

The study's data collection includes a video analysis of the children in co-creation mode with the WAVE and their close other. The video analysis is triangulated with a focus interview conducted with a group of professional experts to elicit their observations of the video footage of the children.[2]

The research question to which this article is devoted reads as follows: *Why do the two children relate so differently to the same musical and interactive tangible, the WAVE carpet, and what would facilitate the most meaningful and health-promoting co-creation experience for each of them?*

The article will start out with a short introduction to the RHYME project and the WAVE. I will then define *co-creation*, one of the core concepts in RHYME as well

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2 These experts included three occupational therapists (specialising in activity and sensory integration and the building of sensory rooms), one special education teacher (specialising in children with autism), and two music therapists (specialising in musical improvisation in therapy). All of the experts were experienced with children with disabilities, and all of them had worked or were working at the school where the data was collected or a school like it. This means that some of them knew Dylan and Petronella well.

as this study, and introduce the two subject children. Before I present the video analysis, I will discuss methods of video analysis more generally. I will also begin to incorporate comments from the interview with the experts.

The RHYME project:[3]

RHYME is a five-year interdisciplinary research project (2010–2015) financed by the Research Council of Norway through the VERDIKT program. Its aim is to develop Internet-based, tangible interactions and multimedia resources that have a potential for promoting health and life quality. The project specifically addresses the lack of health-promoting interactive and musical information and communications technology (ICT) for families with children with severe disabilities. RHYME explores a new treatment paradigm based on collaborative, tangible, interactive Internet-based musical 'smart things' with multimedia capabilities. Within the project, these interactive and musical tangibles are called 'co-creative tangibles' (CCTs). The goal of RHYME is twofold: (1) to reduce isolation and passivity, and (2) to promote health and well-being. The RHYME research team represents a collaboration among the fields of interaction design, tangible interaction, industrial design, universal design and music and health that involves the Department of Design at the Oslo School of Architecture and Design, the Department of Informatics at the University of Oslo and the Centre for Music and Health at the Norwegian Academy of Music. The project encompasses four empirical studies and three successive and iterative generations of CCTs. The media is developed in collaboration with the Haug School and Resource Centre, the children and the families. Its user-oriented research incorporates the users' influence on the development of the prototypes in the project. The users include from six to ten families who have volunteered to participate, and the children with disabilities in these families range from seven to fifteen years old. The children vary considerably in terms of behavioural style, from very quiet and anxious to cheerful and rather active, but all of them become engaged in enjoyable activities when these activities are well facilitated for them. The most extreme outcomes of the variation in behavioural style relate to disability conditions, and mostly those within the autistic spectrum, which applies to four of the children. These conditions include poor (or absent) verbal language and rigidity of movement. Also, the children's mental ages range from six months to seven years, and their physical handicaps range from being wheelchair dependent to being very mobile. The Norwegian Social Science Data Services approved the RHYME project in February 2011, provided it would gather, secure and store data according to the standards of ethics in Norwegian law.

WAVE

The WAVE concept consists of two *different forms* of tangibles, the WAVE carpet and the WAVE orange. The WAVE carpet, which is the CCT used for the present analysis, is a seven-armed carpet, which is wired for a range of cross-media

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3   The section inside the frame below is similar in all of the RHYME articles in this anthology, Music, Health, Technology and Design, by Stensæth (Ed.).

possibilities. The WAVE orange is a wireless iPhone/iPod-based toy/beanbag chair with two arms. This study deals entirely with the WAVE carpet (from now on generally referred to as the WAVE).

Picture 1:[4] *Resting on the WAVE carpet*

The WAVE concept consists of (and in turn reflects) many connections. A wave is frequently used as a representation for music, but it is also a way to interact with accelerometer sensors, which the creators wanted to use. Waves are aesthetically inspiring, particularly in relation to nature – the movement of water in the ocean or of wind across a field of barley, for example. The specific design of the WAVE therefore resonates with wave-related shapes, structures, surfaces, sounds and interactive forms.

The WAVE experiments took place in March 2012 at Haug School and Resource Centre, outside Oslo. During the first empirical studies devoted to a prototype of the CCTs called ORFI at the same place in March 2011, many goals and requirements were proposed and formulated for the first generation of CCTs in the RHYME project – that is, WAVE. As music and health professionals, the project group was particularly interested in the fact that CCTs users wanted *the sound source to be closer to the place of interaction,* along the lines of how an acoustic instrument

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4   All photographs courtesy Birgitta Cappelen.

works. For interactive CCTs, then, this meant placing the input sensors close to the output speakers. Through a more proximate sound source, the children with disabilities would generate a more direct response to their actions. The research group concluded that this would not only help them to understand the CCTs' responses to their actions but also stimulate those actions (and reactions) more directly.[5]

For similar reasons, in terms of lighting, the project group learned that CCTs' users wanted *proximity between input sensors and light.* The group also sought a sensor that would be easier to interact with than the bending sensors they had in ORFI, which were tested the year before WAVE.[6] The bending sensors worked in a sense that the user had to bend a part of the CCTs to get a response, which was (too) difficult for some of the weak children. In the end, then, WAVE incorporated significant cross-media collaborative interaction, combining musical interaction with visual interaction using a camera and projection.

Because the WAVE carpet is connected to an external computer and the power grid, it features many input and output possibilities and offers new cross-media interactions that transcend those of the ORFI.[7] The creators described one of the new qualities of the programs incorporated into WAVE as 'Music Interaction – Voices' because of the play with voices that is involved, whether synthetic and computer-generated or simply human. For example, users can record their own voices (recall vignette 1). Being a participator in the RHYME research team I suggested this particular functionality because, for one thing, the microphone is typically very attractive to children. How many times do we find children singing into a hairbrush in the bathroom mirror, imitating a pop star holding a microphone? In addition, I realised from my experience as a music therapist, if the CCTs were able to strengthen these children's (tentative) voices, the use of a microphone could also fulfil another health-related potential of the CCTs.[8]

In order to stimulate the users in a bodily and sensory fashion, which we know is vital from successes with music therapy on people with severe disabilities, the

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5   The creators of the CCTs remark upon the complex design challenge that is involved here, especially regarding wireless objects, in terms of object size and weight, sensor qualities, sound quality and wireless sound transmission. Due to these various complications, they believe it would be wise to base future prototypes on Smartphone technologies, because they have perfected a very compact package of wireless technology, sensors, battery and sound transmission.
6   The creators faced design challenges here as well, regarding the transparent (illuminating) material, its tactility and the desirable qualities of the sensors. They wondered: How could they design sensors that motivated the user to interact comfortably in a variety of ways over an extended period of time?
7   See the article on ORFI by Stensæth & Ruud (2014) or elsewhere in this anthology.
8   See the article about vocal interaction in RHYME by Andersson & Cappelen (2104) or elsewhere in this anthology.

research group also wanted to *include vibration responses* in the CCTs. A vibration element is therefore built into the WAVE in the centre of the WAVE carpet.

In all, then, the WAVE carpet includes the following input and output devices:

- Six infrared sensors with light response in a bubble-shaped field (see picture 5)
- Microphone with light response in one arm (see picture 4)
- Camera with light response in another arm (see picture 2)
- Pico projector in another arm (see picture 3)
- Two bend sensors with light in two separate arms
- Two accelerometer sensors with light in two separate arms
- Sound vibration element (Visaton)
- Two speakers
- LEDs included in the orange, velvet textile

As we have seen in the vignettes, the two children discussed in the present study were attracted to the camera element and the microphone element in WAVE. Petronella also played with the WAVE bubbles. These elements are depicted in the photographs below:[9]
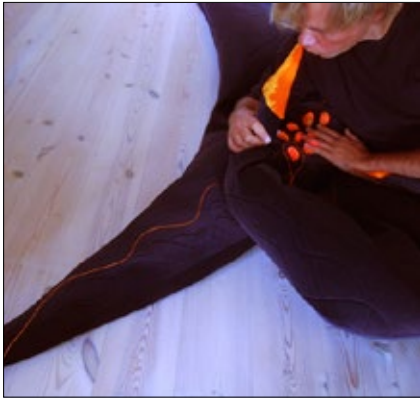

Picture 2*: WAVE Arm with camera*

Picture 3*: WAVE Camera projecting on a wall*

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9   Video illustrations of the WAVE carpet can be seen at http://rhyme.no/?page_id=1034.

Picture 4: *Singing into the WAVE microphone*

Picture 5: *Playing with the WAVE 'Bubbles'*

Additionally, the WAVE carpet includes the following technology:

- Arduino Mega and a custom shield
- Arduino software for controlling the input and output
- Two amplifiers
- Mini-Mac
- SuperCollider as sound software
- Processing as video and graphical software[10]

Defining co-creation[11]

In the RHYME project, *co-creation* is a key word – in fact; it describes the very path to achieving the project's aforementioned goals of defeating isolation and promoting health and well-being. In the present article, I will rely upon my earlier elaboration of the notion:

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10 For more about this technology, see www.rhyme.no
11 See also Eide (2014) or elsewhere in this volume.

> First, co-creation implies health musicking, which incorporates the family's desire *to do* (action) *something* (activities) *meaningful* (intentional) together (*intersubjective and interpersonal*). This is an ecological aim in that it implies the process of continuously promoting health while also preventing poor health. It also implies a strengthening of agency and mastery, as well as the creation of embodied, sensory and empowering interactions with both the tangibles and other people (Stensæth, 2013, no paging).

The specific notion of *health musicking*, to which I will also refer below, is borrowed from Stige (2012), who in turn draws upon Small (1998) to link the workings and ramifications of music to actual musical and social activity – that is, to 'doing'. Andersson (2012), one of the creators of the CCTs, concludes that the main musical 'doings' consist of playing, listening, exploring, composing and collaborating. In the present study, of course, such doings engage the users with the CCTs, because, in order to fulfil its *health* potential, musicking must also become a 'provider of vitality' (Bonde, 2011; Ruud, 2010) or, further, a 'tool for developing agency and empowerment; a resource or social capital in building social networks; a way of providing meaning and coherence in life' (Ruud, 2010, p. 111). This mode of thinking anticipates a salutogenetic understanding of health that privileges the factors that support health and well-being over those that cause disease. Antonovsky's (1987) notions of health as a personal experience (and an ongoing process) rather than a biomedical state inspire this understanding. An underlying question for the present study, then, is whether its data reveals such an occurrence of health musicking?

Through the process of co-creation, the three concerned 'parties' – the child with disabilities (CwD), the close other (CO) and the CCTs – can realise complex collaboration combinations. Figure 1, which is collected from my earlier work (Stensæth, 2013), shows what collaboration combinations can come into play. It is presented here in order to map some of the ways in which Dylan and Petronella might co-create with their close others and WAVE.
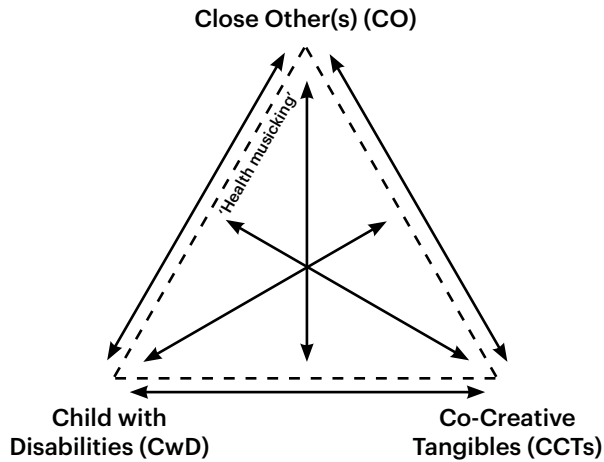
Figure 1: *Collaboration combinations in co-creation*

The figure is explained as follows:

The triangle has three corners. The three actors, CO, CwD and CCTs, are each placed at a corner. The arrows outside the triangle show possible collaborations between the actors in each corner; they can also be understood as *relations* and consequently as units that can in turn collaborate with another actor in another corner. The arrows inside the triangle show what these potential collaboration combinations are:

a) The relation between the CwD and the CCTs collaborates with the CO.
b) The relation between the CwD and the CO collaborates with the CCTs.
c) The relation between the CO with the CCTs collaborates with the CwD.

I further noted that these various collaboration combinations are both *flexible* and *situated*. This means, among other things, that the same people can create various collaboration combinations in different situations, and that the intensity and level of co-creation will vary. For example, when a child has a tough day (physically or/ and mentally), she can be more dependent upon her close others. She will then perhaps not play so much with the CCTs. It is also true that sometimes it is simply more fun to explore the human relation than the relation with the CCTs. Sometimes

it is the other way around; the child finds it more fun to explore the CCTs. In such cases, one collaboration combination will supersede the others. Often, however, especially after some collaboration time, several collaboration combinations will be in play:

> Over time, it is likely that experienced and embodied collaboration combinations pave the way for other collaboration combinations. The child with disabilities, having co-created intensively with her brother, might then expect more intense co-creation with other close others as well (Stensæth, 2013, no paging).

Collecting the data for the WAVE actions

When the WAVE experiments started in March 2012, the children arrived at the music room at the school together with an adult from their class whom they knew well and trusted, and they stayed for half an hour each time over the course of four executive Fridays.[12] In preparation for the test, the room's piano, chairs and musical instruments had been removed, and the WAVE carpet was placed in the middle of the empty floor.

Throughout the WAVE actions, few instructions were actually given to the participants. The close others who accompanied and 'advised' the children were told simply to 'go ahead as they liked'. One person from the research team welcomed them and remained passively in a corner of the room, after having first showed them what they could do to produce responses from the WAVE carpet; this person was also available for any necessary technical assistance. Other than this, no rules were announced in relation to how to use the WAVE carpet.

All of the consequent actions were recorded using three video cameras, to assure the most comprehensive access to the data. Two of the cameras were fixed to the wall, one trained upon the screen in the background, the other one on the wall furthest away that could capture the whole scene from a distance. The member of the research team who was in the room used a handheld camera.[13]

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12 Testing related to ORFI, the prototype of the first CCTs, is discussed in Stensæth & Ruud (2014) elsewhere in this volume.

13 This person did not know any of the participants who entered the room. As he was going to be there anyway, we considered it expedient to have him try to capture subtle movements and facial expressions to complement the fixed-camera data.

The selection of video clips and children

The use of videos made it possible for research team members to study a given interactive event systematically, repeatedly, and deliberately. Videos were also useful for analysing emotions and body expressions, including the subtle nuances of mimicry and the small body movements that could be associated with the process of co-creation. The method used for the present study is *structured video analysis* (inspired by Lindahl; see Stensæth, 2008), which requires the researcher to verify his or her assumptions about what to look for in the videos over the course of multiple viewings.

In order to determine particularly evocative video clips, I had to first review all of the video material of all of the participating children. The next step was to scan for clips that revealed moments of both strong and weak collaboration combinations in the co-creation process. The best clips derived from those glimpses and camera angles that most clearly demonstrated co-creation activity, for example when the face expressions and actions were clearly interpreted as unequivocal.

There were several reasons why Dylan and Petronella were picked for the video analysis process. First, in the interests of a comparison study, Petronella's *active* exploration of the microphone seemed to supply useful information about the *positive potential* of the WAVE, whereas Dylan's rather *passive* exploration of the camera seemed to supply useful information about the potential *challenges* associated with the WAVE. Second, Petronella in particular was chosen because she showed such a specific interest in the microphone, which was one of the new elements implemented in the WAVE. Also, it was largely due to Dylan's involved engagement with the cameras in the observation room during the ORFI actions of the previous year that the creators of the CCTs decided to build a camera into the WAVE carpet. It was therefore of special interest to the project group to return to Dylan and his use of the new camera effect.

Of course, the use of video recording in the research process can cause problems as well. There is, for example, the danger that 'seeing becomes believing'. If one spends too much time with the two-minute video clips of Petronella and Dylan, one might begin to think that they will *always* approach the world in the same manner as in the clips, which is not the case. We must always remember that, in a comparison study such as this one, the selection of video clips is designed to reflect the aims of the research – in this case, the possibilities and challenges that ought to inform the development of interactive and musical tangibles for children with various disabilities. The clips are not otherwise indicative of much of anything, including the general behavioural inclinations of the children in question.

I must further note that, having worked as a music therapist in the school where these project actions took place, I knew both of these children, and I am constantly conscious of the fact that my double role as a music therapist and a researcher can create a conflict of interest. However, I prefer to think that my twenty years of experience with children like Petronella and Dylan informs my role as a critical researcher, and that any potential bias that might result will not skew my discussion in any substantive sense.

Introducing Dylan and Petronella

The overview profile (figure 2) explains some of the differences in the ways in which Petronella and Dylan relate to the world:

Name and Year of Birth	Interests / Personal Characteristics	Communication	Physical Condition / Treatment	Diagnosis	Sensory Preference	Cognitive Level
Dylan, 1996	Likes technical things, computer work, music (has favourites) and cooking. Is anxious and withdraws easily in social settings. Loves trains and everything connected with trains (gets easily caught up in activities that include trains, as in a type of absorption which is also a characteristic of the autism spectrum). Turns to adults when he has needs.	Verbal (simple sentences), ICT (can send e-mails and find things on YouTube), visual communication	Heart problems/ medicine	Atypical autism, mental retardation	Vision	→4 years
Petronella, 1996	Loves dancing, music, and baking/ cooking. Is social with one person at a time (either children or grown-ups). Can be shy sometimes.	Verbal (two- to three-word sentences) and signs of speech	None	Down syndrome, mental retardation	Uses all senses, but cuts out vision sometimes	→5 years

Figure 2: *The children's profiles*

Both children function well physically and use verbal language, though in a limited fashion. They both like to be with others, but they do not actively seek them out for company. Their cognitive levels, at up to four or five years old, are comparable. We might add that Petronella joined the RHYME project just before the WAVE was introduced, and the video analysis captures her first interaction with the CCTs. She communicates with both words and sign language and is a fun girl who likes to explore new things but also keep everything in order. Dylan had experience with the CCTs through the ORFI actions of the previous year. He is fun too, a boy who

smiles a lot and is generally ready to try new things. However, he needs time and familiarity before he feels secure enough to surrender any control. Dylan can use words, but they do not always mean much to him; he communicates more precisely using mimicry/mimicking and body language. His visual sense is quite strong, which is probably why he is good with ICT, screens and computers.

Presenting the video analyses and some reflections

In what follows, Petronella's active exploration of the microphone in the WAVE carpet will be analysed in detail, as will Dylan's rather passive exploration of the camera there.

The largest font in the table of observations indicates the most obvious actions to be seen on the video (whether by the child, the close other or the CCTs). The text in red indicates my interpretation of what was happening. The green arrows suggest collaboration lines in the co-creation that was observed between the child, the close other and the CCTs.[14] The video clips of both Petronella and Dylan share a length of about two minutes.

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14 Note that 'Mic' is short for microphone, P for Petronella and W for WAVE, and C for Caroline.
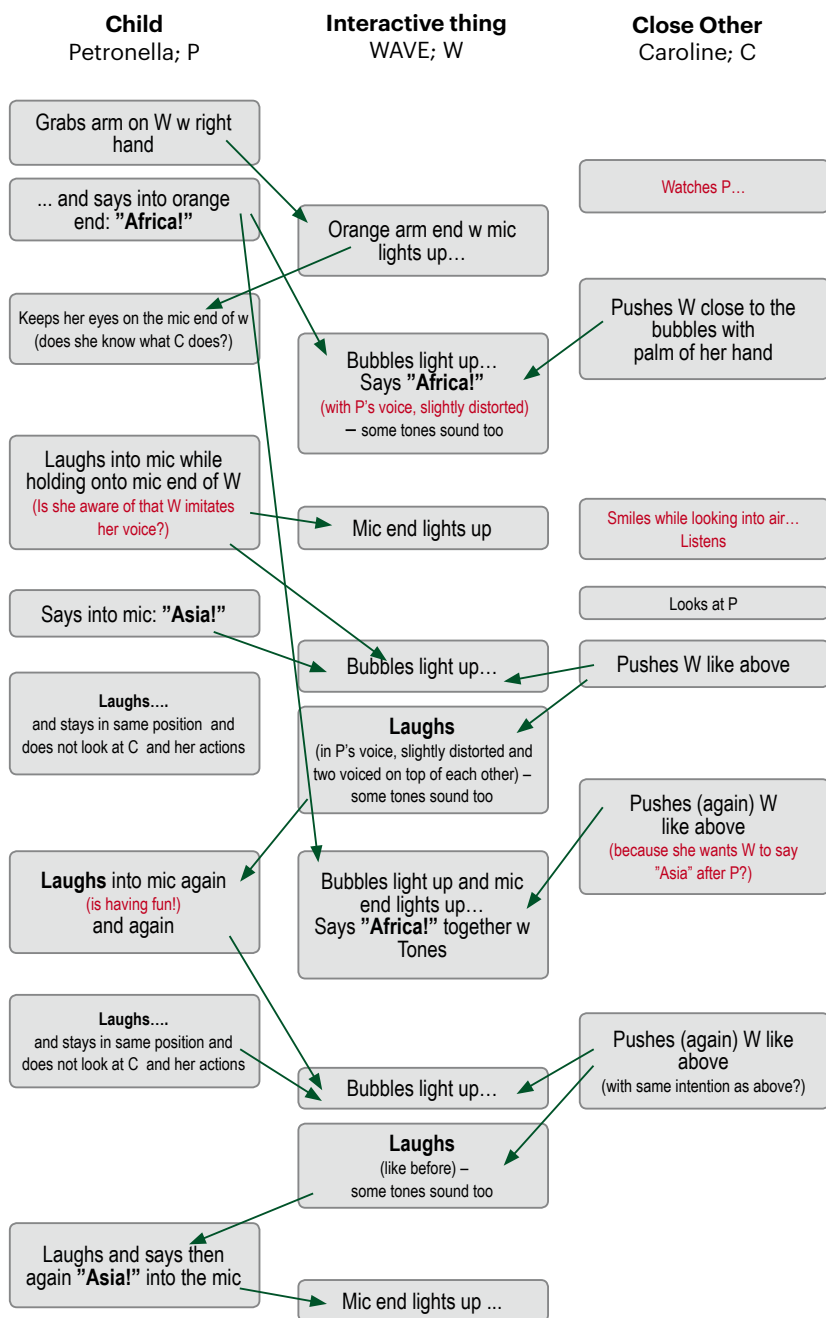
Child Petronella; P	**Interactive thing** WAVE; W	**Close Other** Caroline; C
Grabs arm on W w right hand		
... and says into orange end: **"Africa!"**	Orange arm end w mic lights up…	Watches P…
Keeps her eyes on the mic end of w (does she know what C does?)	Bubbles light up… Says **"Africa!"** (with P's voice, slightly distorted) – some tones sound too	Pushes W close to the bubbles with palm of her hand
Laughs into mic while holding onto mic end of W (Is she aware of that W imitates her voice?)	Mic end lights up	Smiles while looking into air… Listens
Says into mic: **"Asia!"**		Looks at P
	Bubbles light up…	Pushes W like above
Laughs…. and stays in same position and does not look at C and her actions	**Laughs** (in P's voice, slightly distorted and two voiced on top of each other) – some tones sound too	
Laughs into mic again (is having fun!) and again	Bubbles light up and mic end lights up… Says **"Africa!"** together w Tones	Pushes (again) W like above (because she wants W to say "Asia" after P?)
Laughs…. and stays in same position and does not look at C and her actions	Bubbles light up…	Pushes (again) W like above (with same intention as above?)
	Laughs (like before) – some tones sound too	
Laughs and says then again **"Asia!"** into the mic	Mic end lights up ...	

Figure 3: *Video analysis showing co-creation between Petronella, the close other and the WAVE carpet, part 1*
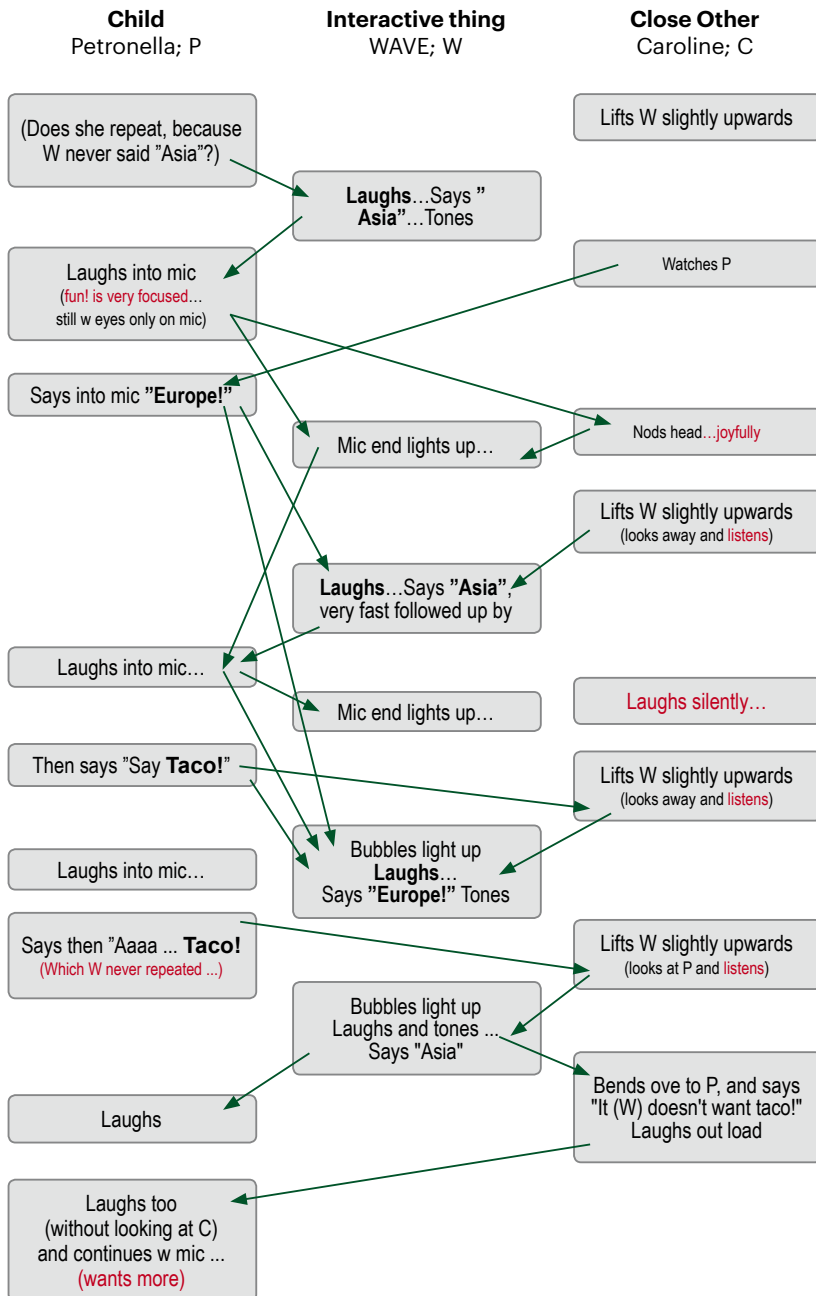
Figure 3: *Video analysis showing co-creation between Petronella, the close other and the WAVE carpet, part 2*

Reflections on the analysis involving Petronella

As we can see from figure 3, which works from a micro-level perspective, there is a lot happening in all three columns between Petronella, her close other (Caroline) and the WAVE. All three parties are active in the co-creation that is underway – the arrows indicate many lines of collaboration moving between, across, and through them. Upon closer examination, the arrows also reveal a chain of co-creative actions: when Petronella says something into the WAVE microphone, it responds by lighting up, at which point Caroline pushes the bubbles and the WAVE responds by imitating Petronella's voice (more or less) and words. This soon-predictable chain of responses rapidly occasions joyful co-creation that builds expectations in both Petronella and Caroline and makes them want to continue to play on. All of the sudden, however, the WAVE does not respond as Petronella and Caroline expect. When Petronella announces 'Say Taco!' into the microphone arm, the WAVE responds (after Caroline's push) with 'Europe!' Here, the CCT breaks from expectations, which surprises Petronella and Caroline and then makes them laugh.

It is unclear how aware Petronella is of all of the links in the chain of co-creative actions. When Petronella grabs the WAVE's arm and says 'Africa' into it, and the microphone arm responds by lighting up, Petronella keeps her eyes on the microphone arm and does not appear to be aware of what Caroline is doing. While Petronella *hears* the WAVE respond to her and is perhaps aware of the fact that the WAVE is imitating her (after a fashion), she may not associate any of this with her close other. This could indicate a weak collaboration link between her and Caroline. However, because they are sitting rather close together, it is reasonable to assume that Petronella is somehow aware of what Caroline is doing. Their shared laughter at the end of the clip also appears to acknowledge their mutual investment in the co-creation process.

Caroline knows Petronella well and here accepts the fact that Petronella does not approach her directly but stays focused upon the microphone. Caroline draws upon her knowledge and skills to remain patient and supportive of the child's interaction, even intensifying it by pushing the bubbles and makes the WAVE respond with sound. Without Caroline's collaboration, in fact, the fun and motivating co-creation among the parties here probably would not have happened – that is, the video analysis would have indicated fewer and weaker collaboration combinations.

To sum up, we might say that this short video clip shows how a child with a disability and her close other realise a meaningful togetherness with and through the WAVE. The collaboration links between the child, the close other and the WAVE are

numerous, which indicates a complex and active co-creation process among them where many collaboration combinations come into play. For this child, in particular, the microphone element was especially attractive, and when the CCT breaks the chain of expected responses, it seemed to be very enjoyable and amusing.[15] The sympathetic behaviour of the close other towards the child is of course also an important element of this interaction's success.

Let us now see what happens when Dylan and his close other encounter the WAVE:

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15 Learn about how the designers designed and developped WAVE and its microphone effect in the articles by Andersson & Cappelen (2014) and Cappelen & Andersson (2014) or elseshere in this volume.
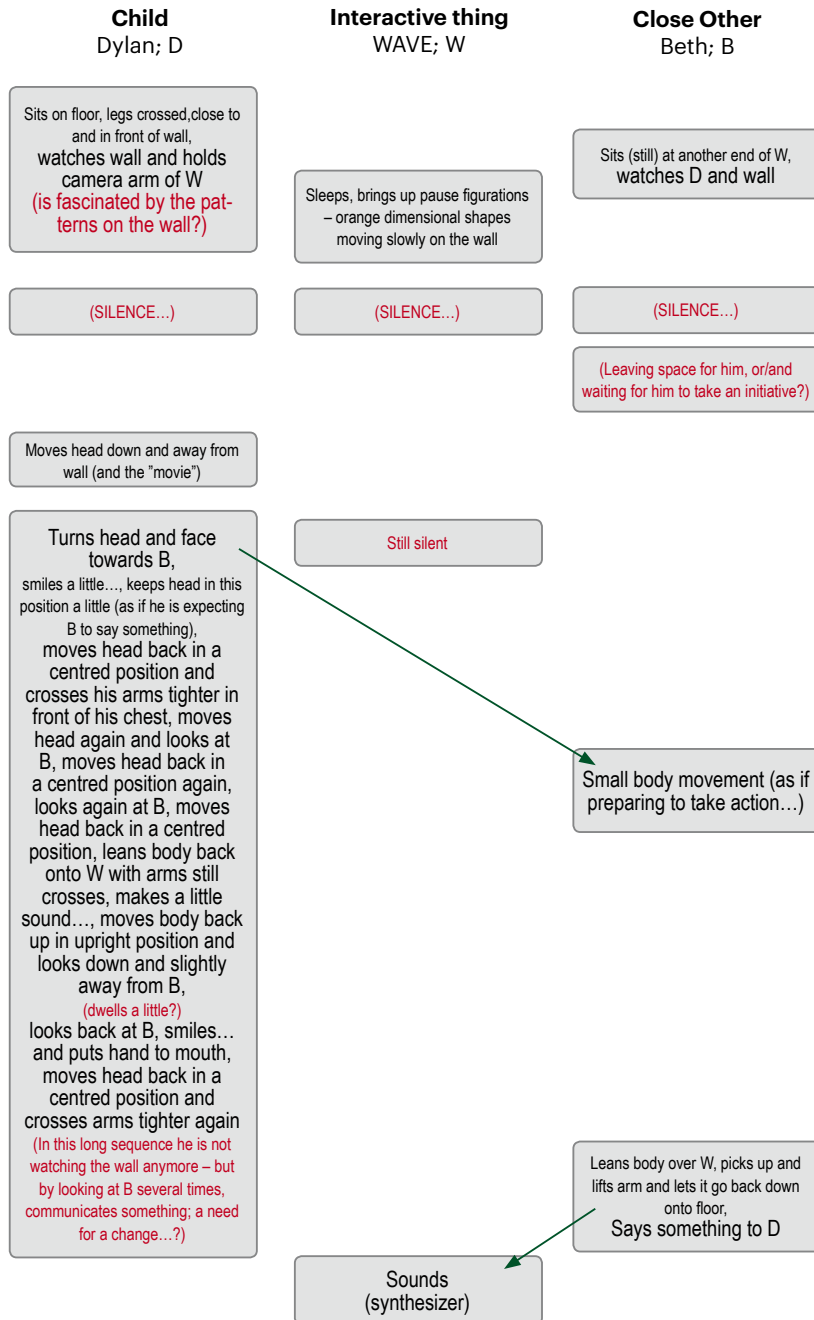
Child Dylan; D	**Interactive thing** WAVE; W	**Close Other** Beth; B
Sits on floor, legs crossed,close to and in front of wall, watches wall and holds camera arm of W (is fascinated by the patterns on the wall?)		Sits (still) at another end of W, watches D and wall
	Sleeps, brings up pause figurations – orange dimensional shapes moving slowly on the wall	
(SILENCE…)	(SILENCE…)	(SILENCE…)
		(Leaving space for him, or/and waiting for him to take an initiative?)
Moves head down and away from wall (and the "movie")		
Turns head and face towards B, smiles a little…, keeps head in this position a little (as if he is expecting B to say something), moves head back in a centred position and crosses his arms tighter in front of his chest, moves head again and looks at B, moves head back in a centred position again, looks again at B, moves head back in a centred position, leans body back onto W with arms still crosses, makes a little sound…, moves body back up in upright position and looks down and slightly away from B, (dwells a little?) looks back at B, smiles… and puts hand to mouth, moves head back in a centred position and crosses arms tighter again (In this long sequence he is not watching the wall anymore – but by looking at B several times, communicates something; a need for a change…?)	Still silent	
		Small body movement (as if preparing to take action…)
		Leans body over W, picks up and lifts arm and lets it go back down onto floor, Says something to D
	Sounds (synthesizer)	

Figure 4: *The video analysis showing the co-creation between Dylan, the close other and the WAVE, part 1*

Child
Dylan; D

Interactive thing
WAVE; W

Close Other
Beth; B

Makes an utterance
(with head away from B)

Looks at B

Lets arms free…
looks at wall Turns head
towards B, looks at her,
waits…

Moves body back
in an upright position

Bubbles light up,
Sounds,
Rhythms start

Points at wall (where movie is)
while looking at D

Sounds and rhythms sps

Looks at his watch, says
"Twenty past eleven…"
(is he out of room already?)

Pushes bubbles on W,
1,
2,
3 times

Makes throat sounds, Moves
body back and fourth
(as if preparing himself bodily for a
change in position)

Gets up, turns body and
head away from B,

Walks away, towards window

B rises and walks over to D,
saying something to him…

Leans down towards D
and asks
"Do you want to try something else
(of the cocreative tangibles)?"

Watches D walk away,
smiles a little…

Figure 4: *The video analysis showing the co-creation between Dylan, the close other and the WAVE, part 2*

Reflections on the analysis involving Dylan

Compared to the analysis of Petronella, Dylan's analysis is obviously very different (see figure 4). As we can see, there is little text in the three columns describing the co-creation between Dylan, his close other (Beth), and the WAVE. Little seems to have happened, and there are few collaboration lines among the three of them. In addition, if users remain passive beyond a given time period, the WAVE is programmed to fall asleep. When it did, patterns of screensaver graphics turned up on the wall in front of Dylan. Then Dylan too seemed to 'fall asleep' too, in his utter absorption in the graphics. Later on I will return to how the focus group discussed this built-in screensaver.

If we look more closely at the arrows that do reflect an act of collaboration between two of the three parties in the analysis above, the first arrow indicates a moment when Dylan turned his head towards Beth and smiled a little. This smile is not an invitation to play or a reflection of his general contentment, however; instead, it is a hesitant cry for help to Beth, because Dylan has become lost in the situation and unsure about what to do with either the WAVE or Beth. He then crosses his arms in front of himself, several times, as a sign of not wanting to act, or not knowing how to act, or just wanting to depart from or otherwise deny the situation.

But Beth, who knows Dylan very well and notes these actions, does not take the initiative. Instead, she contents herself with remaining actively present, making small body movements 'as if preparing to take action'. In a test situation like this, where one knows one is being filmed, it takes courage to simply await responses from the other two parties in question. Beth evaluates the situation and decides only to prepare herself to help Dylan if he invites help. In this way, she tries to give Dylan space to come up with his own initiative. She knows that Dylan needs time, and she knows that for him to get involved, he needs to find his own way. If she takes control and interrupts this process too soon, Dylan could withdraw completely and leave her to play alone, which is not what she wants. In the end, Beth does take action by bending one of the arms of the WAVE carpet and saying something to Dylan as well. She tries to come up with new ideas for their co-creation, but Dylan, who first looks at his watch and then the window, is not interested.

To sum up, this video clip shows how another child with different disabilities and his close other struggle to create meaningful togetherness with and through the WAVE. There are few arrows in the analysis that indicate collaboration lines between the child, the close other and the WAVE. The fact that the close other was so tolerant could explain why the child stayed in the situation at all, rather than withdrawing completely by leaving the room.

As mentioned, the camera element was expected to be of special interest to this child. Surprisingly, however, as the lack of collaboration lines among the three parties in this video clip shows, Dylan's genuine interest in cameras was not enough to promote co-creation here.[16] There must be other reasons for the strong and the weak co-creation processes in the cases of Petronella and Dylan, respectively. In the following discussion, then, we will triangulate the results of the video analysis with the results of the focus interview with the group of professionals.

Discussion

The idea in this discussion is to systemise the ways in which the video analysis and the interview relate to the research question that inspired this article. The people in the focus group, in turn, were presented with the following question: *On the basis of your professional competences, your general experiences with the children with disabilities, and what you have seen in the videos, what are your impressions of the WAVE, and what do you think its potentials and challenges are in enabling co-creation for the participating children and their close others?*[17]

Methods and results of the interview

Malterud (2008) inspires the method that I used to systemise the video material, because I pursued those aspects of most relevance to this study specifically by identifying extracted units of meaning. Those units were collected in the following manner:

1) Derive an impression of the whole situation.
2) Identify meaningful units/parts.
3) Abstract the content from each of the meaningful units.
4) Sum up the meaning of it all.

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16 Read about how the designers developed WAVE and its camera effect in the article by Cappelen & Andersson (2014) or elsewhere in this volume.

17 The focus group saw videos of several children and several CCTs, not only the two dealt with here and not only the WAVE. Therefore, the following discussion focuses upon an extract of the larger interview that relates specifically to Petronella, Dylan and the WAVE in relation to the research question.

Step 2 implies a process of *interpretative coding*, as described by Bruscia (2005), which means that, as the researcher, I will be interpreting the data based on my insight (my experience, knowledge of theory, and research) into the coded material. This interpretation will be informed in particular by theories of co-creation such as those presented by the creators of the CCTs in RHYME – Bruscia (2005, p. 183) describes this process as 'the researcher imposing an outside construct or idea on the data; (see also Eide, 2014). Naturally, I am also influenced by music therapy thinking in regarding communication and improvisation (in Stensæth, 2008).

The interview lasted approximately two hours, and I transcribed it for this study. The results from the interview can be summarised according to three main categories:

- the children's profiles, (cognitive) levels and use of senses and interests;
- the flexibility of WAVE (including its staging and facilitation);
- the close other's skill and understanding of both the child and the WAVE.

The children's profiles

As discussed above, Dylan and Petronella are comparable when it comes to age (both born in 1996), cognitive levels (four to five years old), and ability to use words (however limited). They also have clear interests: Petronella likes music and dancing and Dylan likes ICT and trains. In addition, the focus group found them both rather social in relation to many children who are facing the same types of challenges as they face. Petronella is perhaps more socially interested than Dylan. Both children showed great interest in one of the elements of the WAVE – Dylan grabbed the camera, while Petronella favoured the microphone. According to the focus group, this indicates a shared inclination towards active collaboration with things (interactive or otherwise) and with severe disabilities.

Ultimately, the focus group observed that it is their use of the senses, and especially sight, that appears most relevant here in terms of challenges to the WAVE platform for interaction. These observations are extracted in the following unit:

For the child to make active use of his/her personal resources, knowledge about his/her profile and in particular how he/she uses his/her senses is needed in order to facilitate WAVE in the most suitable way for him/her. The visual sense is very strong and dominating. That which stimulates vision can be both engaging and inhibitory with regard to the use of the other senses. This tendency is often reinforced in a child with disabilities, who relates to the world differently than expected, perhaps in a rigid way and/or in a narrower way than many other people, in that he/she uses fewer senses at a time.

The focus group believes that for Dylan in particular, vision is more dominant than the other senses. When Dylan is interested in what he sees, in short, he promptly abandons his other senses – recalls the point in the video analysis when Dylan gets stuck watching the screensaver graphics on the wall and forgets about both the WAVE and Beth. In this case, Dylan does not use his vision in a creative way. The graphics on the wall are so absorbing to him that it is impossible for him to co-create with the WAVE or Beth. For him, the camera, and especially the patterns in the graphics, has an almost hypnotic effect, in the same way that the sight of running water or flames will consume other children with autism. The focus group therefore concluded that the way in which the camera element in the WAVE functions can inhibit interaction:

For Dylan, the camera element seems to invite him to escape and to move into his own world … [This] can be desirable too, of course, but if he gets stuck or lost in there, which is something a boy like him with such autistic challenges easily does, this could be negative too … In fact it could strengthen his isolation …

The same person in the focus group wondered if the screensaver graphics could be disabled. If the close other could turn this function off, Dylan might return, in a sense:

Instead of leaving him in isolation … the thing [WAVE] should at a certain time do something in contrast, something that affords action and/or co-action, so the child gets out of isolation.

Another person in the focus group added that this had something to do with ethics. For people who cannot move away from stimuli, including those with severe physical challenges, WAVE should provide a means for the person to otherwise change or conclude an interaction that could be experienced as overwhelming, intrusive and/or frightening.

So, while the focus group agreed that it was still a good idea to build a camera element into WAVE for children like Dylan who have a strong visual sense, it was not entirely clear how to ensure that they experience WAVE as a means of co-creation. It would be necessary, they thought, to know a child's personal profile and how he or she would use the senses. Because vision is such a dominating sense for Dylan, it might be helpful to look at how the WAVE could be constructed and/or programmed to make it more likely that his use of a strong sense would activate his other senses as well. One person suggested:

If the camera could project onto the thing [WAVE] something that is tactile, Dylan could combine vision with the tactile sense. Cloth that 'lives', like tulle, invites touching … Additionally, if WAVE could respond with sound to his touching, it is possible to include his hearing as well!

By combining the senses in this way, Dylan would be encouraged not only to remain at the centre of the interaction but also to overcome his instinct to drift off into his own world. Instead, the focus group noted, he would be inclined to interact more actively with the WAVE as well as with his close other.

For Petronella, the situation is very different. Although she uses all of her senses, she also uses her vision in a special way: she keeps her eyes solely on the microphone and does not look at Caroline or the rest of the WAVE. Does she do this to maintain contact with the microphone, which is at the centre of the fun co-creation that is developing around her? Maybe she feels that if she looks at Caroline or some other part of the WAVE, she would lose track of the process? Or, by partly abandoning the use of sight, in a sense, is she allowing herself to focus more on the sound, which is the focus of her interest, after all? Or, of course, we will recall that Petronella can be shy, and maybe eye contact with other people is simply difficult for her?

Ultimately, we can conclude that Petronella did not depart the situation like Dylan; instead, she used her sight to stay within the situation, and to stay in contact with the meaningful co-creation that was developing there.

The flexibility of the WAVE

Rigid behaviour is sometimes difficult to overcome, but the focus group came up with several suggestions to help children like Dylan to relate to the WAVE in a more creative and interactive way. These suggestions are extracted in the following unit:

To match the child's way of communicating, which can be different from the expected and dependent on individual idiosyncrasies, WAVE must be flexible. This means that for the child to feel that WAVE communicates with him/her, its response must also be experienced as close enough and clear enough. The import of familiar elements, such as images of family members or sounds that resemble the child's voice, is often motivating. Also, WAVE's potential to respond in unexpected ways is a good idea but should be adaptable to the child's cognitive level and sense of timing. WAVE must, in other words, interact in many, varied ways, to fit with what each child finds to be safe and exciting and what maintains his/her interest over time.

More specifically, one person in the focus group suggested that the WAVE should allow projecting images onto the WAVE carpet itself rather than the wall. She thought that this might create a situation in which a child like Dylan and his close other could sit and watch together and perhaps feel as though WAVE were a part of them. Physical proximity to the WAVE carpet would be important to many children with challenges within the autistic spectrum, such as Dylan, and a wall that is five or six meters away is counterproductive in this regard.

The focus group also noted that the quality of the projection should be better in order to engage Dylan more actively. From what they saw on the videos of Dylan, there was too little contrast between the images and between the projected area and elsewhere on the wall. In tandem with the limited lighting in the room, this relative uniformity of image intensity did not really invite activity on his part. For Dylan, a dark room and weak images actually *increased* his passivity and withdrawal. It could even make the setting seem threatening to him, so that he ended up feeling insecure and lost.

The focus group also noted that the WAVE should invite a child like Dylan to combine his senses, in order to ease him out of isolation and into co-creation. But it is likewise possible that, for other children, the WAVE would have to do the opposite. For children with vulnerable sensory apparatus or challenges related to sorting out the various sensory stimuli, for example, it must be possible to eliminate some of WAVE's responses as well. For these children, whose cognitive level is lower than one year old, too many responses at the same time or too many responses following upon one another quickly create chaos and frustration and thus inhibit health. Therefore, the option to add and/or exclude some of the functions in WAVE, and even to control the intensity and/or length of the responses, is important. Such an option would also be useful for children just like Petronella and Dylan when they are having a bad day or are in a bad mood.

One aspect that impressed the focus group was WAVE's ability to occasionally surprise the users by rotating in responses from former utterances. This is evident in the video analysis (as well as vignette 1) when WAVE says 'Europe!' rather than 'Taco!' as expected. This ability, which motivated Petronella so profoundly in relation to the co-creation between her, Caroline and WAVE, is called 'shifting', here described by the creators of the CCTs Cappelen & Andersson (2011):

> The interaction rules are the computers' treatment of the users' interactions, and the interesting aspect is that the computers do not treat the interactions mechanically, as a piano for example would do. Rather they treat the interactions dynamically; they are based on the user interactions over time and the composition rules, which in turn are based on aesthetics and/or musical genres and the narrative structure over time. It is this use of the computers' dynamic capacities that makes it possible for the CCTs to vary and shift their responses.[18]

Shifting not only introduces an element of surprise into the co-creation but also involves WAVE as a 'player' in a fashion that is different from the way musical instruments or toys work. Cappelen and Andersson (2011) assert that the CCTs therefore behave more like 'improvising co-musicians or co-players', or even as 'friends and partners in dialogue'.[19]

For Petronella, WAVE's ability to respond dynamically this way, by acting both as expected and not as expected, makes her happy but also motivates her to play and use her creative fantasy. It also encourages her to take an active part in what is around her and to relate to her close other while playing. The microphone is especially attractive in this regard and in turn stimulates her to use her voice. In fact, from what I know of her, Petronella used her voice more in this video clip than she generally does in other school situations. This could be explained by the fact that Petronella encounters the CCTs for the first time here, so they represent a curiosity for her. But it might also be true that WAVE engages Petronella in ways she has never experienced before, motivating her and perhaps, most excitingly of all, promoting her health.

Shifting is a consequence of programming, which determines parameters including the duration of the interval between the user's initiative and WAVE's response as well as the length of time before the surprise arrives. When WAVE is

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18 See also Stensæth (2013).
19 These are the words of Cappelen & Andersson (2011).

experienced as an independent actor, as it was for Petronella, co-creation involving it can supply motivation and produce a feeling of mastery. For Petronella, then, the programming of the shifting in WAVE was just right. For other children, though, it might need to be different. If a child is frustrated by the surprise element, for example, one ought to be able to turn it off as well.

The co-creators' skills and understanding of both the child and the WAVE

In the video analysis of Petronella and Dylan, we have seen that the roles of the close others were crucial. The two close others displayed great skill and sensitivity; they were tolerant and empathic and matched their actions with the child's needs. Without these close others' active participation, the co-creation would probably not have been as successful. It was Caroline's pushing of the bubbles that made WAVE respond to Petronella's speaking into the microphone – Caroline linked the actions of Petronella, herself, and WAVE together into a chain of fun and stimulating co-creation. Beth also acted skilfully. Though it did not lead to more co-creation for Dylan, her tolerant and watchful stance prevented Dylan from leaving the room.

The focus group mentioned that the flexibility that is needed for WAVE and other CCTs is likewise needed in the children's collaboration partners. Actually, said one person, it would be even better the other way around:

> The flexibility that the close others show when they co-create with the children is what it takes to develop an ideal co-creative WAVE!

It strikes me that the idea that of WAVE's resonance with the instincts and actions of the human caregiver is perhaps as its best the path forward in development of WAVE's (as well as other CCTs') capacity as devices. This is perhaps why the unpredictable element brought into the co-creation via shifting fascinated Petronella so much? This means that WAVE needs to be considerate in the same fashion as the close others and adopt its actions to the personal profiles of the child with disabilities. Also, it means that it should act in a 'human' fashion, for example as an improvising actor that comes up with new ideas every once in a while. Preferably, this should be possible to manipulate through the programming of WAVE.

However, other close others are not likely to act in the professional manner of Caroline or Beth. In a home setting, which is what the CCTs are ultimately intended for, the children's sibling who know their sister and brother well, are also well

qualified to be close others. The setting is simply a bit freer at home. Here, more provocative and rougher interaction would be allowed; siblings would probably not be as considerate and tolerant as the close others on the project video. Therefore, says the focus group, the development of WAVE must take into account the ways in which *any* close other might co-create with the child with disabilities. Moreover, the WAVE should respond to their interests as well, so that they would engage in co-creation out of self-interest as well as some sort of charitable impulse.

Conclusion

The research question of the present study reads as follows: *Why do the two children (Petronella and Dylan) relate so differently to the same musical and interactive tangible, the WAVE carpet, and what does it take to facilitate the most meaningful and health promoting co-creation for each of them?*

As we have seen, the answer to this question relates largely to

a) the children's individual profiles, cognitive levels, and use of senses and interests;

b) the flexibility of WAVE (including its staging and facilitation); and

c) the co-creators' skills and understanding of both the child and WAVE.

The focus group suggested that WAVE should suit the child's 'zone of communication' – that it should accommodate the child's sense of timing, sense of space, interest level and use of senses so that the child feels that the WAVE's responses are directed towards him or her. Petronella felt that WAVE was actually talking to her, and in fact she negotiated and played along with the WAVE carpet. WAVE's reproduction of familiar elements such as the child's own voice worked well, reinforcing her feeling that the CCT approaching her in a 'personal' way.

Dylan, on the other hand, found that the camera element in WAVE created a greater distance between him, the CCT and Beth. As a means of defeating his instinctive sense of isolation and attracting him to co-creation, WAVE must be programmed differently. Preferably, it should encourage Dylan to combine his senses (including sight, touch and hearing), and to respond in some active way.

To sum up, we might say that, in order to accommodate a huge range of cognitive levels as well as the complex combinations of interests and needs in children with disabilities and their close others, WAVE should be able to operate on different levels at the same time. If a child with severe disabilities needs to focus on

one sense at a time, WAVE should be programmed to exclude the others. However, to simultaneously sustain the interest of an older brother, for example, the WAVE would need to retain some flexibility even here. This could be accomplished in many ways and is well within both the creative and the technical potential of the CCTs.

We have also learned that the flexibility of the close others is a good model for developing an ideal co-creative WAVE. Ultimately, of course, it is not possible for an inanimate object to actually match human feelings. The WAVE will never be able to read Dylan's body language like Beth does. Yet this technology does have the potential to be programmed to suit a given child's personal profile to some extent. As such, a CCT like the WAVE carpet vastly exceeds manual musical instruments and traditional toys in its interactivity.

We should also remember that the material informing the present study has been limited to only two children, to short video clips, and to well-qualified and professional close others. WAVE affords many other forms of interaction and possibilities for use than what has been revealed here – forms that these children and their close others did not appropriate. WAVE therefore possesses potentials to enable concrete and tangible health-promoting co-creation.

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