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How Children with Mild Intellectual Disability Experience Self-driving Buses: In Support of Agency

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ABSTRACT: Emerging technology for public transportation is often not fully aligned with an inclusive design strategy. Many people with intellectual disability experience their needs and desires not being fully considered. Responding to this problem, the purpose of this study is to investigate how children with mild intellectual disability experience self-driving buses. On each bus, a person called "safety driver" monitors the ride and takes control if a problematic situation arises. The purpose is also to investigate what roles support persons and safety drivers play. In addition, the research aims to propose improvements in how the design of these self-driving buses can better motivate children with intellectual disability to use them in support of their agency. To address this, we arranged and studied seven rides on self-driving buses, for 16 children diagnosed to have mild intellectual disability, and their support persons. Interviews with the children were held after the rides, and both the rides and interviews were video recorded. The analysis was in part inductive but also employed a theory based on motivation: self-determination theory. For several children, the bus worked as a vehicle for a social sightseeing tour of the local environment, and the current design did not hinder such an experience. Overall, many of the children had a positive experience, but there is room for improvement regarding the design of the buses. Some children expressed curiosity and a few frustrations with how the bus behaved in traffic. For instance, it was difficult for the children to understand why the bus braked for things that were hard for them to perceive. From observation, it appears that the accompanying support person and safety driver played an important role in making children safe and shaping the social environment on the bus. The support persons were also essential for some children to ride the bus at all. The safety driver provided the children with information about how the bus worked. Both the safety driver and the support person had a positive impact on the children's experience. To meet the children's needs and skills, and to improve their motivation for riding the buses again, the buses need to decelerate less abruptly, have easier and consistently designed seatbelts, and communicate what they do, see, and signal more clearly. We argue that further studies at this level of detail are crucial to ensure that new technologies are indeed designed for everyone.

KEYWORDS: Accessible and sustainable mobility services; Self-driving buses; Children with intellectual disability; Self-determination theory; Agency

1. INTRODUCTION

Thanks to the regional project "Ride the Future" (www.ridethefuture.se) two self-driving buses have started serving the Valla Campus of Linköping University in Sweden and the neighbouring residential area of Vallastaden. Figure 1 below shows one of the buses, and clips of the buses can be seen at www.ridethefuture.se/filmer/. The buses are programmed to cover a 3.7 km route, and currently operate between 8 am and 5 pm. On each bus, a person called "safety driver" monitors the ride and takes control if a problematic situation arises. The safety driver is also responsible for answering passengers' questions. In this study, we investigate how children with mild intellectual disability experience these self-driving buses.

Technological innovations that are intended to serve a community must be suitable for people with diverse needs and abilities. Design strategies such as universal design, inclusive design, accessibility, and design for all have been well-articulated over recent decades (Holloway & Barbareshi, 2022; Persson et al., 2015). However, Gjermestad et al. (2017) have suggested that people with intellectual disability (ID) feel that their desires, motivations, and sense of control in everyday life are not being adequately addressed. Their principal concern relates to being in control and having choices, and transportation is an important aspect of everyday life where people with ID feel that this is lacking (Bodde & Seo, 2009; Verdonshot et al., 2009). In short, there is still work to be done to ensure that new technologies intended to improve public transportation are indeed inclusive. An example of a study that explores how people (young adults) with ID can use public transportation is McDonnell et al. (2021). They report that young adults with ID can increase their transportation travel skills by utilizing assistive technology (e.g., printed Google Maps directions).

There is some research into children's thoughts about self-driving vehicles. For instance, Charisi et al. (2017) highlight the need for children to understand that the vehicle is autonomous for safety reasons. Larsson (2021) conducted interviews with 11-12 year olds about their experiences of riding the buses that are the focus of the current study. We return to this study in the discussion. There is, however, less research on how children with ID experience self-driving vehicles. There is little research on the design of artificial intelligence (AI) more broadly, and children with ID. AI has the potential to support the agency of children with ID but, from the area of assistive technology, we already know that it is often the case that these technologies demand the very abilities that they have been designed to support (Palmqvist & Danielsson, 2020). Further, children with ID are often accompanied by a person who supports their use of technology and transportation services, so it is important to understand the support

person's role and how children's dependence on them can be minimized in favour of fostering the child's own agency.

Figure 1: One of the buses in the Ride the Future project (www.ridethefuture.se)

2. BACKGROUND AND THEORY

We set out to build on two areas of research: intellectual disability studies, and self-determination theory.

2.1 Intellectual disability

To reach a good enough design for children, as well as adults, with Intellectual Disability (ID) it is important to understand what it means to have such a diagnosis. Disability can be understood as health conditions which impair the structure of the body and limit a person's involvement in certain activities exist (Schalock et al., 2007). Intellectual disability is defined by the American Association on Intellectual and Developmental Disabilities (AAIDD) as having limitations in both intellectual functioning and adaptive behaviour that originates before the age of 22 which has negative consequences for social, conceptual, and practical skills. Intellectual functioning includes abilities such as reasoning, planning, problem solving, and learning from experience (Schalock & Luckasson, 2004). Adaptive behaviour includes abilities such as changing one's behaviour in response to circumstances or context, and both knowing what to do and when a particular behaviour is or is not appropriate. How well the individual adapts to new circumstances is the core of adaptive behaviour.

Theories of intellectual disability focus on interactions between the individual and their environment, in particular how their participation in everyday activities compares to the norms for their age group. Other factors of interest are the health status of the individual, and the social context that they are in, for instance how well family and the neighbourhood support their development and wellbeing. Intellectual disability is a complex diagnosis that involves both how the individual performs and how their abilities work in context.

Mild ID involves all the above dimensions but in a relatively mild form. People with mild ID exhibit slower language development but can participate in conversations and use language in everyday life. Most people with mild ID can live independently, for instance, managing eating and dressing by themselves. However, they may have issues with reading and writing which make it difficult to engage in a mainstream class at school.

When studying children with an intellectual disability it is therefore important to understand the child's experiences in relation to the immediate social and physical environment. Importantly, children with mild intellectual disability can use community services if they are not too complicated to understand and operate.

2.2 Self-determination theory: intrinsic and extrinsic motivation

Self-determination theory (SDT) is a framework for understanding motivation, and it focuses on how cultural and social factors support individuals' initiatives, wellbeing, and the quality of the actions they perform (Ryan & Deci, 2000). SDT suggests that the psychological states of autonomy, competence, and relatedness create the greatest will and motivation for activities. Specifically, it is suggested that these three states result in intrinsic motivation through intrinsic regulation; better self-regulation of extrinsic motivation through identified and integrated regulation; and good health and wellbeing. If a social environment does not support these three states, it will instead harm the individual's wellbeing.

Intrinsic motivation makes us challenge ourselves and increases our will to learn. Healthy children are playful, curious, and active even when there is no reward for this behaviour (Ryan & Deci, 2000). However, research shows that intrinsic motivation requires a supportive environment to linger and prosper (Ryan et al., 1997).

By contrast, extrinsic motivation involves social pressure and demands that an individual act and perform tasks in particular ways that are not necessarily of interest to the individual. Extrinsic motivation focuses on results while intrinsic motivation builds on the personal satisfaction of doing something. SDT suggests that the feeling of autonomy may develop in response to extrinsic motivation (Ryan & Deci, 2000). Someone who acts or performs in a certain way because she knows that it will benefit her in the long run does so because of extrinsic motivation and may have a sense of control and autonomy as a result, without having felt any intrinsic motivation to carry out the act. Within SDT this is described as the motivation being regulated by

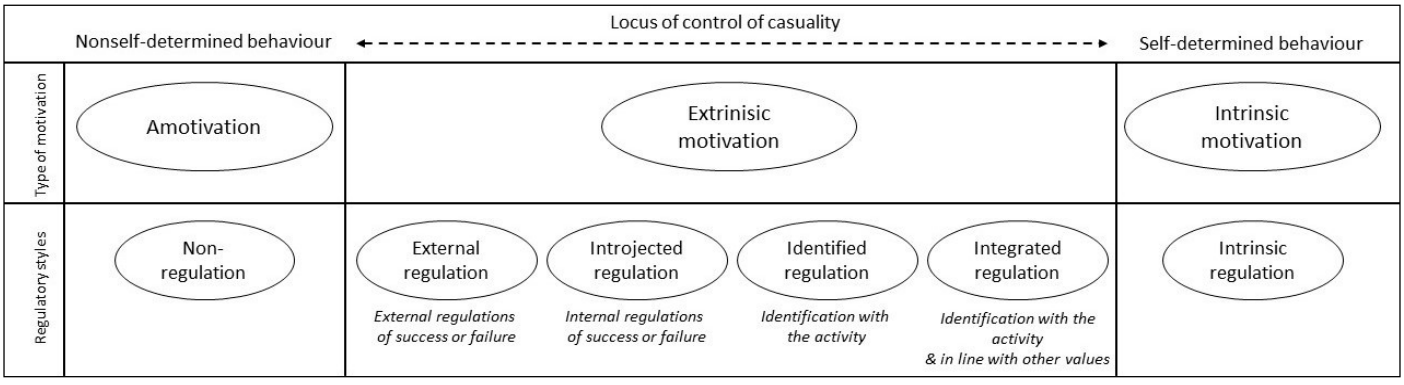

Figure 2: Overview of Self-determination theory

identification or integration (see figure 2 above). In contrast, someone who acts in a particular way to please someone else, such as a parent, also does so because of extrinsic motivation but is less likely to feel autonomy. Within SDT this is described as the motivation being externally or introjectively regulated.

SDT can be understood as a continuum on which the locus of control of causality and regulatory processes goes from impersonal and external to internal (see Figure 2). How we internalize extrinsic motivation, therefore, influences how autonomous we feel. The further we are to the right of the SDT continuum the more likely we are to feel autonomous. People are more likely to experience this positive internalization if they feel related to the social environment they are acting in, and less likely to experience it if they do not feel competent (Ryan & Deci, 2000; Ryan et al., 1994). Further, if an individual feels competent enough to perform an activity and it is valued by others, the likelihood that it will be performed increases.

Cognitive Evaluation Theory (CET) builds on SDT. CET suggests that communication, optimal challenge, positive feedback, and rewards that support the feeling of competence, contribute to intrinsic motivation (Ryan & Deci, 2000). CET also suggests that the feeling of competence depends on a feeling of autonomy. Studies show that intrinsic motivation is strengthened when an individual expresses their feelings and understands the options and possibilities available to them because these contribute to a feeling of autonomy (Ryan & Deci, 1985). A feeling of relatedness is also important for intrinsic motivation. Children who are given interesting tasks will be less motivated to perform them if an adult present is unengaging and ignores the child (Anderson et al., 1976). Motivation, therefore, decreases when there is less relatedness to the task and people involved.

3. PURPOSE AND RESEARCH QUESTIONS

The purpose of this study is to investigate how children with mild intellectual disability experience self-driving buses, and what roles support persons and safety drivers play in shaping this experience. Beyond this, a further purpose is to propose design improvements which can better motivate children with intellectual disability to use the buses in support of their agency. Finally, we argue that studies such as the one reported in this article are crucial to ensure that new technologies are indeed designed for everyone—including those that relate to public transportation.

We use SDT and CET to understand how the buses support the agency of children with mild ID, and what needs to be changed to support that agency better. With this introduction and background in mind the research questions are:

1. How do children with mild ID experience travelling on self-driving buses?
2. What roles do safety drivers and other support persons play within these experiences?
3. Which key areas of design need further development to support the agency of children with mild ID and motivate them to use the buses?

4. METHODOLOGY

This study is part of an overarching project which builds on a so-called Research through Design (RtD) approach, which means that the systematic practice of design is constitutive of studying a phenomenon (Archer, 1995). The study includes observations of and interviews with users of the self-driving buses described in the introduction. The phenomenon under study is how children with mild ID experience the existing services, and how future services should be designed to support their independent use by children with mild ID.

4.1 Participants

Participants were recruited from schools for children with mild ID. Parents of children with a relevant diagnosis were contacted via the headmaster and responsible teachers. Parents gave their written consent first, and then the children gave their video-recorded oral consent to participate in the various parts of the study. Since this study involved children with special needs it was necessary to take extra care in ensuring that they participated voluntarily. For instance, the children and their support persons were informed that they could end their participation at any time. If the bus ride and interview were felt by anyone present to be stressful for the child, the child was allowed to leave immediately with a support person. This occurred once during an interview following the bus ride. The study has been approved by the national ethics review authority (Dnr 2021-06604-01).

16 children participated in the study (M_{age}=9.75, SD_{age}=1.61). 13 of them completed a short 4-item version of the Technology Readiness Index 2.0 (TRI, Parasuraman & Colby, 2015). Each item represents a dimension of being ready for new technology: optimism, innovativeness, discomfort, and insecurity. The questions and response scales used deviated from the original and were specifically adapted for this study, to work well with children with mild ID. For instance, the question representing discomfort was taken from TRI 1.0 because we deemed that the equivalent question in TRI 2.0 would be hard for children with mild ID to comprehend. The use of the scales was also supported with pictures. See Appendix A TRI-index for the questions we used. Three children did not answer the questions. The children who did answer them scored a mean of 2.65 (SD=.44, 1=not ready at all, 4=very ready) which means that, as a group, they are cautiously ready for new technology. In general, the children reported feeling discomfort (M=1.85, SD=1.14) when someone sees them struggling with technology, and insecure (M=1.69, SD=.75) about the fact that people use technology so much, but were also optimistic about new technology (M=3.54, SD=.88) and their abilities to use it (M=3.54, SD=.52).

To get a better description of the participants they were asked to complete the digital short version (24 items) of Raven's Progressive Matrices 2 (RPM 2, Raven et al., 2018). 10 children did this while 6 children were not able to. The score for those who completed the test (M_{age}=9.9, SD_{age}=1.91) was equivalent to that of children aged 6.03 years (SD=1.19).

4.2 Data collection

Data collection was carried out in steps, to suit the schools' schedules and the children's needs. Firstly, the children gave their oral consent, immediately after which they responded to the TRI-questions. Next (on another day) they completed the Raven's Progressive Matrices 2. Finally they went on the bus ride. The children were divided into 7 smaller groups. Each group travelled by the bus once. As a rule, the children took these rides with at least one other child, the exception being two children in wheelchairs who each went on a single-child ride. We were told that the buses could not accommodate more children while a wheelchair occupied the relevant space. However, in hindsight, this was not necessarily the case. For one child, the bus ride took place on the same day that the Raven's Progressive Matrices was administered. For the rest, the ride occurred on a different day soon after or before completing the Raven's Progressive Matrices. Immediately after the bus ride, the children were invited for a short interview. For some children with specific needs, this interview took place individually, immediately after disembarkation, while for the

majority it was carried out while they are sitting together in a quiet place nearby.

The normal bus ride lasts about 40 minutes, but the teachers responsible regarded a 40 min ride as too long for the children, and it was therefore cut to about 20 minutes, which constituted a pre-programmed journey covering half of the normal route. Each ride was accompanied by one safety driver, one researcher (PL or MF), and any support persons needed by the relevant children. The ride was video-recorded with two GoPro Hero 10 cameras which captured the interior of the bus from two different angles and, to some extent, the bus's immediate surroundings. Embarkation and disembarkation were video-recorded with a handheld Sony HDR-CX450. The subsequent interviews were video recorded with a GoPro Hero 10. See figure 3 below for a sketch of one of the rides with three children travelling on it.

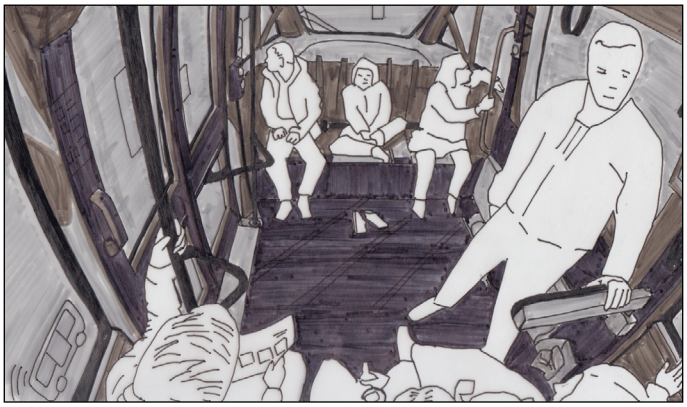

Figure 3: Sketch of one of the rides. Three children sit in the upper section of the picture, the safety driver stands to the right, and researcher and support persons sit in the bottom section of the picture.

An interview guide (see Appendix B) was used to guide questions during embarkation, the ride, disembarkation, and the interview afterwards, during which most questions includedpicture support. Before the ride, participants were encouraged to share their thoughts and feelings. During the ride, participants were asked how they felt if something happened: e.g., sudden braking, the safety driver taking control of the bus, the bus standing still for some time, and at least once during every ride even if nothing special happened. They were also asked what they felt if they gave the impression, verbally or physically, of thinking about something special. Every question about how they felt was followed by prompts about what made them feel like that and, if they expressed a negative feeling, how they would change the bus or the bus interior for the better. The subsequent interview included general questions about how they experienced the bus and the bus ride, and what they thought was positive and negative about the bus and the bus ride, followed by a question about how they would change things if they could. Finally, they were asked if they would like to go on the bus again.

4.3 Data analysis

The analysis can be described as what Braun and Clarke (2021) call a Codebook Thematic Analysis. The themes are based on the research questions in chapter 3 and on SDT (2.2 Self determination theory: intrinsic and extrinsic motivation), which has been used as a codebook to understand the children's experiences, the buses' characteristics, and the roles of safety drivers and support persons.

Because SDT has guided the analysis it can also be described as, in part, a deductive qualitative analysis. It is also inductive in the ways it has sought to describe the children's experience of the bus and the bus ride.

The analysis followed some of the steps outlined in Braun and Clarke (2006) but since it was a Codebook Thematic Analysis it also differed in some areas (primarily (c) and (d) below). The steps followed in this study were: (a) familiarization with the data by watching all the video evidence several times and noting down initial ideas; (b) generating initial codes and checking for consistency or deviation across the video evidence, for instance how participants behaved differently in similar situations; (c) understanding the initial codes and their (in)consistencies in relation to SDT, particularly how expressed experiences and observed behaviours might be understood in terms of whether the service was supporting or not supporting autonomy, competence, and relatedness; and (d) understanding the expressed experiences and observed behaviours in relation to the observed behaviour of the safety driver and support persons and, from these, generating codes relating to these roles and how they support the children's autonomy, competence, and relatedness.

5. RESULTS

The results are described under four themes: autonomy, competence, relatedness, and safety driver and other support persons, see Table 2. The first three themes relate to the three basic concepts of SDT (see 2.2). These answer the first research question, about how children experience the bus ride, through the lens of SDT, and establish the guiding themes for answering the third research question, about how the buses should be designed to support the agency and motivation of children with mild ID.

The last theme answers the second question: what roles do the support persons and safety drivers have in the children's experiences? Table 2 below summarizes the themes and gives examples of content.

5.1 Autonomy

On several occasions, participants demonstrated autonomy before, during, and after the bus rides. One frequent observation was that several participants could physically step onto the bus by themselves, often without clear instructions from support persons or the safety driver. On one occasion this was preceded by the children running towards the bus. On another occasion the children waited on the pavement next to the support persons, talking about the bus ride and engaging with each other before being instructed to enter the bus. Before formally inviting the children to enter the bus the safety driver said "Hey" and immediately, without responding verbally, two of the three children oriented themselves towards the bus and one of them even got into a running pose. These sequences demonstrate the children's independent will to ride the bus.

Further, several children took the initiative to discuss and decide where to sit on the bus. The bus has regular seats in the back (facing forward) and in the front (facing backwards) but there are also folding seats opposite the bus doors. Several children had a go at using these folding seats (displaying competence, see 5.2 below), probably because they were the first seats they saw when entering the bus. It was clear to the children that they were not allowed to stand during the bus ride, and one child took control of this situation, telling the safety driver (who always stands) that he should also sit down.

Another display of autonomy was shown in episodes where the children got off the bus without any prompting from the support person. Some jumped off the bus while some stepped off more carefully, holding the sliding door. The bus stops have not been adapted to these buses so there is some distance between the bus floor and the ground. These episodes show the children taking initia-

Subthemes	Theme: Autonomy
Autonomy supported	Wants to ride the bus and wants to step into the bus before being instructed to do so
	Steps into and out of the bus by themselves
	Puts the seatbelt on by themselves
	Takes the seatbelt off by themselves
Autonomy not supported	Does not put the seatbelt on by themselves
	Does not take the seatbelt off by themselves
	Does not step into or out of the bus by themselves
Subthemes	**Theme: Competence**
Competence supported	Folds down the seat on the side and understands how it works
	Shows interest in the autonomy of the bus
Competence not supported	Expresses difficulties in understanding the autonomy of the bus
	Does not understand why the bus stops
Subthemes	**Theme: Relatedness**
Relatedness supported	Has fun during the ride and expresses verbal and bodily satisfaction
	Shows interest in the screens on the bus
	Wants to ride the bus again
Relatedness not supported	Expresses that the bus is too slow
	Feels insecure when the bus decelerates abruptly
	Does not think that the ride is fun
	Does not want to go on the bus again
Subthemes	**Theme: Safety driver and support persons**
Safety driver	Tells children that the bus does not have belts in front seats facing backwards
	Explains why the bus stops
	Children ask the safety driver who drives the bus
	Tells children where they can sit
	Explains what the bus sounds mean
Support persons	Tells children the belts are a must
	Ensures that the children are OK
	Tells the children where to sit
	Helps children on and off the bus

Table 2. Themes and examples of contents

tive to leave the bus when the journey was over, and taking the initiative to manage the distance between the bus floor and the ground. Further, several children were able to manage the seat belts, putting them on and releasing them by themselves. However, only the children sitting in forward-facing seats had seatbelts which, for some, was a breach of expectations. For instance, one child searched for the non-existent seatbelts, after seeing his peers in the back put theirs on.

The management of seatbelts also provided some clear cases of autonomy not being supported. In several instances, children could not put the belts on, or release them upon returning to the start/end point. They tried but lost their grip on the belt, whereupon it automatically pulled itself back. This may have indicated that those children lacked the strength to pull the belt around themselves while keeping a firm grip. In several cases support persons assisted and one child asked for help, saying "I can't get the belt off". Not being able to put the belt on is a safety risk and suggests that the bus does not support these children's competence (see 5.2 below). Not being able to release the belt in a situation where no support person or safety driver is available also creates a safety risk for those children who are less likely to take initiative in problem-solving or call for help. It is also a clear instance of the bus failing to support the autonomy of some of the children.

5.2 Competence

The episodes just described, in which the children managed the folding seats and waited on the sidewalk, are two examples of competence. Although the children were initially instructed to wait on the sidewalk, they did not need any further prompts to do so, even though the bus was standing at the bus stop right in front of them. They handled the situation of having to wait, and at least two of three children were ready for the signal to enter, only needing a "Hey" from the safety driver to start doing so.

The management of seatbelts is also a clear competence marker. On one occasion one child, on realizing that this was a bus with seatbelts, said to everyone "Hello, you need to have seatbelts.". This is a further competence marker because the child displayed his knowledge about what is important when travelling by bus. Several children reported that they frequently travel on regular buses and/or transportation services for people with disabilities, and these services vary in terms of whether or not they have seatbelts. Therefore 'seatbelt or not' is a consideration that must be addressed by both the child and the safety driver, for every ride.

On some occasions support persons did not anticipate seatbelts being necessary, at least for adults, probably because from an outsider's perspective the buses move slowly (maximum 13 km/h). However, the instant decelerations that these buses (particularly one of them) make when they

identify obstacles are harder than people are accustomed to when humans brake. One safety driver explained that how the deceleration works differ between different bus designs. Improving how autonomous shuttles decelerate is still a work in progress but the data showed clearly that the force of the braking had an element of negative surprise for all children, and support persons, who rode the bus that was used for five of the seven rides.

Another type of episode that can be understood as showing competence is the instances of children knowing what autonomous buses are and what they do. Several children expressed that they understood what this meant, for instance by stating the obvious "It drives by itself" in answer to the safety driver's humorous question of whether the child was driving the bus because he himself was not. Some of the children asked questions about how the bus works. On several occasions, the safety driver explained how it scans the environment with sensors and how the screen in the bus, which shows what the bus sees, works. One child, after a ride, instructed the researcher to walk around the bus so he could see how the screen changed. This episode shows how the children could be in control of gaining competence regarding how the bus works. In relation to this, children asked why the bus stopped, and why it did not drive according to normal give-way rules. For instance, one child became slightly angry at the bus and yelled "Drive!" when it stood still at an intersection, giving way to regular buses that passed by despite having clear time margins to move. Since these are children without driver's licenses, they do not necessarily know when to give way or not. But it may be that it is easier to question an autonomous vehicle because we can assume that it will not make the same decisions as humans. Either way, some children explicitly questioned the bus's behaviour and, to some extent, lacked competence about how it should behave. The bus does not provide support in terms of informing passengers about its behaviour, and this could impede the children's feeling of competence.

In contrast, some children sat quietly throughout the ride without expressing anything obvious, other than giving a thumbs-up upon being asked whether everything is alright. These heterogeneous responses to riding an autonomous bus show that for some children buses inspire curiosity but for others they are nothing special.

5.3 Relatedness

In many episodes, the children expressed enjoyment about riding the bus. Some children danced in their seats and made jokes with each other, the support persons and the safety driver. Relatedness was supported in this comfortable and fun environment. The social context seemed to be an important factor in feeling related to the bus ride. The children felt related to the bus ride via their relatedness to each other. For some children relatedness was also expressed by the enthusiasm they shared during the first half of the ride. For instance, one participant asked whether the bus could drive to the train station because he wanted to go to a particular amusement park in Stockholm. Another child expressed enthusiasm through iterative thumbs-up signals and positive expressions. These can be understood as the children socializing with each other. Several participants, including the child who imagined travelling on to Stockholm, expressed disappointment when the bus turned around halfway for the return journey. This can be understood as showing that for some children the bus symbolized opportunities, and perhaps also autonomy, that extends beyond what they experience in their everyday lives.

Relatedness to the bus ride is also supported by the data from the post-ride interviews during which the children were asked if they would like to ride the bus again. Two children said no to that, for instance referring to the slow speed of the bus (see below). In various ways, though, the other children expressed that they would like to go on the bus again. One child said as much, directly upon disembarkation. Another child, sitting in a wheelchair with limited communicative and physical abilities, was asked directly outside the bus after disembarkation. He instantly grabbed his wheels to signify his enthusiasm to go again, even though he had just answered yes to a question as to whether he found the ride scary. Scariness is a complex emotion and, in this case, it seems that scariness meant a degree of excitement. The same child expressed that he found the "ptschh" sound of the doors opening (which is the same on regular buses) scary and he laughed when the bus made a relatively quick acceleration. Instances of excitement can be seen to indicate feelings of relatedness to the bus ride. The feeling of relatedness to the bus may relate closely to the details. On entering the bus one child instantly recognized the controls used by the safety driver to take control of the bus, which is actually a hand control from a common games console. The hand control, along with the screen that shows what the bus sees, made some children relate to the bus as a kind of video game.

One clear factor that contributed to a lack of relatedness was the experience of the bus being slow, as mentioned above. For instance, during a ride, one child said "It goes really slow". The speed of the buses reflects the fact that they are prototypes, and run on walkways, cycle lanes, and roads. Experiencing them as slow may have contributed to some children not seeing a purpose for the bus, since they all had experiences of riding regular buses or other transportation services for people with disabilities that go faster than the autonomous buses. One child used this as an argument for not wanting to ride the bus again: "Well, a regular bus goes faster." Another reason for not wanting to ride the bus again was the hard decelerations that differed negatively from what they were accustomed to, affecting the experience of relatedness. For instance, one child yelled "Ow" three times after hard decelerations.

While one type of relatedness concerned experiences of the bus itself, and the social environment in the bus, another type concerned how the children's attention were directed outwards to the wider environs. One child occupied herself with searching for dogs, and another articulated the things she saw, for instance, the local pizzeria which she recognized. As previously noted, some children seemed to experience the bus as nothing special, which could potentially be an indication that they were attentive to something else, for instance, the local environs to which they already had some relatedness. Importantly, the bus ride was not only about the bus itself, it was also about what they experienced outside the bus. The ride was as much a journey as an experience of an autonomous bus, which aligns with what the buses of the future should amount to.

5.4 Experience of safety driver and the children's support persons

The primary objective of the project was to understand the children's experiences of the buses, and how it might be possible for the children to use the buses with less reliance on their support persons and on the "safety driver", in line with the theory of self-determination. It is therefore important to understand the roles that support persons and the safety drivers play within the experience of the bus ride, to better understand what the buses themselves may lack in functionality and design.

It is clear that on all the bus rides the safety driver informed participants about important aspects of the bus ride: there are seatbelts in the back but not in the front; where to sit and where not to sit; how the bus senses the environment;

that the bus drives by itself; why it suddenly stops; what the sounds mean; and what the screen shows.

Despite that the safety driver informed about where the children could not sit, it was mainly a negotiation between the children and the support persons where each child should sit. The support persons took responsibility for the children according to their individual needs and abilities. This was also the case when the support persons helped some children with seatbelts, but not others. The support persons also helped the children into and out of the bus if necessary. Occasionally, the safety driver helped children into and out of the bus, for instance on the two rides that involved a child in a wheelchair and the ramp was too steep to go down with the wheelchair facing forward.

Overall, the safety driver and the support persons played important roles in ensuring the children's safety and making sure that all children had a pleasant ride. They likely influenced the children's experiences of the rides, by making them safer than they would otherwise have been. They also facilitated a better learning experience than would have been had without them. This is important because the learning experience contributes to the likelihood of the children adapting to the new experience of riding these buses, which requires behaviours in traffic that the children are not accustomed to.

6. DISCUSSION

The first two objectives of this study have been to understand how children with mild ID experience travelling with self-driving buses and what roles the support persons and safety drivers have in the children's experiences. The goal of this section is to discuss the results of these two objectives in relation to previous research on intellectual disability and self-determination theory that together will answer the third objective: How should the buses be designed to support the agency of children with mild ID and motivate them to use the buses?

6.1 Autonomy

Autonomy has been highlighted in various ways throughout the preceding discussion. It remains to discussion to what extent the children's behaviour is driven by intrinsic regulation or extrinsic motivations (Ryan & Deci, 2000). The children's positive behaviours towards going on the bus, for instance running towards it, could be understood as showing both that they are intrinsically motivated to go on it, and that they have been asked to go on it. Their parents consented to their participation, and children knew that some of their peers from school would also go along, so were possibly intrinsically motivated by this social context rather than necessarily the autonomous buses themselves. It is likely that, for those children who entered and exited the buses by themselves, or managed the seat belts by themselves, feelings of autonomy were strengthened. Intrinsic motivation is also strengthened when people have choices and can self-determine what to engage in (Ryan & Deci, 1985). To some extent, self-determination seems to be illustrated by the positive expressions before the ride and the social situation on the bus regarding where to sit and what to talk about, which were somewhat determined by the children. From a service design perspective, several children would therefore fall under the metaphorical umbrella of those who are included as users of the service (Huan et al. 2020). The design meets their needs, goals, and skills, and hence supports children's motivation to ride the bus.

However, this heterogeneous group of children also shows that the design does not support autonomy, and therefore motivation, for everyone. Not being able to enter the bus, secure one's seatbelt, or exit the bus without help from the support person or safety driver is likely to reduce children's experience of autonomy and their motivation to ride the bus again. Larsson's (2021) interview study of children without ID did not note such a problem relating to seatbelts, even though it did find that seatbelts are experienced as important for safety reasons. The problem encountered in our study was that securing oneself with a seatbelt demands strength, precision, and arm reach that some children lack. Those children who did not secure or unfasten their seatbelts themselves usually took no initiative to do so. Instead, a support person took initiative. One of the children who sat in a wheelchair managed to unfasten the belts in front of the wheelchair which secure it to the floor but not those behind the chair, which were out of reach. Unfastening seatbelts seemed to be easier than fastening them, and only one child had issues with this despite trying. The future development of prototypes should explore how seatbelts and safety belts for wheelchairs can be designed to support the autonomy of their users. That said, in this study, most children managed the seat belts by themselves. Entering and exiting the bus would be made easier if bus stops were adjusted to decrease the height difference between the bus and the street.

Overall, the bus supports the children's autonomy to some extent, because it is not altogether different from what they are accustomed to. However, it is also clear that the support persons and safety drivers are important for some of the children to be made ready for the ride.

6.2 Competence

Our observations showed that the design of the autonomous buses supports a feeling of competence. As explained earlier, a feeling of competence is necessary for intrinsic motivation. We can also assume that the examples of autonomy discussed above have consequences for the feeling of competence (Ryan & Deci, 2000). Being able to manage seat belts, and entering and exiting the bus without assistance from a support person or safety driver are significant experiences of competence. There were several instances of children initiating discussions about where they should sit. When such negotiation starts without being initiated by a support person or the safety driver, it shows that the children feel competent to decide where to sit, at least when they are together. Several of them also understood how the folding seats worked, and some children expressed their understanding that the buses were autonomous. These experiences and expressions can be understood as demonstrating the children's competence in using the buses and, according to SDT (Ryan & Deci, 2000), such feelings mean that the children will be more likely to want to use the bus again. This expectation is supported by the findings from the post-ride interviews in which most children said that they would like to go on the bus again.

According to Ryan and Deci (2000), confidence, humour, and liveliness indicate a feeling of competence. Confidence was evident in the example of seating negotiation. It is also evident in the observation that most children have fun during the bus ride, sometimes making jokes with each other, the support persons, and the safety driver. Some rides were particularly lively, with, for example, children dancing in their seats.

In several instances, children were observed to have queries about how the bus works and why it behaves as it does. The clearest case of this is related to sudden decelerations. Larsson (2021) noted a similar pattern. Usually, the bus makes a 'bing' sound before it stops, to warn whoever is in front of the bus, and some of the children asked about this. In most of these instances, the safety driver or support person answered the children's questions. Children with mild ID generally struggle with conceptual skills (Schalock et al., 2007) and their curiosity may not lead them towards full

competence in terms of understanding how the bus works, although it increases their opportunities to feel competent. The role played by the support person and safety driver in explaining such things is likely to support the children's development of competence. It can also be argued that being framed as a competent asker also increases feelings of competence in the child. However, the many sounds experienced on the bus are also sources of feeling less competent. Children did not ask about every sound, and safety drivers did not explain every sound. Were these children to travel alone on the autonomous buses in future, the service would need to include an explanatory function which would help them understand what the bus does, sees and communicates. It is also not clear from observations in the current study that children's reactions of surprise to sudden decelerations lessen, even when the safety driver has explained the relevant warning sound. However, the safety drivers' explanations were not consistent from ride to ride, and we can therefore only conclude that signalling before and after decelerations needs further development.

Participants in Larsson's (2021) study reported similar experiences. Specifically, they found the safety driver to be someone who you could ask questions of, and who could offer reassurance that the buses would not have an accident. However, the children in that study experienced the decelerations as both positive and negative: negative for the same reason as the children in the current study, but positive because it assured them that the bus would not crash. In fact, they felt that the buses decelerated better and more safely than regular buses.

6.3 Relatedness

It is clear from the observations that most children who go on the bus feel related to it. To some extent, this is probably because it is not very different from what they are accustomed to, both in terms of vehicle interiors and seeing familiar things in a new setting (e.g. hand control from a games console). The bus ride also became a setting for enjoyable social interaction between the children, the safety driver and their support persons, which gave rise to excitement and positive opportunities. Past research shows that children regulate positive feelings about extrinsic motivations when they feel secure and related to the situation (Ryan & Deci, 2000; Ryan et al., 1994). If the children experience being on the bus as a situation in which they can have fun, make jokes, and speak freely, they are more likely to feel related to it. It is clear from our observations that the children often created such a setting by themselves, but it is also apparent that the safety driver and support persons are sometimes the key to enabling this through the ways they discuss the experience with the children, explain how things work, and make jokes.

Anderson et al. (1976) showed that if relatedness is not supported, motivation levels decrease. It may be that those children who expressed hesitance in response to the question of going on the bus again felt less related. The slow speed and sudden decelerations were the most prominent reasons for this. If the bus is to symbolize opportunities that can transform everyday life, making the children feel more autonomous, the journey and the vehicle must meet the criteria of being comfortable and able to transport the children at the speed that they expect. This concern also arose in Larsson's (2021) research, in which the children found the buses too inefficient speed-wise to be used in their everyday lives. However, although most children experienced the bus as rather slow, one child laughed when it accelerated and answered yes to the question of whether it was going fast. It is important to address these individual differences among children with mild ID. From the observations in this study, it seems that some children with mild ID can benefit from travelling at a slow speed which gives them time to talk about what they are seeing and experiencing. Slowness can also make the journey a sightseeing experience rather than primarily a transportation service from A to B. Several children commented on what they saw and treated the wider environment as part of the (social) experience of going on the bus. Hence, for most participants in this study, the bus ride experience was all about the positive social atmosphere and sightseeing in the environs. We did not give the children any ideas about what the bus could be used for in the future, but from their spontaneous expressions, two types of services can be argued for: a sightseeing service and a transportation from A to B service. These are utterly different services that come with different expectations, and different criteria in terms of the feeling of relatedness. It is also interesting to see that how the bus behaves in traffic and issues with managing the seatbelts are not bothersome enough to erase the positive social atmosphere and sightseeing experience. Something similar was found by Larsson (2021), where children reported that the bus was more fun to ride than regular buses because it has cool props. This finding contributes to contemporary theories of how we are increasingly entangled with physical/digital things (Wiberg, 2018) (e.g. autonomous buses), as the notion of relatedness speaks to the feeling of being entangled in or related to things or its absence.

From our observations, it is hard to account for why most children answer yes to the question of wanting to go on the bus again because they do not put forward particular arguments for this in the same way that those who do not want to go again do. The child who started to explore the bus's sensors after the ride, by instructing the researcher to move around the bus, also expressed feelings of social discomfort during the bus ride (as did one other child) but told his support person that he wanted to go again, while they were walking away from the bus. Generally, children with mild ID struggle with social skills (Schalock et al., 2007) and can therefore experience the social situation as uncomfortable. It seems that different children had different reasons for wanting to go on the bus again, with some being more motivated by the bus's autonomous behaviour and others by the social context or the sightseeing experience. It is also interesting to see that several of the children were observed to express curiosity about how the bus works, for instance how it senses the surroundings, decides when to decelerate, and how and why it signals.

6.4 Method discussion

It is important to understand the results of this study in light of the heterogeneity of the sample, albeit that they all have been diagnosed with mild intellectual disability. Some observations and experiences were common across participants and rides (e.g. responses to sudden decelerations), and therefore these observations can be considered to have met *saturation* (see Braun & Clarke, 2021b for a critical discussion), meaning it is unlikely that we would find anything different were we to recruit more participants. However, the children differed from each other in terms of physical and communicative characteristics. For example, one child used a wheelchair and had limited physical ability to turn around while in the chair or keep his head up straight to focus on the far distance. This child was also communicatively limited to answering yes/no questions through sign language and laughing. These characteristics amount to a different experience than that of the other participants, making us question simple observations such as the bus being too slow. In this way, the heterogeneous sample can also be understood as holding reasonable *information power* (Malterud et al., 2016), because the information we received (some of it from just one participant) was relevant to our research questions.

It would, however, be informative to compare our findings with those obtained from a group of children without intellectual disability. To some extent we were able to do this drawing on Larsson (2021), whose study focused on the same buses and showed both similarities and differences to those we have reported in the discussion here. However, the methodologies were also different in that Larsson (2021) was an interview study without observation.

In many ways, the experiences of the children in our study do not differ from those of a more typical group of children. This does not mean that the insights we gained from them are irrelevant, only that we cannot define precisely which populations would benefit from the design recommendations that flow from our observations. It would also have been interesting to follow the same children in other transportation situations. This may have helped us to better understand some observations. For instance, how autonomous are these children when they travel on regular buses or transportation services for people with disabilities? How related and competent do they feel when using the transportation services that they normally use? For example, we observed one participant's hope that this service would allow him to go wherever he wanted to go, perhaps signifying that this was something different from the services he normally uses. However, without having studied these other situations, we cannot know precisely what those differences are. Autonomous buses are also a service that people are likely to use more than once. Some of the results we have shown in this study may have arisen because the children were using it for the first time: for instance, this may have made them more likely to be enthusiastic. Autonomy, competence, and relatedness are all feelings that can change through experience, both for the better and for the worse, and would therefore be better understood if we could have followed these children across several rides. As noted, most of them wanted to go again.

Finally, our analysis and interpretation of the findings are rooted in the self-determination theory and the theoretical framework it offers. We find that this approach worked well for answering the research question on how autonomous buses support agency, but less well in answering how participants experience the buses. A more reflexive thematic analysis (Braun & Clarke, 2021) may have been a better approach for exploring the children's experiences in depth.

7. CONCLUSION AND GENERAL DESIGN RECOMMENDATIONS

For many of the children in this study riding on these buses is a positive social experience during which they have fun with each other and talk about what they can see outside the bus. The bus ride can therefore be understood as a social sightseeing experience that supports relatedness, and for which the rather slow-going buses are quite suitable. This experience has relatively little to do with the buses being self-driving, other than that their design does not obstruct the social sightseeing experience. Another type of experience is shown through some children's interest in the autonomous aspects of the buses. All fourteen children who went on one of the two buses expressed surprise the first time the bus suddenly decelerated, reflecting a lack of understanding (i.e. competence) that the bus could work in that way. Most of these children would probably benefit from an explanation and something more effective than the current warning sound that is made before the deceleration. Fewer children take an active interest in things like why it stops, how it senses its surroundings, and why it gives way to other vehicles in some traffic situations. These children seem to need more information and communication about how the bus works. For some, such information may be needed to reduce the risk of them becoming angry with the bus, and for others, it may satisfy their curiosity about its autonomous aspects.

Support persons and safety drivers play important roles in creating a positive atmosphere (e.g. joking), anticipating circumstances for the children (e.g. when it will decelerate), explaining things (e.g. what the sounds mean), and increasing the children's safety (e.g. securing their seatbelts). In a few cases, they are crucial to enabling children to go on the bus at all. This need is clearest for children in wheelchairs. Less clear examples arise when children cannot secure themselves with seatbelts or when they cannot easily step into or out of the bus. Some of these limitations are not unique to children with ID but are common to a larger population of passengers.

In many ways, the buses support children's agency in that they support the children's feelings of autonomy, competence, and relatedness. In this study, all of these feelings have been observed through the ways children act and express their feelings and thoughts. To further meet the children's needs, self-driving buses need more development in certain key areas. These include practicalities such as how these children can enter/exit the buses and secure/unfasten their seatbelts, more easily and largely by themselves, including those who are travelling in a wheelchair. Experiential areas for improvement include the need for the buses to be able to brake more smoothly, go faster in some contexts, and be better at communicating what they are doing, seeing, and signalling. Such improvements will hopefully increase children's feelings of autonomy, competence, and relatedness. Nonetheless, most of the children were positive when asked if they would like to ride on the bus again so, under current circumstances with support persons and safety drivers, these buses can be argued to already work well enough. However, the goal for services for children with mild ID is that they become more self-determining, and this means that future research must explore more closely how the buses would work without support persons and a safety driver. In addition, we would like to argue that further studies at this level of detail, and with people with special needs, are of crucial importance to ensure that new technologies are indeed designed for everyone.

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APPENDIX A. TRI-INDEX[1] (ORIGINAL QUESTION AND ADAPTATION FOR THIS STUDY WITHOUT PICTURE SUPPORT)

Optimism:
- TRI 2.0: New technologies contribute to a better quality of life
- This study: Ny teknik bidrar till ett bättre liv

Innovativeness:
- TRI 2.0: I can usually figure out new high-tech products without help from others
- This study: Jag kan oftast förstå hur ny teknik fungerar utan hjälp från andra

Discomfort:
- TRI 1.0: It is embarrassing when I have trouble with a high-tech gadget while people are watching
- This study: Jag tycker det är pinsamt om andra ser när jag har problem med teknik

1 These questions comprise the Technology Readiness Index 2.0 and 1.0 which is copyrighted by A. Parasuraman and Rockbridge Associates, Inc., 2014. This scale may be duplicated only with written permission from the authors.

Insecurity:
- TRI 2.0: People are too dependent on technology to do things for them
- This study: Människor använder teknik för mycket

APPENDIX B. THE INTERVIEW GUIDE (TRANSLATED FROM SWEDISH TO ENGLISH WITHOUT THE PICTURE SUPPORT)

The theme for the semi-structured interviews is how participants experience and think about the autonomous buses. Questions are intended to be asked during embarkation, the journey, disembarkation, and after disembarkation. Picture support [not presented here] is available for several of the questions.

Interview guide during embarkation, journey, and disembarkation:

Before the journey, participants are invited to say what they think during the journey. Questions are asked if (1) a participant takes the initiative to say something or gives the expression of feeling something; (2) something particular happens (e.g. deceleration, safety driver takes control of the bus, the bus cannot proceed due to gps-problems); and, even if neither of these opportunities arises, (3) at least once every journey.
- What do you feel?
- What makes you feel like that? (encourage participant to point)
- How would you like to change (if something negative)

Interview guide after disembarkation:

After disembarkation, the theme of the interview is similar to what was asked during the journey but takes place in a room at their school.
- How did you experience the bus – what makes you feel like that?
- How did you experience the bus ride – what makes you feel like that?
- What was good?
- What was bad?
- If you were allowed to change something, what would that be? Anything else?
- Would you like to go on the bus again in the future? Why/why not?

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