Usability of the SAFEWAY2SCHOOL system in children with cognitive disabilities

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ORIGINAL PAPER

Usability of the SAFEWAY2SCHOOL system in children with cognitive disabilities

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Abstract
Purpose SAFEWAY2SCHOOL is a programme based on several systems for the enhancement of school transportation safety for children. The aim of the study was to explore whether children with cognitive disabilities will notice, realise, understand, trust and accept the SAFEWAY2SCHOOL system and act in accordance with its instructions.
Methods Fourteen children with cognitive disabilities and a control group of 23 children were shown five videos of scenarios involving journeys to and from school. During the first viewing visual scanning patterns were recorded with an eye tracking device. After a second viewing the participant was asked ten questions per scenario. Five questions addressed what the children saw on the video, and the remaining five what they would need to know and/or do within the scenario. Additional ratings of trust, likability, acceptability and usability were also collected.
Results Very few differences were found in the visual scanning patterns of children with disabilities compared to children who participated in the control group. Of the 50 questions regarding what children saw or needed to know and/or do, only one significant difference between groups was found. No significant differences were found regarding self-reported ratings of trust, acceptability or usability of the system. Despite some significant differences across five of the 11 likability aspects, ratings were consistently high for both groups.
Conclusions Children with cognitive disabilities proved that the SAFEWAY2SCHOOL system is as useful for them as it was for children in the control group. However, a valid estimation of the full utility of SAFEWAY2SCHOOL requires in situ testing of the system with these children.

Keywords Children · Eye tracking · School · Traffic safety · Transport

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1 Introduction

About 250,000 children, aged 6–16, travel by school transportation in Sweden, using both specially purchased buses and regular bus traffic [1]. Local authorities in Sweden have to provide free transportation for a pupil if necessary, taking into account distance between home and school, traffic situation, any disabilities of a child and other special circumstances [2]. However, the drivers of school transportation vehicles are not specially educated for handling children with disabilities (CWD) [3].

In Sweden, it is estimated that at least 1–2 % of all children have a disability [4]. Of all children, 0.6 % suffer from a loco-

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motor disability [5]. The majority of those children are transported seated in their technical aids, i.e., in 59 % of the cases [6]. These children travel in specially equipped buses, since they are hindered by their disability from riding in ordinary school buses [7]. However, the actual number of children transported by specially equipped buses can be estimated to be 1 % of all children, i.e., 18,000 on a daily basis [8]. Upon adding CWD not affecting their loco-motor abilities or cognitive status so severely that they cannot ride with the ordinary school bus, i.e., yet another percentage of the total child population, some 36,000 or 8 % of the children in school transportation presumably have a disability [9].

From the users' perspective, traffic safety for CWD is a complex issue [4]. It involves not only medical, technical and ergonomic aspects, but also legal, organisational, economical and psychological ones [10]. Authorities on a municipal and county level are supposed to co-operate, but existing models and best practise examples on how to distribute responsibilities are often missing [11]. Moreover, existing legislation is not transparent and unambiguous and, hence, open for interpretation. This situation often leaves the parents of CWD to solve the problems of their children's transportation on an individual level, without societal support [12].

As shown in Fig. 2, SAFEWAY2SCHOOL[1] is a concept based on several systems for enhancement of school transportation safety for children [13]. The intent is to make the system work for all, i.e., it has adopted the general idea behind the "design-for-all" concept [14]. SAFEWAY2SCHOOL has designed, developed, and integrated technologies for providing a holistic and safe transportation service for children, from their door to the school door and vice versa, encompassing tools, services and training for all key actors [13] in the travel chain [15]. From the children's perspective, the "Intelligent Bus Stop" [2, 16], with flashing running lights triggered by a radio transmitter fitted onto the children at a distance of approximately 100 m, and the "On-board computer" providing the driver with detailed information about the child, both further described in [2, 13, 16], are the most salient features of the system. The children are fitted with the tag, shown in Fig. 2, i.e., the so called Vulnerable Road User (VRU) unit. The VRU unit consists of a small standalone radio transmitter that sends information on the ISM radio bands about the presence of a specific child. The VRU unit communicates with the intelligent bus stop (IBS) and with the Driver Support System (DSS). The VRU unit is only active when the VRU is in motion, including riding on the bus. However, the SAFEWAY2SCHOOL system also comprises a unique school bus sign and SMS updating service to the users' mobile phones. The "Intelligent Bus Stop" implies that the children do not need to wait next to the road, since being in the vicinity of 100 m of it ensures that the school bus driver and other drivers know that there are children to pay attention to. The "On-board computer" will ensure that the child is recognised, greeted, registered and monitored for correct alighting spot. Given that the child notices the existence of these two features and, in addition, realises, understands and trusts them, they are expected to act in accordance with the intention of them [13].

The SAFEWAY2SCHOOL project comprises CWD as a natural target group aiming to provide safe and secure school transportation for them, as for any other child. Consequently, their understanding, and ultimately their usability [14], of the SAFEWAY2SCHOOL concept needs to be evaluated. As mentioned, the vast majority of those with loco-motor disabilities, e.g., children who are wheelchair users, are accommodated for by special transport services with door-to-door function, which from the SAFEWAY2SCHOOL system's perspective makes their particular needs of less interest. Instead, children with cognitive disabilities are of interest in the present study, since supposedly they should be able to travel on school transportation utilising the SAFEWAY2SCHOOL technology system. Hence, the aim of the present study was to ensure that children with cognitive disabilities will:

I. **notice**, i.e., to ensure that they are given an adequate stimulus to be perceived, with respect to modality, frequency and amplitude.
II. **realise**, i.e., to ensure that they will realise that this stimulus is, in fact, a SAFEWAY2SCHOOL system and nothing else.
III. **understand**, i.e., to ensure that they know what it implies in terms of actions expected from them.
IV. **trust**, i.e., to ensure that they believe in the message conveyed to them by the system and/or that the system will "alarm"/support them when expected to.
V. **accept and act**, i.e., to ensure that they accept the SAFEWAY2SCHOOL system and actually have the possibility to act as they are instructed to.

If this 'chain' (I–V) is not solid in each of its links [17] the system will not function as intended [13].

2 Materials and methods

2.1 Design and measurement tools

For obvious safety reasons the study was carried out as laboratory based 'user clinics', i.e., real time live tests with a selection of children with cognitive disabilities, and children without any disabilities as a control group. Children received the same information as any child included in the real SAFEWAY2SCHOOL project, both orally and in writing.

[1] http://safeway2school-eu.org/

Table 1 The five steps in the 'chain' and how they were measured

Step:	Measurement tool	Specification
I	Eye tracker	SMI RED 500[a]
II	Structured questionnaire 25 statements	Asking *What is it you see?*
III	Structured questionnaire 25 statements	Asking *What do need to know/to do now?*
IV	Acceptance and Usability Questionnaire	Verbal/written response to 4 trust statements
V	Acceptance and Usability Questionnaire	Verbal/written response to 17 accept/act statements

[a] http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/red-red250-red-500.html

The methods outlined in Table 1 were used to measure I–V 'chain'.

2.2 Participants

Two groups of participants were recruited for the present study. One group comprised 14 children with cognitive problems (diagnosed with Down's syndrome and/or autism spectrum disorders, as reported by their parents), mean age of 14.1 years (SD=2.8, ranging from 12 to 16) of whom nine were male. The control group comprised 23 children without disabilities, mean age 11.6 (SD=1.1, ranging from 7 to 15) of whom 16 were male. The former group will henceforth be labelled as CWD and the latter group Con. The CWD participants were recruited from three different schools and one paediatric centre in southern Sweden. Two of the three schools were also used for recruiting the control group. All 37 children were experienced school bus users.

The gender distribution between the groups was not significantly different ($p=.51$), whereas the age difference was ($t=3.86$, $p<.001$). However, the ages of the children in the CWD group are less relevant, since it is their cognitive capacity that is relevant to the trials. The fact that CWD were significantly older is actually an asset for this study, given that cognition develops with age.

2.3 Stimuli

The stimuli presented to the participants were five video recordings of the seven scenarios, presented in Table 2 and with their Areas of Interest (AOIs) shown in Fig. 1. Each participant completed all five scenarios in a logical order pertaining to a journey. The videos were presented on a 22″ screen placed 50–60 cm in front of participants.

2.4 Procedures

Children and their parents could choose where and when to complete the trial. It could be at home, in their school or any other place chosen by them and their parents/teachers.

As the trial started, participants were given the same information as all participants in the real world SAFEWAY2SCHOOL trials were given. They were also shown slides depicting the relevant parts of the SAFEWAY2SCHOOL system (Figs. 1 and 2) and were read a short and informative narrative of two children using the system. The short story was about a boy and a girl who are best friends; one waiting at the bus stop and the other already on the bus. The short story was told in first person and also described what they experienced while going to school and back with the SAFEWAY2SCHOOL system. The participants were then seated in front of the screen in a comfortable viewing position. Placed underneath the screen, an SMI® RED eye tracker remotely recorded the participants' eye movements while they watched the five scenarios for the first time. After the scenarios were viewed in one long sequence, they were shown one by one again.

2.5 Questionnaires

After viewing the five scenarios in a row for the first time, each scenario was then played a second time followed by ten scenario-specific questions for each individual scenario. The questions were structured so that, per scenario, five addressed what the children saw on the video and five asked what they needed to know and/or do given the content of the scenario. For each statement, the child had three options:

1, to correctly identify the statement as correct or incorrect;
0, to avoid commenting on it, or;
−1 to incorrectly identify the statement as correct or incorrect.

The children's responses were scored accordingly and summed. In total, 21 of the 50 statements were true.

Finally, the children were asked four questions about trust and 17 questions about acceptance and usability of the system, in addition to five demographic questions. All questions and the response alternatives were read out loud to the participants by the experimental leader and were also shown on hard copy. All responses were double-checked by asking the child to confirm their responses. For clarity reasons, pictograms were used where applicable. All children completed the trials, which took 20–30 min in total.

2.6 Eye tracking

Eye tracker data were recorded across all first viewings for each participant using the Remote Eye Tracking Device

Table 2 The five video recordings of the seven scenarios

Scenario number	Description of the scenario	Final video scenario	Time in seconds
1	The child on the way to the bus stop	1 Walk to the bus stop	87
2	The child at the bus stop	2 Wait at the bus stop	28
3	The child entering the bus	3 Entering the bus	59
4	The child during the bus trip		
5	The child exiting the bus	4 Exiting the bus	35
6	The child at the bus stop		
7	The child on the way home	5 Go home	88

(RED) system developed by SensoMotoric Instruments (SMI). This system is contact-free with automatic eye-tracking and head movement compensation solutions. The RED system provides reliable binocular and pupil gaze data and allows subjects to wear glasses or contacts. The RED system was interfaced with a laptop and stimuli were presented on a stand-alone 22″ monitor. Stimuli presentation and eye tracking data acquisition were controlled by Experiment Centre 3.0 and iView X, respectively. Fixations were defined temporally and spatially using a pre-set minimum fixation duration of 80 milliseconds (ms) and a maximum dispersion value of 100 pixels. Prior to commencement of the videos, a 9-point calibration procedure was performed by the SMI Experiment Centre software.

For the analysis of the eye-tracking data, AOIs were defined for each video scenario, as shown in Fig. 1. Their relationships to the video scenarios and their abbreviations are detailed in Table 3. These AOIs were used to capture information regarding fixations on important features of the video scene. Each AOI was manually defined and adjusted frame-by-frame for each scene to create dynamic AOIs (Fig. 1).

Eye movement data were then analysed using the SMI BeGaze software package. Of the analysis possibilities provided by BeGaze, the AOI fixation event statistics were selected for the proceeding analyses. Specific parameters of interest were the fixation count (number of fixations inside the AOI), first fixation duration (duration of the first fixation to hit the AOI) and total fixation time (sum of the fixation durations inside the AOI). The starting point of each scenario was defined as the very first video frame immediately after the introduction slide naming the scenario was gone.

2.7 Data analyses

Data were analysed using SPSS 20 (SPSS Inc.). The Kolmogorov–Smirnov test was used to test the data for normal distribution, which was only found for the responses to the 50 statements in relation to the five scenarios and regarding the participants' age. These data were analysed with independent samples t-tests.

Fig. 1 The five video scenarios (scenario 2, Wait at the bus stop, is represented by the *upper right hand slide* and the *middle left hand slide*) and their relevant areas of interest (AOIs)

Fig 2 The SAFEWAY2SCHOOL system. The relevant parts for the present study were the flashing "Intelligent bus stop", the radio transmitter that the children carry as their "bus ticket", the special yellow signage on the school buses (similar in the video but not identical), the mobile phone which can receive live SMS updates, and the "On-board computer" carrying all the relevant information about every child boarding and alighting the bus

The remaining questionnaire, background information and eye tracking data were analysed using Mann–Whitney U-tests for group comparisons and χ^2-tests/Fisher's exact tests to analyse categorical data. In all analyses, the α-level was set to .05, with the level adjusted by Bonferroni correction where applicable. To estimate the clinical relevance of the findings, Cohen's effect size (Cohen's d) [18] was used for parametric outcomes (large effect ≥0.8) and r [19] for non-parametric outcomes (large effect ≥0.5). Based on the 14 participants in the smaller group (CWD), a power of 80 % (β=0.2) was provided by the sample size to detect a standardised difference (Cohen's d) between the CWD and the Con groups of 1.3 given the α-value of .05.

2.8 Ethical considerations

The study design and procedures conformed to the Helsinki Declaration. The present study did not fall under the Law of Ethical approval according to Swedish Law (§4a&b 2003:615). However, advisory Ethical approvals were granted for both the eye tracking part of the trial, as well as the child participation. The children all gave their assent and the parents their written informed consent. They were informed about the aim of the study, that data were confidentially handled and stored, that they could quit the trial at any point in time without having to explain why and that the data were only going to be used for the present study. As a token of appreciation, the children were given a cinema ticket.

3 Results

3.1 Background information

The children in the two groups were asked whether they travelled by school bus to and from school and whether they carried a mobile phone. The children could respond "almost always" (which implied 3–5 times per week), "often" (which implied 1–2 times per week), "seldom" (which implied not every week), or "almost never" (which implied 0–2 times per month). In the analyses "almost always" and "often" were collapsed and so were "seldom" and "almost never". Going to school by school bus was more common ("almost always + often") in the Con group (78 %) compared with the CWD (43 %), p =.039, whereas there was no difference in going by school bus from school. Whilst all CWD had mobile phones, this was not the case in the Con group (57 %, p =.003).

3.2 I Notice

In total 1,604 fixations were analysed. Fixation count, first fixation duration and total fixation time were compared between the two groups, across the five video scenarios and seven AOIs. As shown in Table 4, fixation count only differed significantly between the Con group and CWD for three AOIs. For both the focus of expansion in the first video and the bus in the second video, CWD recorded more fixations, whereas the Con group recorded more fixations than CWD on the bus stop in the first video scenario.

In regards to both the duration of first fixation and total fixation duration for each AOI, no differences between CWD and Cons were found, as shown in Tables 5 and 6.

Table 3 Dynamic AOIs for each of the five video scenarios

Video scenario	AOI (code)	Additional AOI (code)
1 Walk to the bus stop	Focus of expansion (FoE1)	Bus stop (BS1)
2 Wait at the bus stop	Bus (B2)	Bus stop (BS2)
3 Entering the bus	Bus driver's face (F3)	
4 Exiting the bus	Bus stop (BS4)	
5 Go home	Focus of expansion (FoE5)	

Table 4 Group differences in number of fixations for each AOI

AOI code	Median		Z-value	p-value	r
	Con	CWD			
FoE1	4	6.50	−2.06	.04*	0.34
BS1	21	15.50	2.26	.02*	0.37
B2	13	12	2.08	.04*	0.34
BS2	6	5	0.75	.46	0.12
F3	4	3	0.35	.74	0.06
BS4	3	2	1.41	.16	0.23
Foe5	23	19.50	0.64	.53	0.10

AOI codes are presented in Fig. 1 and Table 3. * indicates significant difference between the two groups

3.3 II Realise

The children were provided with 25 statements regarding what they saw on the five video scenarios. They were scored according to their response to the statements. As shown in Table 7, there were no significant differences between the two groups regarding their scores on the "*What do you see?*"-questions. Interestingly, both groups scored below 0 on the going home scenario.

3.4 III Understand

The children were provided with 25 statements regarding what they needed to know and/or do in relation to the five video scenarios. They were scored according to their response to the statements. As shown in Table 8, there were only one significant difference between the two groups regarding their scores on the "*What would you need to know and/or do?*"-questions, namely regarding what to do on the way home. The CWD group scored 0 on this question.

Since the "Go home" scenario was complicated to score with respect to what all children saw and what they needed to know and/or do among CWD, the answers were analysed statement by statement across the two groups. CWD had larger problems in identifying that the intelligent bus stop flashed because they were in the near vicinity of it and that the flashing informed other road users about that. It was also somewhat more common that CWD thought that as soon as the bus left the flashing would stop. However, the same statements were formulated for the "Walk to the bus stop" and the "Wait at the bus stop"-scenarios and there these statements constituted no problem for the CWD.

Table 5 Group differences in duration of first fixation for each AOI

AOI	Median		Z-value	p-value	r
	Con (ms)	CWD (ms)			
FoE1	250	292	−0.47	.64	0.08
BS1	1267	609	1.85	.07	0.30
B2	517	375	0.89	.38	0.15
BS2	167	158	1.43	.16	0.24
F3	533	508	1.32	.19	0.22
BS4	500	325	0.97	.34	0.16
Foe5	450	325	1.30	.20	0.21

AOI codes are presented in Fig. 1 and Table 3

Table 6 Group differences in total fixation duration for each AOI

AOI	Median		Z-value	p-value	r
	Con (ms)	CWD (ms)			
FoE1	1385	2283	−1.47	.15	0.24
BS1	20532	13132	1.75	.08	0.29
B2	4449	3483	1.57	.12	0.26
BS2	1267	1174	1.61	.11	0.26
F3	2300	1825	0.80	.43	0.13
BS4	1717	1042	1.94	.05	0.32
Foe5	10965	9691	0.10	.33	0.16

AOI codes are presented in Fig. 1 and Table 3

3.5 IV Trust

The children were asked if they trusted the system in four questions, addressing overall trust, safety, security and reliability. The children responded on five-point Likert scales, ranging from (1)"*Not at all*" to (5)"*Yes completely*". As shown in Table 9, there were no significant differences between the two groups. Both groups scored high on the trustworthiness of the SAFEWAY2SCHOOL system. On average they scored 4.4 (SD=0.3, median 4.4) of 5 on all four questions.

3.6 V Accept and act

As part of the acceptance, the children were asked if they liked the SAFEWAY2SCHOOL system overall from 11 different aspects using five-point Likert scales, ranging from (1)"*Not at all*" to (5)"*Yes completely*". The results are presented in Fig. 3.

As shown, the general ratings were high. On average they scored 4.3 (SD=0.4, median 4.3) of 5 on all 11 items. There were differences between the groups with respect to comfort ($Z=-2.43$, $p=.015$), efficiency ($Z=-2.29$, $p=.022$), to how assistive the system was appreciated to be ($Z=-2.37$, $p=.018$), safety ($Z=-2.20$, $p=.028$), and security ($Z=-3.41$, $p=.001$).

As a last step the children were asked about possible future usage of the SAFEWAY2SCHOOL system. Six statements

Table 7 Scores for the five "*What do you see?*"-statements across the groups and the five video scenarios

What do you see when you:	Mean scores		*t*-value	*p*-value	Mean difference	95 % confidence interval of the difference	
	Con	CWD				Lower	Upper
Walk to the bus stop?	1.65	1.50	.811	.423	.15	−.229	.533
Wait at the bus stop?	1.78	1.64	.807	.425	.14	−.212	.491
Entering the bus?	2.13	2.00	.459	.649	.13	−.447	.707
Exiting the bus?	.26	.29	−.129	.898	−.03	−.416	.366
Go home?	−.87	−1.43	1.843	.074	.56	−.057	1.175

Bonferroni corrected α-value=.01

regarding usage were put forward. The children responded on five-point Likert scales, ranging from (1)"*Disagree completely*" to (5)"*Agree completely*". As shown in Table 10, there were no significant differences between the two groups. Again, both groups scored high on the acceptability and usability of the SAFEWAY2SCHOOL system. On average they scored 3.4 (SD=1.1, median 3.5) of 5 on all six statements.

At the very end the participants were asked whether they wanted the SAFEWAY2SCHOOL system to be implemented in their community. They could respond "Yes", "No" or "Don't know". In total, 74 % of the Con group and 71 % of the CWD responded "Yes" (χ^2=3.85, p=.146). Only 2 CWD (14 %) responded "No".

4 Discussion

4.1 Over all finding

The children with cognitive disabilities in this study showed that the SAFEWAY2SCHOOL system is as useful for them as for other children. This finding suggests that the system has, in fact, successfully adopted the "design-for-all" concept [14]. Despite the fact that the CWD in the present study all had cognitive disabilities affecting their intellectual capacities, they were able to not only notice, realise and understand the system, but also trusted and accepted it. From these aspects there were no differences between the two groups.

4.2 Understanding

However, when it came to knowledge and how best to act, there was one single difference between the two groups. Albeit the fact that in four of the five video scenarios both groups scored equal, what to know and do in the Go home scenario was the divider between them. The CWD scored nil on what to know and do and negative on what they saw in that video scenario. As a matter of fact, so did they Con group as well, with respect to what they saw, but not to the same extent. It appears that this particular scenario was associated with a larger proportion of erroneous responses than the other four across the groups. Knowing that the typical traffic injury event affecting school children happens on the way home from school, with the child running out behind or in front of the school bus and being hit by oncoming cars [13, 20], this finding is alarming. However, further scrutiny of the responses revealed that both groups did actually understand the SAFEWAY2SCHOOL system's functionalities, but did not set that knowledge into context of that particular scenario. Why this was the case remains unknown. It could simply have been an effect of how the scenario was filmed or a fatigue effect among the participants based on the fact that several of the statements were quite similar but just adapted to each

Table 8 Scores for the five "*What would you need to know and/or do?*"-statements across the groups and the five video scenarios

What would you need to know and/or do when you:	Mean scores		*t*-value	*p*-value	Mean difference	95 % confidence interval of the difference	
	Con	CWD				Lower	Upper
Walk to the bus stop?	1.91	1.43	2.084	.045	.48	.012	.957
Wait at the bus stop?	.74	.36	1.089	.289	.38	−.348	1.112
Entering the bus?	1.30	.93	1.096	.281	.37	−.320	1.072
Exiting the bus?	.96	.36	1.574	.124	.60	−.174	1.372
Go home?	1.00	.00	3.423	.002*	1.0	.407	1.593

Bonferroni corrected α-value=.01. * indicates significant difference between the two groups. Cohen's d of the significant difference=1.3

Table 9 Scores for the trust questions across the groups

Trust	Mean scores		Mean difference	*Z*-value	*p*-value
	Con	CWD			
Overall	4.70	4.14	.56	2.02	.043
Safety	4.70	4.14	.56	1.93	.054
Security	4.70	4.43	.27	0.81	.416
Reliability	4.30	4.07	.23	1.01	.313

Bonferroni corrected α-value=.013

specific video scenario. Regardless, the last leg of any return school bus trip is the most risky one [8, 21], and this message should come across to the children utilising the system, as well as to parents, bus drivers, other road users and stakeholders.

4.3 Visual scanning patterns

The children's visual scanning patterns were almost identical, the only differences being a higher number of fixations on three objects. However, all of them were only of medium effect sizes. With respect to fixation durations, no differences were found. Longer fixation durations are known to occur when an object is hard to recognise (bottom-up processing) or when it is of great interest (top-down processing) [22–25]. Given the design of the study, in which participants viewed the videos for the first time without knowing what to expect, except for the features presented in Fig. 2, a certain element of bottom-up processing could be anticipated. People with cognitive disabilities could be expected to be slower in their bottom-up processing ability and, hence, they were expected to display longer fixation durations. This was not found. With respect to top-down processes, children without cognitive disabilities were expected to be quicker in identifying objects defined as AOIs. This was not confirmed either. However, the first fixation durations were on average longer than expected (413 ms, SD 274 ms, Median 448 ms) [26, 27]. It may be that the children were very interested in the video or had a hard time understanding what the interesting and relevant information in it was. However, given the fixation data the video scenarios were apparently similarly approached by both groups. This finding suggests that the SAFEWAY2SCHOOL system does, in fact, affect the visual search strategies in a similar fashion regardless of cognitive disabilities, which in turn implies that the system could be used by the target group of the present study.

4.4 Trust

The children in both groups trusted the system. They rated it to be safe, secure and reliable. However, to make a valid estimation of the trustworthiness requires real life testing of the system for the target group of the current study. Since the system is already up and running in four European test sites, this is the next logical step in the pursuit to make it accessible and usable for children with cognitive disabilities, as well.

4.5 Accept and act

The travel chain approach [15] is based on the fact that safety and security for children in school transportation is no better than its weakest link. This line of reasoning includes the end users accepting the system and that they actually like to use it. From that perspective it was interesting to notice that overall the participants, regardless of group belonging, were satisfied with the SAFEWAY2SCHOOL system. Children with cognitive disabilities rated lower regarding safety and security, in addition to comfort and how much the system would assist their school transportation. Safety and security are rather abstract concepts when it comes to road safety. Most people are never involved in any crash [28], and the likelihood of children with disabilities to be involved is equally low [6, 7], so safety is hard to measure given the experimental set up of

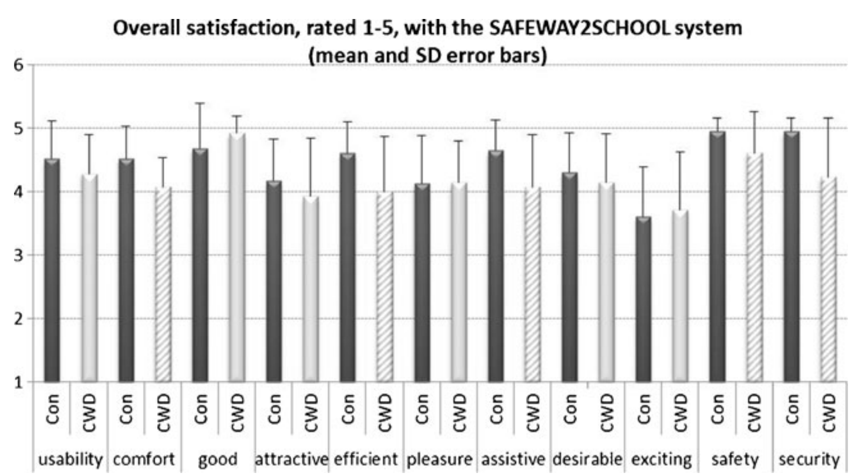

Fig 3 The overall mean satisfaction with the SAFEWAY2SCHOOL system across both groups from 11 different aspects. The rating ranged from 1 to 5. The *error bars* display the SD. The CWD group rated significantly lower than the Con group where indicated by their rating bars being *striped*

Table 10 Scores for the six usage statements across the groups

Usage	Mean scores		Mean difference	Z-value	p-value
	Con	CWD			
I would use it often	4.48	4.29	.19	0.65	.519
I want to use it often	4.65	3.79	.86	2.80	.005*
It is easy to use	4.65	4.14	.51	1.89	.058
¥*I need help to use it*	2.13	2.29	−.16	−0.34	.732
¥*I will struggle to remember the transmitter*	2.61	3.07	−.46	−0.88	.377
¥*I have to learn a lot before I can use it*	1.65	3.14	−1.49	−3.32	.001*

¥ indicates that in the responses to these statements lower scores are positive. Bonferroni corrected α-value=.008. * indicates significant difference between the two groups

the present study. Security, however abstract it may seem, is probably easier to anticipate for the children, since their parents seem to be able to pick up their child's feelings of insecurity in the transport situation [29]. Comfort and assistance were also rated lower by CWD, but not low (above 4 out of 5 in both instances). Again, getting the system explained and watching the videos may not be the best way to estimate comfort, but the degree of assistance the system potentially offers may very well be possible to appreciate. They were also asked whether the system seemed to be effective overall, where CWD rated lower but not low. How to estimate the effectiveness of the system may be an issue open for debate and the responses to this ambiguous statement should be taken with this in mind.

4.6 Usage

Looking at possible usage, it was no surprise to find the CWD to a larger extent wanted to learn more before they could use the system. As a matter of fact, it displays an insight into their own cognitive problems, which implies that the training package that comes with the SAFEEAY2SCHOOL system needs to have extra modules for additional training of the target group of the present study. Both groups realised that they will be introduced to the system, but while the Con group were extremely positive, the CWD were a little more cautious.

In order to be a valued member of society that engages in culturally significant occupations such as going to work, playing sports and socialising, transportation is a necessary component of each of these tasks [15, 30–32]. Transport in itself can also be a valued occupation for many [15]. For those with a cognitive or developmental disability who are unable to engage in transportation independently, it can act as a significant barrier to occupational balance and community participation [33]. Public transport is a feasible means of transportation for those with cognitive disabilities as driving is not often an option [33]. Due to a decreased ability to drive and transport oneself, this group often faces social exclusion and are confined to the home which is evidenced by a decreased level of community participation in those with intellectual disabilities when compared to those without [34].

4.7 Limitations

In all, the present study suggests that the next step is to include children with cognitive disabilities into a full scale trial. However, there were several limitations with the present study that should be considered. The limited number of CWD made the entire study prone to type II errors. To give an indication of how prone, non-significant p-values are provided throughout the Section 3. Contrary to this statement, and in line with other applied research, it does make sense not to power studies in order to identify effect sizes under approximately 0.8 (Cohen's d) or 0.5 (Rosenthal's r) [18, 19, 35]. In this study the Cohen's d was actually larger than that, suggesting that the conclusion that CWD could utilise the SAFEWAY2SCHOOL system as equally well as other children could be wrong. However, the p-values do not suggest so. Furthermore, the eye movement analyses did not suffer too low power, since the number of data points (1,604 fixations across all participants) was massive.

Regarding the type I error, in some of the analyses the α-levels were Bonferroni corrected, since the items supposedly measured the same construct. However, the questionnaire has not been tested with Rasch analyses, so the construct assumption has not been properly explored. In addition, Bonferroni corrections are not free of criticism [36]. In the present study only two non-significant findings would become significant if the Bonferroni corrections were abandoned. The major findings would, however, not be altered.

The lack of external validity when using video instead of real world trials is also a limitation. The video stimuli presentation method was chosen to guarantee the safety of the participants. At the same time it provided a high degree of control that excluded possible confounding external factors. It also allowed for straight forward eye movement analyses. What remains unknown is whether or not the video was realistic enough for the children to appreciate it as if they were users of the SAFEWAY2SCHOOL system. However, regardless accuracy any video will only be a representation of the real world. As such, it may have restricted the children to take into account information they would normally use. Hence, future real world studies are therefore needed.

5 Conclusions

The present study has proved that:

- The SAFEWAY2SCHOOL system is as useful for children with cognitive disabilities as for other children.
- They were able to notice, realise and understand the system.
- They also trusted, accepted and acted on it in a similar way as children with no disabilities.
- No significant differences were found in the children's visual scanning patterns across the two groups, apart from minor differences in the number of fixations in a minority of the scenarios. Importantly, no differences in fixation durations were noted.
- No significant differences were found on issues regarding self-reported ratings of trust, acceptability or usability of the system.
- The functions to support children during their daily trips to and from school identified in the EU project SAFEWAY2SCHOOL are useful not only for children without disabilities but also for children with cognitive disabilities.

The next step is to include children with cognitive disabilities into a full scale real world trial.

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