A NEW PERSPECTIVE ON ISA-EQUIPMENT: ASSISTIVE DEVICES FOR DRIVERS WITH ACQUIRED BRAIN INJURY

Brith Klarborg[1]*, Harry Lahrmann[2], Niels Agerholm[2], Nerius Tradisauskas[2], Lisbeth Harms[1]
1. Department of Psychology, University of Copenhagen, Øster Farimagsgade 5,
1353 Copenhagen K, Denmark. Phone: +45 30 25 20 99. E-mail: brith.klarborg@psy.ku.dk
2. Department of Development and Planning, Aalborg University, Denmark

Abstract

Intelligent Speed Adaptation [ISA] has proved successful at reducing the speed of normal drivers. However, until now the potential of ISA as an assistive device has been neglected. Two case studies were conducted to test ISA as a support for drivers with acquired brain injury [ABI] in driving with appropriate speed and thereby releasing cognitive capacity for other aspects of driving. The participants were two persons with ABI, who had retained their driving licenses. They were interviewed about their driving strategies before installation of ISA, and about their experience driving with ISA after the test period. The effect of ISA on the participants' speed is analyzed and combined with their evaluation of the utility of ISA. The results suggest that with further customisation ISA may be a suitable "cognitive prosthesis" for drivers with ABI, but with some reservations towards certain cognitive deficits.

Keywords

ISA, Assistive Technology, Acquired Brain Injury, Cognitive Prosthesis

Introduction

The present study is a sub-study within the "Spar paa farten"-project in the County of North Jutland in Denmark (for project presentation see: [1]). Unlike "Spar paa farten", which is open for enrolment for all drivers, this study focuses exclusively on drivers with cognitive deficits due to ABI. It is estimated that 1,1% of the Danish population has an ABI, the main part as a result of cerebrovascular accidents [CVA] and head traumas [2]. Today we lack ways of testing whether a person with ABI is fit to drive, as well as standardized procedures for what to do about a person's driving license in the case of an ABI [3]. This ultimately means that there is an element of chance in who keeps his/her driving license, and who does not. While research is being done clarifying this issue, it is worth investigating whether technology could support this group making the task of driving less demanding and at the same time improve traffic safety.

During the last decade the plasticity of the brain has come into focus, but not all cognitive functions are easily restored. So although our brain has some ability to "heal" itself, and many positive effects have been found from training cognitive functions through rehabilitating programs, many persons with ABI are still facing a number of permanently impaired cognitive functions. Therefore, the focus of rehabilitation has shifted from strategies of restoring to strategies of compensating. Technology plays an increasingly important part in the compensating strategies since technology-based assistive devices can be designed to function as "prostheses" for cognitive deficits. Elliot Cole [4], a pioneer within the field of "cognitive prostheses", has listed a number of defining characteristics for the term. A "cognitive prosthesis" should among other things have: 1) A possibility to customize the "prosthesis", 2) a direct assistance of the individual in performing its' daily activity, and 3) no additional features that are not clinically indicated. ISA-equipment fulfils these requirements but one: It was not originally designed for rehabilitation purposes. However, this may turn out to be an advantage. Customization of technology for people with specific needs is often a more economically realistic alternative to developing "cognitive prostheses" from scratch.

ISA as an assistive technology

ISA has proved successful in a number of previous field studies (for extensive reviews see: [5],[6]). As ISA has become a mature candidate in the field of intelligent traffic systems it is worth to test the potential of ISA also as a "cognitive prosthesis" for drivers with ABI. The present ISA-equipment works by displaying the current speed limit and giving the driver a voice message whenever the speed limit is exceeded by more than 5 km/h. These functions may guide persons with ABI to control speed appropriately. The task of "driving with an appropriate speed" draws upon a number cognitive functions ranging from vision (detecting speed posts and speedometer), attention (attending to speed at relevant times), memory (remembering speed limits), and executive functions (knowing what is an appropriate speed behaviour). Keeping track of speed though is only one out of many subtasks that make up driving; the potential of ISA as an assistive device lies in its hypothesized ability to help the driver to relocate cognitive capacity from focusing on speed to focusing on these other subtasks. A common problem with "cognitive prostheses" is that they demand the exact cognitive function they were intended to compensate for. For instance: Many devices have been constructed for memory support (electronic calendars, pagers etc.), but unless the design of these devices is extremely intuitive, persons with memory deficits may be incapable of learning to use them [7]. Similarly, ISA may support drivers with cognitive deficits in controlling their speed, but the presence of a display and a voice message may also be a source of distraction and disturbance to these drivers. Thereby ISA may end up seizing more cognitive capacity than the functionality of the device releases. The present study aimed at a clarification of this issue, and also at testing the hypothesis that ISA would cause drivers with ABI to experience the same decrease in the amount of speeding as other drivers.

The "intention to speed vs. inattention to speed"-model

On the basis of the two present cases we developed a tool for in-depth analysis of the basic nature of speeding problems; namely, the "intention to speed vs. inattention to speed"-model. Studying persons with cognitive deficits sometimes gives a unique possibility to gain a better understanding of how cognitive functions work and interact in non-ABI persons. Therefore, the model presented in figure 1 is applicable on all drivers, though developed on the basis of data from persons with ABI.

The "intention to speed vs. inattention to speed"-model operates with four different speeding profiles. The model is a cross-tab of two dimensions that were found to be critical factors in the generation of speeding, namely "intention to speed" and "inattention to speed".

		Inattention to speed	
		-	+
Intention to speed	-	**Profile 1: No speeding** Driver has no intention to speed and driver attends to speed	**Profile 2: Sporadic speeding** Driver has no intention to speed but driver is inattentive to speed
	+	**Profile 3: Controlled speeding** Driver attends to speed but driver has an intention to speed	**Profile 4: Excessive speeding** Driver has an intention to speed but also driver is inattentive to speed.

Figure 1 – Speeding profiles: Intention to speed vs. inattention to speed

The model not only introduces the question of whether speeding is deliberate (Profile 3, + intention) or accidental (Profile 2, + inattention), but also the possibility of two contributing factors (Profile 4, + intention + inattention). Furthermore, it specifies the criteria for successful handling of speed as well as the goal for a speed intervention (Profile 1, - intention - inattention). The model is meant as an overall descriptive tool to help characterize the general nature of a person's speeding problems, and will be applied as such in the analysis of the case studies.

Method

Recruitment of volunteers

Volunteers were recruited with support from "The Centre for Brain Injury" (Hjerneskadecentret) in Aalborg, which is a rehabilitation centre for adults with ABI. "The Centre for Brain Injury" was contacted and accepted to send out letters to all clients who had received rehabilitation at their centre during the previous four years, and who had retained their driving licences after the brain injury (a total of 15). Two individuals responded and accepted to volunteer as participants in the present study.

Equipment

The ISA equipment used for this project is the same as developed for the project "Spar paa farten", though with some minor modifications in order to customize the equipment for drivers with cognitive deficits. The equipment consists of an "On Board Unit" [OBU] matching GPS-positions with a digital speed map stored in a database in the car. The display of the OBU shows the actual speed limits and has an electronic voice which gives the message "50 [The actual speed limit] – you are driving too fast" whenever the driver exceeds the limit with more than 5 km/h. The voice repeats the message every six seconds until the speed once again is below the speed limit + 5 km/h. To minimize the information load on the participants' cognitive capacity a "point system" making it possible to see both the accumulated amount of speeding over time and on the present trip was removed from the display.

Design

The two volunteers had ISA equipment installed in their private car. The speed of the cars was logged for a period of 24 weeks, which was subdivided into three periods according to the ABA principle: The first 6 weeks period (A) served as a baseline for comparing the effect of ISA on driving speed. During this period both display and voice message was switched off. This was followed by a 12 weeks period (B) with all equipment switched on. Finally there was a second 6 weeks period (A) with the display and voice message switched off (at the time of writing the second A period is still running and is therefore not included in the analysis presented here). The case studies also include two semi-structured interviews with each participant. The "Interview 1" took place at the time of installation of ISA. The main purpose of this interview was to establish how the participants handled the task of driving with an ABI and served as a baseline for "Interview 2" which was concerned with changes in the drivers' strategy caused by ISA, as well as their experience and opinion of the equipment.

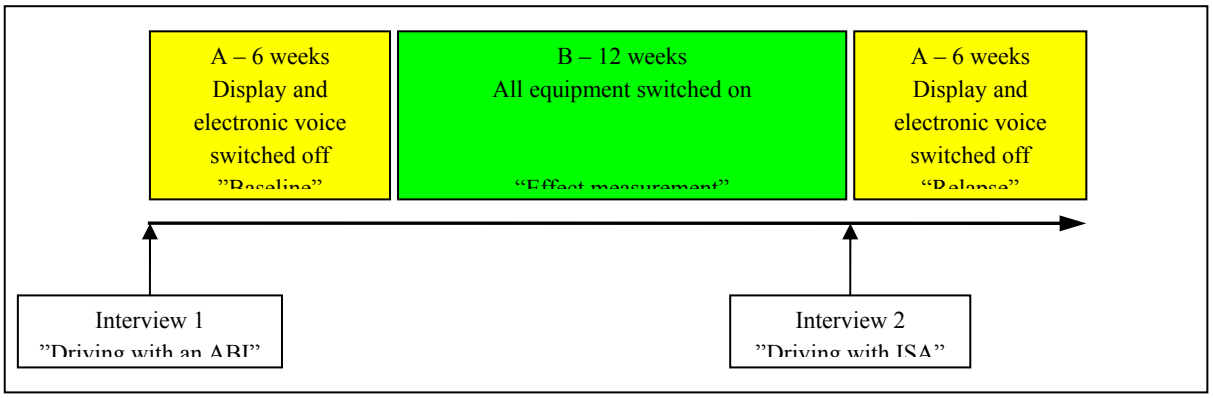

Figure 2: Design of case studies.

Case - GJ

GJ is a woman aged 67, whose ABI was caused by meningitis. Prior to the brain injury GJ worked as head of administration at a business school, but after her illness in 1988, she had troubles returning to work, resulting in early retirement. Before the injury she used her car to work every day, for

transporting her two children, and for family trips and vacations indicating a fairly average mileage. Having increasing mobility problems due to arthritis GJ is now very dependent on her car for everyday purposes. She estimates that she drives about 12000-15000 km per year, which is only a little less than when she was working. Having family in other parts of the country she drives long distances visiting them as well as shorter trips doing everyday purposes.

Neuropsychological profile

When GJ was tested with the standard neuropsychological test battery administered at "Rigs-hospitalet" (Copenhagen University Hospital) on the 12th of June 2002 all test scores in primary areas of cognition (memory, attention, problem solving. language, etc.) were within the range of normal cognitive functioning. However; a psychological assessment made in 2002 states that this result may be due to a very high level of pre-morbid functioning and concludes that a reduction is likely especially in the area of memory, which is GJ's primary subjective complaint. Furthermore, she quickly experiences mental fatigue, which also contributes to the feeling of a failing memory.

Interview 1 – Driving with an ABI

GJ uses a lot of her remaining cognitive capacity on focusing on speed limits. She explains in the interview, how she has to be very concentrated when driving. If, for instance, she has a conversation with a passenger while driving, she often loses track of the route and goes the wrong direction. When asked specifically about her ability to register speed posts, she replies:

GJ	I'll catch it! If it is put in the right place, then I'll catch it. That is for sure. […]
Interviewer	Is that because you are very concentrated?
GJ	Yes, exquisitely. And that also means… Let's say it's on the freeway; then I don't see who's coming [what's going on] in the track going north when I'm going south.
Interviewer	Does that mean that being aware that a sign is coming up also takes up a good part of your attention?
GJ	It does! It definitely does.

GJ is also aware that her strategy fails at times. After GJ acquired her brain injury she decided to obey the speed limits. But she still experiences that she ends up going too fast when focusing on other things:

> GJ … when I reach 130, then I try to keep it there. But if you are just looking… then all of a sudden you get to looking at the speedometer, and then it's gone up to 140! And I don't go too fast because I want to go fast. It simply sneaks up quietly. […] It is because I'm not concentrated enough… exactly on that part. Because I still can only do one thing at a time.

Speed log: Effect measurement

The relationship between GJ's total number of driven kilometres above the speed limit + 5 km/h and the total number below of the "baseline"-period was compared to the same numbers for the "effect measurement", and the decrease in the relative amount of speeding in the latter was tested to be statistically significant (χ^2=82.67, p<.001).

The effect of ISA on the percentage of the mileage driven with a speed which is a minimum of 5 km/h over the speed limit can be seen in figure 3. It is possible to see both the percentages for all kilometres driven across all speed limits, and in addition the same percentages for kilometres done on roads with speed limits of 50 km/h (urban roads) and 80 km/h (rural roads). In the "baseline" measurement GJ has a great variance in the amount of speeding (all limits, SD=6.84); however, when the equipment is switched on the variance decreases (all limits, SD=.82) and the amount of speeding stabilizes at a low level. In six out of the six weeks constituting the "baseline" condition GJ has a higher percentage of

mileage with speeding on 80 km/h roads than on 50 km/h roads, which means that there is a statistically significant difference between data from the two speed limits on a sign test (p=.031). During the "effect measurement" this difference disappears (Sign test, p=.388), meaning that the percentages for both speed limits are so low that there no longer is an effect of the road type on the amount of speeding.

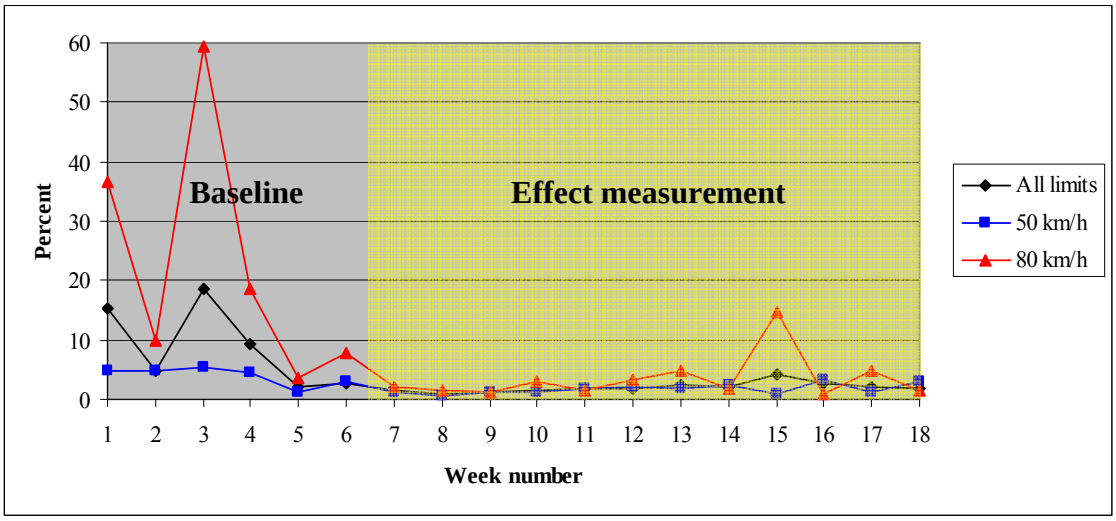

Figure 3: The percentage mileage driven at a speed which exceeds the speed limit with more than 5 km/h by GJ

Interview 2: Driving with ISA

GJ is very content with the equipment. She likes the electronic voice used for the voice message, and thinks that the interval between the messages is just right. When asked about the activation level for the voice message, she says she would put it at 2 km/h above the speed limit (as opposed to 5 in the current settings), could she adjust it herself. When asked if she would like to change anything about the equipment, her only comment is that it would be very helpful, if it was combined with a navigation system because of her problems orienting herself and memorising maps.

GJ states that she has never experienced confusion or distraction as a result of the equipment. She does recall cursing at the voice message in one incident, where she had to exceed the speed limit in order to avoid being hit by a car changing lanes, but says that the message is never annoying. She finds that the greatest advantage driving with ISA has to do with not having to change the direction of the eyes as often as when driving without ISA:

GJ	[…] I'm beginning to be able to see things when I'm driving. For many years it has been so that I don't see very much when we go for a drive, because I am so concentrated on driving. Because you must see both the driving and the traffic, and then you also have to watch the speedometer. Now [with ISA] I have sort of "disconnected" the speedometer. Because I let her [referring to the voice message] decide. And that means, that I once again can start getting a better outlook. So that's a more relaxed way of driving, that's for sure.
Interviewer	You find it more relaxing, because you don't have to move your eyes?
GJ	You don't have to move your eyes quite as much, you don't have to concentrate on quite as many things, right? Because most things concerning driving are on the backbone for us old hands. It's all automatic, right? But the speedometer isn't, it is one of the things that we always had to pay attention to.

Thus inferring from GJ's statements she has made a clear shift in her driving strategy. From using a lot of cognitive capacity on attending to speed limits, she now leaves this task to technology and uses the released capacity on improving her outlook.

Discussion of GJ

GJ has no intention to speed and tries to attend to her speed. But having a reduced cognitive capacity she experiences that her attention to speed is not adequate, making her a "Profile 2"-driver in the "Intention to speed vs. inattention to speed"-model (figure 1). Her inattention to speed is quite successfully compensated by ISA.

The hypothesis that ISA would support a general relocation of cognitive capacity from focusing on speed to focusing on other driving tasks was supported in the case of GJ. But she also gave a more concrete account of the mechanism releasing capacity, as well as the tasks benefiting from the extra capacity. The driving strategy facilitated by ISA where the driver keeps his/her eyes on the road instead of having to shift back and forth between the road and the speedometer is superior to GJ's normal strategy in multiple ways:

1) The speed information is being relocated to the auditive modality, making it possible to keep visual attention on the road and improving the probability of seeing critical information in the traffic scene as well as hearing speed information. This way the two types of information become less competitive because they draw upon the capacity of two different modalities [8].
2) The speed information does not have to be actively nor continuously searched for.
3) The speed information presented timely in the auditive modality improves compliance with the speed limits, which ultimately gives GJ more time to observe and react to information in the traffic scene.

However, the activation level of the current ISA-equipment becomes problematic with the practice of this strategy, since it implies that GJ is lead to drive 5 km/h above the legal speed limit.

Case – KB

KB is a man aged 54, who worked as a sales representative for 29 years prior to acquiring his brain injury, which was caused by a CVA in 1999 and again in 2001. He estimates that he in all his years working drove around 60000 km per year, which is up to four times the mileage of an average driver. After the second CVA KB was fired from his job, which lead to early retirement. He has maintained a considerable use of his car, estimating that he now drives around 45000 km per year. KB makes many visits to people living in other parts of the country.

Neuropsychological profile

During the first interview KB lists his primary problems as a failing short-term memory and being "spatially confused". This subjective account is supported by the neuropsychological tests, which indicate reduced attention and memory functions particularly when presented with "complex material" demanding simultaneous capacity. Both visuo-perceptive and visuo-constuctive functions were found to be reduced, which causes KB to feel confused when trying to navigate in traffic. Test results also reveal a number of problems within the executive functions: KB has reduced problem solving skills with a tendency to an impulsive and uncritical work process with no re-checking. These difficulties also become more apparent with complex material. Furthermore, it is stated in a psychological assessment from the 10th of April 2003 that KB lacks full awareness of his illness.

Interview 1: Driving with an ABI

In general KB is not very concerned about speed limits. When asked why he speeds, he replies:

KB	Basically I think time spent on the road is time wasted […]
Interviewer	Do you always pay attention to your speed?
KB	Yes, I think I do. So it is not because I don't know how fast I am going.

However, he has picked out some situational cues that make him use more of his remaining cognitive capacity on focusing on speed limits. The main cue that he mentions is road work, but he also states, that he in general does not speed on urban roads (50 km/h or below):

KB	… I'm aware about how fast I'm going. Especially where there is road work… then I slow down to the limit. There are people walking in the road and stuff. […] It is extremely dangerous for them if the rest of us race by with 80 or 100 km/h, so there I go 40 or 50, or whatever the limit is.
Interviewer	Does that mean, that in the situations, where it can be dangerous for somebody…
KB	… I drive properly.
Interviewer	But in the situations where it is a highway [KB interrupts]…
KB	… straight out the highway and nobody around, then I speed up.

KB has a very clear intention to speed outside urban areas, but does not think he has a problem with inattention to speed.

Speed log: Effect measurement

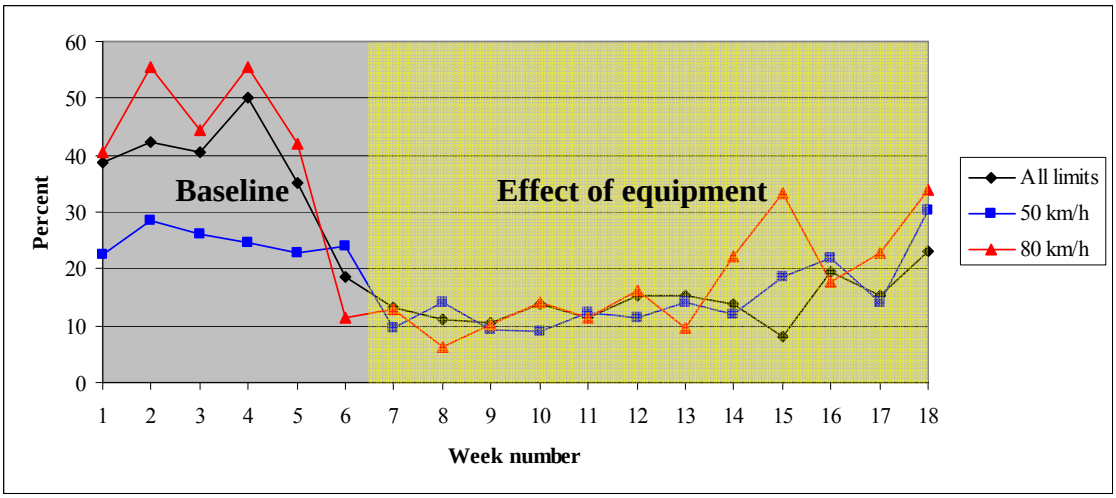

Figure 4: The percentage mileage driven at a speed which exceeds the speed limit with more than 5 km/h by KB

The data of KB as presented in figure 4 has some resemblance to the data of GJ (figure 3), just with a generally higher placement on the Y-axis, which means that a higher percentage of KB's mileage is driven with a speed exceeding the speed limit with a minimum of 5 km/h. As seen in the data of GJ the percentages of mileage with speeding decreases one to two weeks before the activation of ISA. This effect is not known from other studies and we have not found anything in our reviews of data that could explain a decrease preceding the activation of ISA. KB has less variance in the amount of speeding during the "effect measurement" (all limits: SD=4.05) than during the "baseline" (all limits: SD=10.50), though the decrease is not as large as with GJ. Five out of the six weeks of the "baseline" KB has a higher percentage of mileage with speeding on 80 km/h-roads than on 50 km/h. This means that there is a tendency going in the direction of KB's explanation of speeding less on urban roads than on rural roads; however, this tendency is not statistically significant (sign test: p=.219).

The total number of driven kilometres above the speed limit + 5 km/h vs. the total number below of the "baseline" was compared to the same numbers for the "effect measurement", and the reduction in kilometres driven exceeding the speed limit caused by the activation of the equipment was tested to be statistically significant (χ^2=435,83, p<.001). It is worth noticing that the effect towards the end of the second period seems to be slightly decreasing, especially on roads with a speed limit of the 80 km/h. A comparison of the data of the first half of the "effect measurement"-period towards the second half comes out borderline significant (χ^2= 4,64, p=0.031). Correcting for the arbitrary nature of the two

samples used in the last test and the increased risk of Type I errors when doing multiple significance tests, the significance level for this test must be lowered from .05 to .025.

Interview 2: Driving with ISA

KB finds the equipment to be genius. He does not want to change anything about the equipment, because he thinks it is "just right as it is". When it is brought to his attention, that the activation level for the voice message is 5 km/h above the speed limit, he suggests lowering the activation level so it matches the exact speed limit; that way the driver is not "rocked to sleep", that is; thinking he/she is obeying the speed limit when really exceeding it.

KB explains that he has never felt disturbed or confused by the use of the equipment. He does recall being angry at the electronic voice in the beginning, but says that he has become accustomed to it. This "accustomisation" may have to do with the discovery of a strategy for dealing with the voice message: KB describes how he simply turns up the volume on the radio when feeling too busy to comply with the voice message. KB's driving strategy does not become completely clear with respect to visual attention and direction of the eyes. He explains that ISA improves his outlook:

Interviewer	If you compare driving with the equipment to before you got the equipment, do you then think driving has become more relaxing or more strenuous?
KB	It has probably become a bit more relaxing. […] It is because I'm not so busy when I'm looking around, as when I'm speeding. Now I use my energy on driving properly.
Interviewer	Does that mean that when you speed you have to [KB interrupts]…
KB	Well then you really have to be on your toes!

But KB also mentions that a part of his new strategy involves looking much more at the speedometer in order to stay below the speed limit. According to KB he does not find it problematic to do so, since "[…] it is only a question of moving the eyes. And that does not really require any effort".

Discussion of KB

KB states in "Interview 1" that his speeding problems are only intentional, which should make him a "Profile 3"-driver (figure 1). However, taking his neuropsychological test results into account more likely he is a "Profile 4". This discrepancy may stem from KB's incomplete awareness of his illness, which leads him to continue to attribute his speeding to the same cause as before he acquired his brain injury, namely "intention". The speed log demonstrates the positive effects of ISA, and "Interview 2" suggests an experience of a release of cognitive capacity following the speed reduction. However, "Interview 2" also reveals two unsuccessful components in the interaction between KB and ISA: 1) ISA tries to compensate for inattention by a voice message, which leads KB to look more at the speedometer in order to avoid activation of the voice message. Surveying the speedometer may end up consuming some of the capacity released by the speed reduction. 2) Intention to speed is attempted reduced by making the voice message repeat itself as long as speeding occurs, giving the driver an incentive to slow down. But KB does not completely lose his intention to speed, as he instead develops a strategy for overcoming the intervention. Having deficits in the executive functions will often cause a person to choose inefficient and inappropriate strategies, and to hold on to these strategies even after they have proven themselves to be so [9]. Apparently these problems are aggravated by the present design of the case studies. KB had no instruction or training in how to use the equipment, and as a result he has developed an inappropriate use of ISA. Presumably KB and other drivers with deficits within the executive functions need instruction and practice for developing an appropriate strategy for using ISA.

The tendency found in KB's driving data showing a decreasing effect of ISA towards the end of the B period could be caused by habituation to the voice message or by an increase in the use of his "turn up the radio"-strategy. A long-term study is needed to determine whether the effect of the equipment on drivers with ABI found in this study attenuates over time.

Comparison of the two case studies

ISA reduces the amount of speeding in both cases, which is in accordance with findings in other ISA studies with non-ABI drivers. Reducing the amount of speeding is a major safety improvement for any driver, but even more so for a driver with ABI. Some of the common consequences of an ABI are longer reaction times and a reduced cognitive capacity within the primary areas of cognition, e.g. memory and attention, as well as a reduced psychomotoric tempo [10]. Applied to driving this means that it may take longer time to shift visual attention between the road and the speedometer, and longer time to detect and react to critical information in the traffic scene [11]. Considering that persons with an ABI generally need more time than before their injury to perform the task of driving, it is important that speeding is avoided, since a consequence of speeding is less time to perform the task of driving.

While the speed log clearly suggests benefits from ISA with respect to speeding in both cases the interviews suggest that the driving strategy of the two drivers differ. GJ has developed a very successful strategy giving her good compensation for her problems of inattention. However, this strategy makes the driver dependent on ISA and requires both good accuracy and maintenance of the equipment as well as the digital speed map. Any error or break down would leave the driver in a vulnerable situation. It is important to correct all errors in the equipment and keep the dependency of vulnerable drivers in mind when introducing new assistive technologies.

The driving strategies developed by KB are less successful in terms of traffic safety. Although he now is more attentive to speed, looking away from the road to check the speedometer is problematic due to the longer reaction times and the reduced cognitive capacity discussed in the beginning of this chapter. The fact that KB does not recognize it as such must be seen as another example of his incomplete awareness of his illness. KB's other strategy of "turning up the radio to disguise the voice message" is problematic because of the potentially hazardous cocktail that emerges when a person with ABI mixes speeding with using the capacity of the auditory attention for loud radio and continuous ISA voice messages, and thereby blocking out potentially important auditory information. This particular strategy raises a dilemma: The equipment could need a button for switching off or pausing the voice messages for a fixed time interval. This would decrease the amount of distractors in a situation already critical because of the decision to speed. A pause button could also prevent interference from the equipment when doing critical operations like overtaking another car, or in the situation described by GJ, where she had to speed up in order to avoid being hit by a car changing lanes. However, such a button would be a distraction itself, and furthermore it inevitable would lead to an increase in speeding, making it ultimately a change for the worse. The best available solution seems to be educating persons with ABI about the hazards of speeding in general, and the extra necessity to obey the speed limits when having ISA in the car. Agreeing to have ISA installed should be set equivalent of agreeing to attempt not to speed.

In general KB's problems within the executive functions such as choosing inappropriate driving strategies and having poor insight into his own illness seem to be at the root of his unsafe driving both with and without ISA. It is possible that persons with such deficits are incompatible with ISA; however, our approach throughout this paper has been to suggest elements (instruction, training, education) that could be incorporated into the design of future research before determining the utility of ISA with this group.

Conclusion

An analysis of the driving strategies held by the participants in the case studies revealed two critical dimensions in relations to speeding: "Intention to speed" and "inattention to speed". The voice message of the equipment was found to affect both dimensions; it supported the driver with ABI in paying attention to speed at relevant times and was also an incitement to slow down. This is reflected in the speed logs of both drivers, which show a statistically significant reduction in the amount of speeding when using ISA-equipment. None of the two drivers reported being confused or disturbed by the equipment itself, however their use of the equipment varied more than first expected. An analysis

of the two drivers' driving strategies revealed the need for modification of ISA, when used as a "cognitive prosthesis".

In "Case Study 1" a very exemplary strategy was developed taking full use of the possibility offered by the equipment to redirect the speed information from the visual attention to the auditive, which also means that the direction of the driver's eyes no longer had to be moved back and forth between the road and the speedometer. This leaves the driver with more visual attention for the traffic scene. However, the presented strategy puts the driver in a situation with a high degree of dependability on the technology, which gives rise to high demands of reliability for the equipment when implemented. It also stresses the need for adjusting the activation level of the equipment for preventing drivers from habituating to drive 5 km/h above the speed limit.

In "Case Study 2" the reported strategies contained some very inexpedient elements, the main reason being the person's problems within the executive functions. To improve the interaction between a person with these deficits and ISA another two alterations are recommended: 1) A training session in the car instructing the driver in the best strategy for driving with ISA, 2) An educative session informing the driver of the increased hazard emerging when mixing ABI, speeding and further distractions (ISA voice message, radio. etc.).

Results of the present study suggests that ISA may be a suitable "cognitive prosthesis" for drivers with ABI, but with some reservations towards persons with problems in the executive functions. However, the use of ISA as a "cognitive prosthesis" requires both reliability of the technology, further individual customisation, and for some drivers presumably instruction and practice in appropriate use.

References

[1] Agerholm, N., Tradisauskas N., Klarborg, B., Lahrmann, H. and Harms, L. (2007). *SPAR PÅ FARTEN – De Første Resultater af et ISA-projekt med Unge Bilister i Nordjylland*. Paper for "Trafikdage på Aalborg Universitet", 27th -28th of August, 2007.

[2] The Brain Injury Recource Center: *www.vfhj.dk,* Videnscenter for hjerneskade, Stouby.

[3] Meng, A. (2006). *Hjerneskade og kørekort. Centrale problemstillinger og forslag til forbedring af praksis,* Videnscenter for hjerneskade, Stouby.

[4] Cole, E. & Matthews, M. K. (1999): *Cognitive Prosthetics and Telerehabilitation: Approaches for the Rehabilitation of Mild Brain Injuries,* in: Murner, J. & Ettlin, T. M.: HSW-Distorsion & Leichte Traumatische Hirnverletzung Behandlungskonzepte. Basel

[5] Warner, H. (2006). *Factors Influencing Drivers´ Speeding Behaviour,* Acta Universitatis Upsaliensis, Uppsala.

[6] Regan, M., Triggs, T., Young, K., Tomasevic, N., Mitsopoulos, E., Stephan, K. and Tingwall, C. (2006). *On-road evaluation of Intelligent Speed Adaptation, Following Distance Warning and Seatbelt Reminder Systems: final results of the TAC SafeCar project,* Volume 1: Finale Report. Monash University Accident Research Centre, Victoria.

[7] Inglis, E., Szymkowiak, A., Gregor, P., Newell, A., Hine, N., Wilson, B., Evans, J. and Shah, P. (2004). *Usable technology? Challenges in designing a memory aid with current electronic devices,* Neuropsychological Rehabilitation, 14, p.77-87.

[8] Larsen, A. McIlhagga, W., Jaroen, B. and Bundesen, C. (2003). *Seeing or hearing? Perceptual independence, modality confusions, and crossmodal congruity effects with focused and divided attention,* Perception and Psychophysics, 65, p.568-574.

[9] Gazzaniga, M., Ivry, R. and Mangun G. (2002). *Cognitive neuroscience: the biology of the mind,* 2nd ed., W. W. Norton, New York.

[10] Riberholt, I., Lund, V. and Tommerup, M. (2003). *En kortlægningsundersøgelse af voksne med pludselig opstået hjerneskade i Vestsjællands Amt. Hvor mange og hvordan,* Hjerneskadesamrådet, Vestsjællands Amt.

[11] Duncan, J., Bundesen, C., Olson, A., Humphreys, G., Chavda, S. and Shibuya, H. (1999). *Systematic Analysis of Deficits in Visual Attention,* Journal of Experimental Psychology: General, Vol. 128, No. 4, p. 450-478.