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BRAIN-COMPUTER INTERFACE-BASED FEASIBILITY OF ENTERING CUSTOMER CODE ON TICKET VENDING MACHINES

Dénes Simonyi* and Tibor Kovács

Óbuda University, Doctoral School on Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

The availability of EEG-based Brain-Computer Interface (BCI) devices, which are also available in everyday applications, has widened the application environment. Many manufacturers have marketed their own mobile device, which will become virtually accessible to everyone in the near future, opening up new perspectives in the modern world of human-machine interaction. One of its potential areas is to broaden the communication capabilities of people with physical disabilities, providing them with data inputs that they had previously not been able to. Such a feature is a keyboardless text input. In Hungary, in case of online shopping, the receipt of a train ticket through the MÁV ticket sales machines is also possible to be received by entering the customer code by typing numbers on a touch screen. However, due to disability, physical injury or other reasons, there are cases where the user is unable to use hands, therefore this possibility is virtually impossible to access for them. This omission may, in our opinion, be eliminated by alternative identification methods. The purpose of this research is to assess the feasibility of entering characters using EEG based BCI techniques on those machines. The research consists of two parts. In the first part, the technical parameters of railway ticket vending machines were surveyed to determine whether or not they provide an opportunity to connect external devices and provide backgrounds for software communication with BCI. The second part of the research is a questionnaire research. We visited institutions that care for people with reduced mobility and asked them to fill out our questionnaire with their patients to assess the need for a possible BCI tool on rail ticket vending machines. We have also prepared a second questionnaire to measure the attitude of healthy individuals to the use of this device.

KEY WORDS

brain-computer interface, biometric identification, ticket vending machines, rail transport

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*Corresponding author, η: denes.simonyi@gmail.com; +381 601661675;
Narodnog fronta 15, Feketić/Bácsfeketehegy, Serbia

INTRODUCTION

The concept of a smart city means something different for everyone. There is one meaning for an architect, another for a doctor, something else for an entrepreneur. But in the same way, it means something to a child, a different thing to an adult, a healthy person, and a sick person. If you search the web, you will find countless different definitions. Like many decades ago, when the notion of smart cities was only utopian in the public consciousness, today everyone is trying to describe his own point of view in some way. Everyone agrees that, in the case of smart cities, all forms of transport have an infinite amount of potential to exploit. Public transport, including rail transport, plays a key role, as it is one of the most economical and environmentally friendly forms of transport for everyone. Of course, this efficiency can be further enhanced with the introduction of new services and the further development of the existing ones.

This research is concerned with the expansion and possible facilitation of an essential component of rail passenger transport, the purchase of electronic train tickets. It is trying to find out whether technical and social judgment can be implemented in the near future on rail ticket vending machines by entering the customer code using Brain Computer Interface (BCI). This technique would not only be a new option in the ticketing process on vending machines, but it could also provide assistance to people with reduced mobility who are unable to use them due to their illness or disability.

BRAIN COMPUTER INTERFACE

The Brain Computer Interface is a computer communication device that provides a direct, non-muscular communication channel between an individual and the computer. To achieve communication, brainwaves are required. This can be achieved without inserting electrodes (MEG, PET, fMRI and optical imaging) and electrodes (EEG), which can be invasive and non-invasive. At the moment, EEG is the only technology that has short time constraints and can be implemented with relatively simple and inexpensive equipment. The use of currently available techniques only provides some indirect way of text input (selective attention, motor imagery) [1-8].

Three key factors have been taken into account when designing research goals:

1.) It is important that the ticket vending machines are constituting a compact unit, they are not equipped with external USB ports. In these vendors, communication between the BCI device and the machine must be realized through existing external ports. The two most popular BCI devices currently available are Bluetooth or USB port support, but Bluetooth connectivity can also be achieved via USB dongle [9-13].
2.) Society generally does not react with immediate acceptance to technological innovations, following Rogers' innovation curve [14]. How much time is needed for the majority to accept a new innovation product depends on a number of circumstances [15].
3.) Based on the data of the Hungarian census of 2011, the number of physically disabled persons in Hungary is 232 206. This is 2,34 % of the total Hungarian population, and almost half of all the disabled, that is 47 %. 39,87 % of people with disabilities have said that their disability is disturbing in traffic [16].

During the research we examined the following three questions:

1.) Are today's available ticket vending machines able to connect a BCI device to them?
2.) Is such a technical innovation acceptable to users?
3.) Does such a device make it easier for handicapped or disabled people to buy tickets for rail travel?

RESEARCH METHODS

The technical data of railway ticket vending machines was obtained from the data sheets provided by 3 different vending machines. In the second part of the research, we investigated the second and third research domains by anonymous online questionnaire research. We have treated the responses of physically disabled people separately.

RESEARCH RESULTS

It is true that the Neurosky EEG helmet realizes Bluetooth communication [17], but it does not necessarily require a built-in Bluetooth adapter, even with a Bluetooth dongle that can be connected via a USB port. Based on this, the minimum connection condition is the USB port. Emotiv's products supports Bluetooth and USB communication [18].

For the application of a BCI device that can be used on railway ticket vending machines without an external USB port, it is needed to find a solution for communicating with the available input ports. Both manual and automatic bank card readers, with which MÁV's vending machines are also equipped [15], support the ISO7816 standard [19-22]. This means they can read IC cards. The solution requires the creation of a device that creates a connection between the BCI device and the card reader. The ticket machine must also have a software that can read data received from the card reader and transmit it to the software written on the BCI. To do this, the correct data transfer rate must be ensured. Emotiv headset sampling rate is 2 048 bit/second [18], Neurosky headset is 6 144 bit/second [17]. Between the reader and the card the initial speed is 9 600 bit/second [23]. This is sufficient to transfer signals from the device.

Another important aspect was which operation system the BCI software is running on. There are officially available text input softwares, and two of them, BCI2000 and OpenVibe are the most common [24-26]. However, as this area is not fully explored yet, it is constantly under development and research. In addition, firms distributing headsets also provide their products with the so-called SDK (Software Development Kit) for such programming languages that can be used to write application programs on multiple operating systems. Microsoft Windows is supported for each of the devices studied [12, 17, 18].

Three of the examined railway ticket dispensers and their important parameters for research are presented in Table 1. Table 1 shows that all machines have a USB port and operate on a Linux or Windows operation system. This is in line with our expectations and we can conclude from this point that the use of the BCI tool can be used to enter the customer code on the train ticket vending machines.

We tried to get information about MÁV's rail ticket vending machines, but we only found out that they were based on industrial PC. Based on videos found on YouTube, among which there are some showing that the automated operating system sends an error message to the user, the operation system running on them is Microsoft Windows.

Table 1. Railway ticket vending machines and their parameters [13, 26, 27].

Manufacturer	Type	Operation System	Number of USB ports	Built-in Bluetooth
LKS	42" touch screen ticket vending machine with ticket dispenser, ticket printer	Windows 7 or XP operation system, O.S. not included	6	N/A
Elektronet	TVM 0012	Microsoft Windows	8	N/A
Breeze Innovations	Breeze ECC – A SMC/ ATVM Client	Linux	6	N/A

Summarizing the results, we can conclude that the available train ticket vending machines support the BCI tools when the software is installed.

CAN SUCH TECHNICAL INNOVATIONS BE ACCEPTABLE TO USERS?

We tried to answer the question using an anonymous questionnaire survey online, intended to be a preliminary survey, and it can be used for a detailed, comprehensive research later on.

As we have already mentioned when formulating the goals, the wide differentiation of innovation depends on a number of parameters, along the Rogers curve, happening in stages: cognition, interest, evaluation, testing, and acceptance.

The participants in the process, based on the dynamics of innovation, are divided into five groups according to Rogers [14]:

1.) innovators 2,5 %,
2.) early adopters 13,5 %,
3.) early majority 34 %,
4.) late majority 34 %,
5.) laggards 16 %.

The Rogers curve is shown in Figure 1.

With the questions in the questionnaire, we wanted to find out the general information about what they think influences the group of individuals they belong to: gender, education, work, computer skills, internet habits, electronic ticket buying, if they are aware that railway ticket vending machines exist in Hungary.

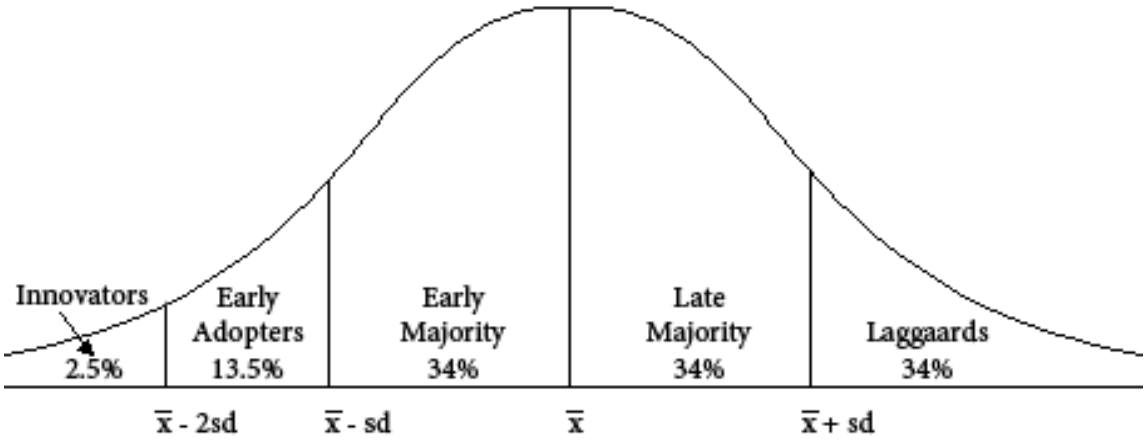

Figure 1. Innovation adoption curve [27].

In addition, we have been looking for the extent to which they show interest in the use of the ticketing automats with the BCI tool, and how often they would use it.

The questionnaire was filled out by a total of 166 persons, of whom 74 were physically disabled or disadvantaged, and 92 were physically not disabled/disadvantaged.

Since our intention was to pay special attention to the responses of physically disabled/disadvantaged respondents, and the ratio did not either correspond to the distribution of population in Hungary, the analysis was carried out separately for the two groups. Therefore, the results of the non-disabled/disadvantaged group and the results of the physically disabled/disadvantaged group will be presented separately.

The gender distribution of non-disabled/disadvantaged groups is 31 women and 61 men, Table 2.

Table 2. Gender distribution of physically not disabled / disadvantaged respondents.

Age	Male	Female	∑
18-24	25	5	30
25-34	20	8	28
35-44	11	9	20
45-54	3	6	9
55-64	1	2	3
above 64	1	1	2
∑	**61**	**31**	**92**

Table 3. Gender distribution of physically disabled / disadvantaged respondents.

Age	Male	Female	∑
18-24	2	4	6
25-34	4	5	9
35-44	3	4	7
45-54	6	9	15
55-64	7	16	23
above 64	6	8	14
∑	**28**	**46**	**74**

Filling out the questionnaire was voluntary, via a web interface, which meant that we could not influence gender. It appears from the tables that the majority of men (66,30 %) are in the non-disabled/disadvantaged group, while in the disabled / disadvantaged group women are, in similar proportions (62,16 %).

In the non-disabled/disadvantaged group, the majority of respondents are under the age of 45 (84,78 %), while the majority of applicants in the disabled / disadvantaged group belong to the age group above 44 (70,27 %).

The questionnaire contained two questions which we used to divide the respondents into three groups. In the first group, following Rogers' division, there were the innovators, early adopters and early majority, the second group was the late majority, while the third group was the laggards and those who are not willing to accept the technology at the moment.

The first group represents those individuals who would use the device on a regular basis to respond to them and would clearly buy it if it was to match the price of a mid-range keyboard.

In the second group, we classified those individuals who would try the device and buy it, or may be uncertain whether they would buy the device if its price would match the price of a mid-range keyboard. In the third group, we grouped individuals who would not try and would not use the device either.

All three groups were based on two replies, the aim of which was to filter out the respondents who gave conflicting answers. After the discontinuation of the controversial questionnaires, we received a total of 61 evaluable questionnaires from the non-disabled / disadvantaged group and 46 questionnaires from the disabled / disadvantaged group.

The gender ratio corresponds to the aggregate ratio in all divisions, so we did not make a separate statement for this.

The aggregate percentage distribution of results is shown in Table 4.

Analyzing the results, it can be stated that 55,74 % of the non-disabled / disadvantaged respondents are in the first group. This is only 5,74 % higher than the rate set by Rogers. In the case of disabled/disadvantaged, it is 43,48 %, which is only 6,52 % lower than that of Rogers.

In the second group, which includes the late majority by Rogers, the proportion of non-disabled/disadvantaged respondents is 11,05 % lower than that of Rogers and 7,3 % higher in the disabled/disadvantaged group. It is a group of two sub-groups and, if we examine it, the difference on one side in both cases is almost exactly reflected in the difference on the other side. In the case of non-disabled/disadvantaged persons it is –5,31 % and 0,78 % for the disabled/disadvantaged group.

The third group is the group of laggards. The proportion of non-disabled/disadvantaged respondents in this group is 21,31 %. The difference of –5,31 % in the second group appears visibly here, as they are also borderline categories. The proportion of disabled/disadvantaged respondents is only 0,78 % different from Rogers, which is a negligible difference.

With this in mind, we have looked at the responses that determine the limitations and we have come to the conclusion that the aforementioned deviations result from these, and that by replicating the research on a larger population, these responses have to be defined in more details and additional opportunities for respondents.

PARAMETERS DEFINING THE GROUPS

As the next step, we determined the factors that are most characteristic of each group. The results were determined according to Table 4. Defining factors within the group were those with the highest number of responses in the given group.

RESULTS OF NON-DISABLED/DISADVANTAGED RESPONDENTS

The first group is characterized by 18-44 year-olds with a high school education at least, and their job also requires at least high school education. They have at least basic IT knowledge, place of living is not a factor. In this group, there are individuals who are familiar with, used, and also do not use the E-ticket service and rail ticket vending machines.

The second group is characterized by 45-54 year-olds, there are no one without profession and none are post-graduates, and their occupation is characterized by being machine builders, operators and drivers as well as agriculture and forestry occupations. They have mid-level IT skills. Following the first group, this group has the majority of people living in the capital city. One third of the regular users of ticketing machines are in this group.

The third group contains the majority of people over the age of 54. This group includes non-educated people with primary education, non-skilled workforce and most of the people who do not have the proper IT background knowledge to use the computer on their own. The same number of people lives in county capitals as in the first group, and one third of them uses rail ticket vending machines.

The resulting curve is shown in Figure 2.

RESULTS OF DISABLED/DISADVANTAGED RESPONDENTS

The first group includes 25-44 year-olds and those above 54, college, university and postgraduate qualifications, and most of the people requiring higher education. There is the same number of non-qualified workplaces in this group as in the second (40%). The group is characterized by medium-level IT skills and IT knowledge. This group contains the majority of people living in Budapest, in other cities and in the villages. This group has the most individuals who have not used it yet, have used it or regularly use the E-ticket service. In this group there are the most individuals who know the existence of railway ticket vending machines but have not used them yet.

Table 4. Percentage distribution of the factors investigated by groups.

Factors examined	Non-disabled/disadvantaged			Disabled / disadvantaged		
Group	1	2	3	1	2	3
Total	**55,74%**	**22,95%**	**21,31%**	**43,48%**	**41,30%**	**15,22%**
Age group						
18-24 years	59,09%	31,82%	9,09%	20,00%	80,00%	0,00%
25-34 years	62,50%	18,75%	18,75%	57,14%	42,86%	0,00%
35-44 years	66,67%	8,33%	25,00%	50,00%	50,00%	0,00%
45-54 years	33,33%	50,00%	16,67%	25,00%	62,50%	12,50%
55-64 years	33,33%	0,00%	66,67%	41,67%	33,33%	25,00%
under 64 years	0,00%	0,00%	100,00%	60,00%	10,00%	30,00%
Highest education level						
Without graduation	0,00%	0,00%	100,00%	0,00%	100,00%	0,00%
Primary school	0,00%	33,33%	66,67%	33,33%	66,67%	0,00%
High school / Grammar school	58,62%	24,14%	17,24%	30,00%	45,00%	25,00%
College, university	57,69%	23,08%	19,23%	58,82%	29,41%	11,76%
Post-gradual (Masters/PhD)	100,00%	0,00%	0,00%	100,00%	0,00%	0,00%
Occupation						
Other jobs, with tertiary or secondary degree	61,11%	27,78%	11,11%	63,64%	27,27%	9,09%
Jobs with individual use of tertiary degree	46,67%	20,00%	33,33%	62,50%	25,00%	12,50%
Leaders in fields of economy, management, interest representation g	0,00%	0,00%	0,00%	33,33%	66,67%	0,00%
Machine operators, assemblers, and drivers	0,00%	100,00%	0,00%	33,33%	66,67%	0,00%
Jobs in industry and architecture	60,00%	20,00%	20,00%	0,00%	0,00%	0,00%
Office and business (customer relationship) professions	80,00%	0,00%	20,00%	33,33%	50,00%	16,67%
Trade and service occupations	77,78%	11,11%	11,11%	22,22%	44,44%	33,33%
Occupations in agriculture and forestry	50,00%	50,00%	0,00%	0,00%	0,00%	0,00%
Jobs not requiring any professional skills	0,00%	25,00%	75,00%	40,00%	40,00%	20,00%
Jobs at armed services	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%
IT knowledge						
No proper knowledge for individual IT usage	33,33%	0,00%	66,67%	33,33%	33,33%	33,33%
Basic	50,00%	16,67%	33,33%	31,25%	43,75%	25,00%
Intermediate	36,84%	31,58%	31,58%	43,75%	43,75%	12,50%
Advanced	73,68%	21,05%	5,26%	33,33%	66,67%	0,00%
IT professional	64,29%	21,43%	14,29%	100,00%	0,00%	0,00%
Place of living						
Budapest	55,56%	44,44%	0,00%	50,00%	35,71%	14,29%
County capital city	40,00%	20,00%	40,00%	18,18%	63,64%	18,18%
City	56,00%	24,00%	20,00%	42,86%	35,71%	21,43%
Municipality / village	59,09%	13,64%	27,27%	71,43%	28,57%	0,00%
Are you aware of the MAV's E-ticket service?						
Yes, but I haven't used it yet.	53,33%	26,67%	20,00%	22,22%	66,67%	11,11%
Yes, I have used it.	54,55%	36,36%	9,09%	66,67%	22,22%	11,11%
Yes, I use it regularly.	50,00%	16,67%	33,33%	100,00%	0,00%	0,00%
No, I am not.	58,62%	17,24%	24,14%	50,00%	27,78%	22,22%
Do you know that certain train stations have ticket vending machines?						
Yes, but I haven't used the yet.	48,00%	28,00%	24,00%	64,00%	20,00%	16,00%
Yes, I have used a machine like that.	62,50%	25,00%	12,50%	37,50%	62,50%	0,00%
Yes, I regularly use them.	33,33%	33,33%	33,33%	0,00%	0,00%	0,00%
No, I don't.	64,71%	11,76%	23,53%	7,69%	69,23%	23,08%

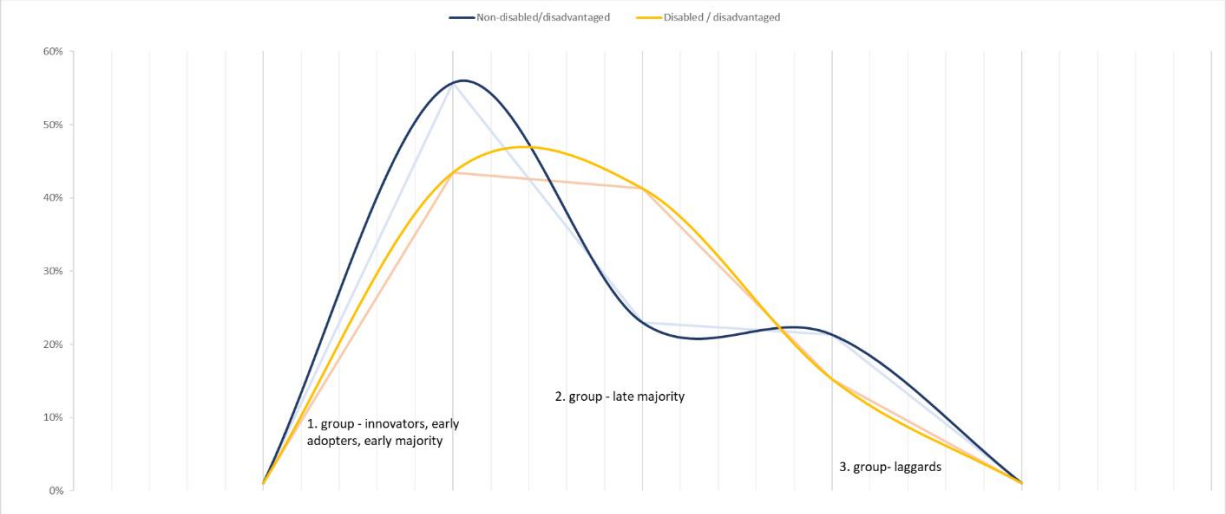

Figure 2. Distribution according to the groups.

The second group is between 18-24 and 35-54 years of age, having high school, grammar school or lower education. The most typical occupations of the group are: economists, administrative workers, interest representation leaders, legislators, operators, assemblers, drivers, office and business (customer relationship) professions, trade and service occupations and armed services. It is characterized by basic, intermediate and advanced IT skills. This group contains most individuals living in county capital cities. In this group, there are the most people who know about the E-ticket service, but have not used it, have used it, as well as those who have not used a train ticket vending machine yet.

The third group is characterized by a low percentage in all areas. Its members are older than 45, and no factor is representative in this group.

WOULD SUCH A DEVICE MAKE IT EASIER FOR DISADVANTAGED PERSONS/PEOPLE WITH DISABILITIES TO PURCHASE RAIL TICKETS?

In this issue only the responses of people with reduced mobility/disabilities have been analysed.

There was only one person who did not use the Internet. 27,03 % lives in Budapest, 25,68 % in county capitals, 32,43 % in towns and 14,86 % in municipalities or villages. 88,33 % spends several hours a day on the Internet. 45,95 % of them says that rail ticket purchases are made easier by E-ticket service, 9,46 % says there is no difference between them and traditional ticket purchases and only 1,35 % thinks it makes it more difficult. Regardless of the place of residence, the majority, who believes that E-ticket services make purchases easier, prevails everywhere. 14,86 % does not agree that rail ticket vending machines make it easier for them to buy tickets. 82,43 % of them agrees, the remaining 2,70 % did not give a sensible answer (they cannot use or do not use ticket vending machines).

The answer to the question if they had the opportunity to use a tool to enter the code into the ticket vending machine without typing, would they try/use it, is that 14,86 % would not try it, 52,70 % would try it, but not use it regularly, 32,43 % would use it regularly.

The same device would be bought by 58,11 % if it existed and would not cost more than a mid-size keyboard (of which 22,97 % would purchase it unconditionally). 29,73 % does not need it, 9,46 % thinks it is expensive and would not buy it. The remaining 2,70 % is uncertain, they cannot imagine using it.

By reviewing the responses, we can conclude that the responding disabled/disadvantaged population is open to using such a tool and sees potential. The answer to this question is yes, according to those surveyed; such a device would facilitate the purchase of rail tickets for people with mobility impairment.

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