Mental Models of a Cellular Phone Menu. Comparing Older and Younger Novice Users

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Abstract. This study shows the interrelationship between mental models of a phone menu and performance depending on users' age. The mental representation was assessed through card-sorting technique in 32 novice users (16 aged 20-32, 16 50-64 years).

First, they had to process four common tasks on two simulated mobiles enabling online logging of users' actions. None of the older participants had a correct mental representation of the route to be taken to solve a task, and some were not even aware of the hierarchical nature of the phone menu. Younger participants, in contrast, had a fairly correct mental model.

Furthermore, it was shown that the better the mental map of the menu, the better the performance using the device. In conclusion, it is important to know the hierarchical structure of the menu in order to use a cellular phone properly. Therefore, it should be made more transparent to the user.

1 Introduction

Why do older adults in particular face extreme difficulties when starting to use a new electronic device, for example a mobile phone? As reported by Maguire and Osman [7], the development of mobile phone technology seems to concentrate on what young and experienced users want. In contrast, for the older users, an easy to use menu is the most important issue [7].

When older people purchase their first cellular phone, they are offered some attractive services and features which they are interested in. For example, they think the opportunity to check train departure times while being on the move seems to attractive to them. However, after getting the phone and trying to use it for a short while, these plans often fail.

It's not just older users. Younger people are also having trouble using new mobile devices. However, the difficulties of the elderly seem to be located at a more fundamental level. To get a better understanding of their specific problems, we should consider differences in the basic cognitive requirements between younger and older people while dealing with hierarchical information structures, such as the mobile phone menu.

1.1 Differences in Information Processing Between Younger and Older Adults

What are the differences in younger and older people's information processing? Several fundamental abilities necessary for information processing come into play when using a technical device with a complex hierarchical menu structure.

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The decline in **memory capacity** in older adults is a well-known issue [9]. However, good memory abilities should be of importance for the use of devices since the user has to memorize the functions and their location within the menu. Indeed, in a recent study it was shown that the higher users' memory capacity, the better their performance using a mobile phone [3].

Further, **spatial abilities** have proven to decrease as people live longer. For example, in a study comparing participants aged 19-27 and 66-77 [5], mental rotation was reduced by 96%. Since the menu of the phone is organized in a tree structure, spatial abilities may play an important role for the use of mobile phones. Also, because menu functions are organized in various levels, spatial visualization abilities could be necessary for the correct use of the menu.

In the mobile phone, where the overall structure of the menu is not transparent, spatial abilities may be more important, because the user has to build a mental representation of the structure when navigating through the functions. In this case, older people experience difficulties navigating in the user interface of a mobile.

If you compared navigation behavior in a mobile phone menu with that in the natural environment, according to theory [10] three types of knowledge should be of importance:

1) **Landmark knowledge** representing main features on the route
2) **Procedural knowledge** (or Route knowledge) of the sequence of actions required to get from one point to another
3) **Survey knowledge** representing the overall structure of the information and an overview of locations and routes in the environment.

It remains to be seen whether older adults show more difficulty acquiring all three types of knowledge important for spatial orientation compared to younger users.

The third possibility is that young people have been exposed to menu-driven technology since earlier times (such as video games). This should have influenced their mental model of the functioning of menus in general - that is the tree structure. This knowledge can be transferred to new devices, such as mobile phones. On the other hand, the elderly may not have a proper mental representation of a mobile phone's organization of functions in categories within a "menu". The concept of a "menu" may be unfamiliar to them.

The present study aims at exploring the mental model of a mobile phone menu in younger and older novice users after having processed four common tasks on the device.

To conclude this section, the purpose of this study is:

1) Find out reasons for older users' bigger difficulties using mobile phones compared to younger users
2) Method: assessing users' mental model of the mobile phone menu
3) Finding connections between mental models and performance using the mobile phone

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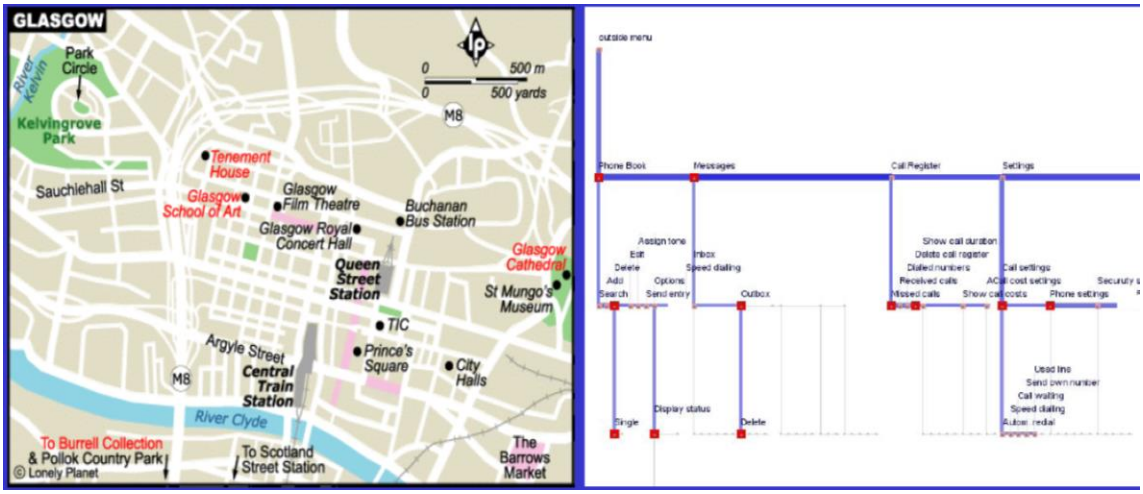
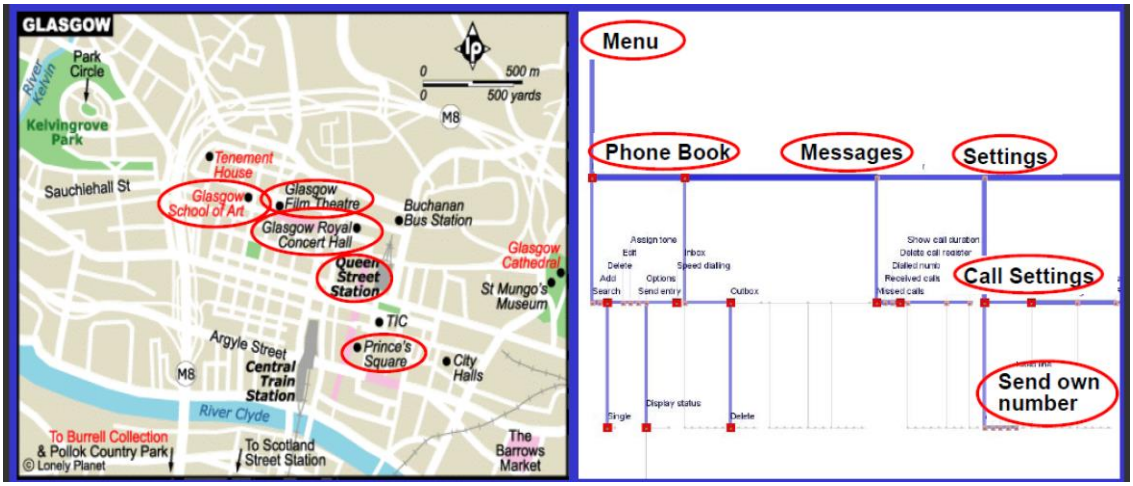
For 2), the mental models of a mobile phone menu:

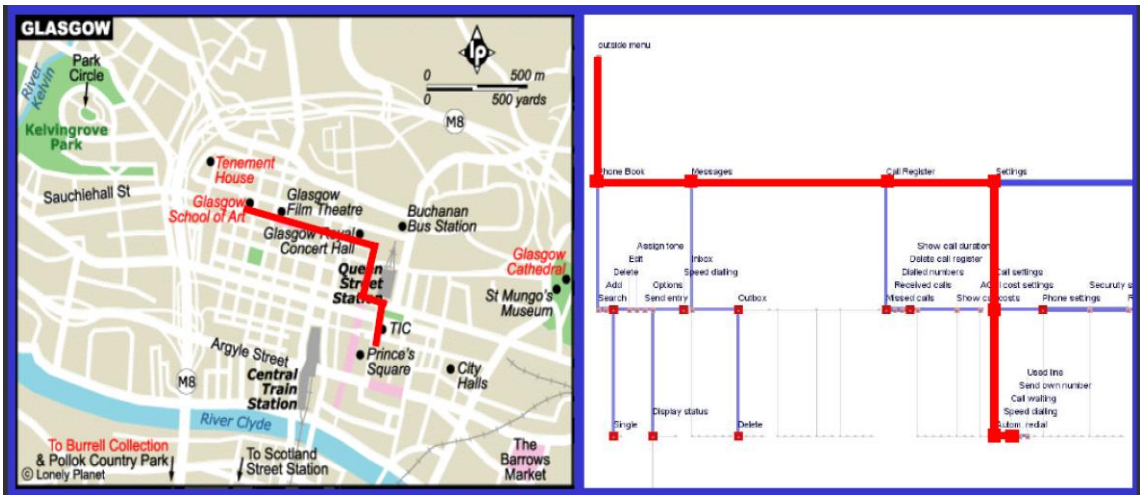
1) Parallels with spatial representations



2) Landmarks



3) Route knowledge



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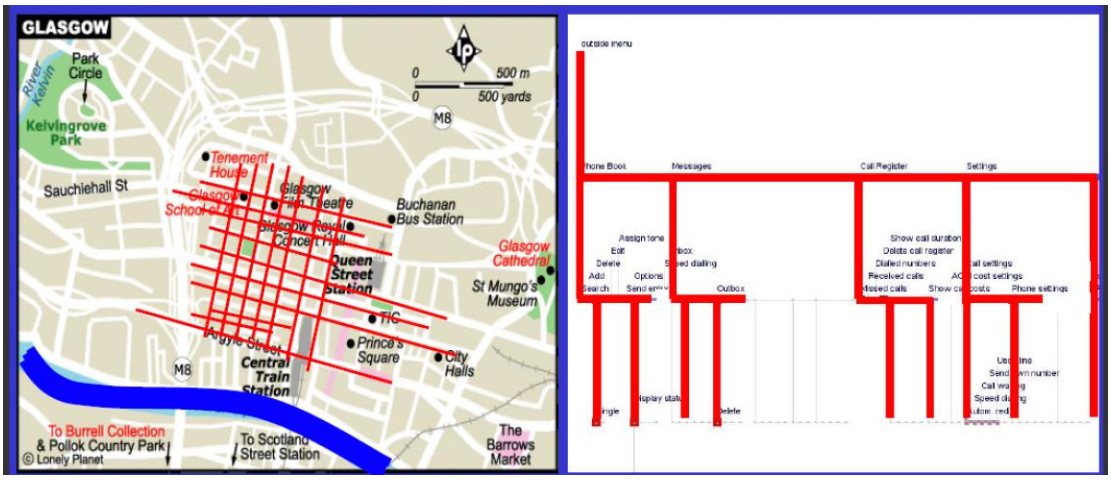
4) Survey knowledge



2 Method

Sixteen university students (aged 20 to 32) were recruited for the experiment. For a comparable sample of older adults with regard to educational background, 16 persons with a university degree aged 50 to 64 were selected.

The subjects processed **four tasks** which correspond to frequently used functions of a mobile phone:

1) *calling someone using the internal phone directory*
2) *sending a text message to a person whose number is saved in the phone directory*
3) *setting the phone to the status where the user's own number is not transmitted when calling someone (the task of hiding the own number)*
4) *editing an entry in the phone directory*

The tasks were not processed on real mobile phones but rather two models, the Nokia 3210 and the Siemens C35i, were simulated on a personal computer with a touchscreen in order to log user actions online (see Figure 1, left). Furthermore, the simulation enabled us to increase the size of the display and the keys to make sure that older participants are not disadvantaged due to poor readability of the menu or their inferior fine-motor abilities. Both simulated phones had comparable sizes (display, keys and fonts) and **three menu items** could be seen at a time on the display, as it is often the case in real mobile phones. A time limit of 10 minutes per task was set.

Half of the participants (8 of the younger and 8 of the older group) solved the tasks using the Nokia 3210 simulation, half using the Siemens C35i. We have chosen to use two different widely-used mobile phone models, which dispose of a comparable functionality, for reasons of ecological validity. In the following, they are not further differentiated but results are reported for both phones taken together.

Before processing the tasks on the simulated cellular phones, participants completed a questionnaire assessing age, profession and their experience using a number of technical devices (frequency of use and experienced ease using it). 21 of the 32 participants did not possess a mobile phone of their own. Of the 11

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people who were owners of such a technical device, only one reported using the internal phone directory and sending text messages, while the others used it only to make and answer calls. The questionnaire was presented to the participants on a touchscreen, which enabled the users to get familiar with the experimental apparatus.

After working on the solution of the fourth task, participants were asked for their experienced ease using the mobile phone and their difficulty understanding the menu functions as well as the keys of the phone.

Then, the users' mental representation of the mobile phone's menu was assessed through a **card sorting technique** (see Figure 1, right).

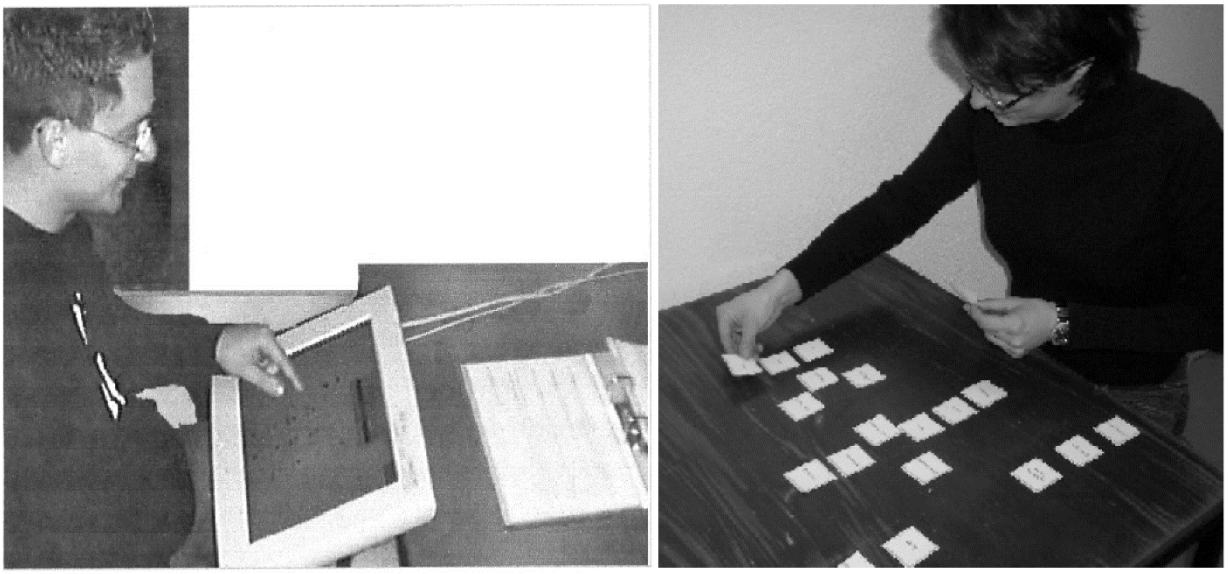

Fig. 1. Left: Participant solving the phone task on a computer simulated cellular phone; right: participant arranging the menu functions in the card sorting task

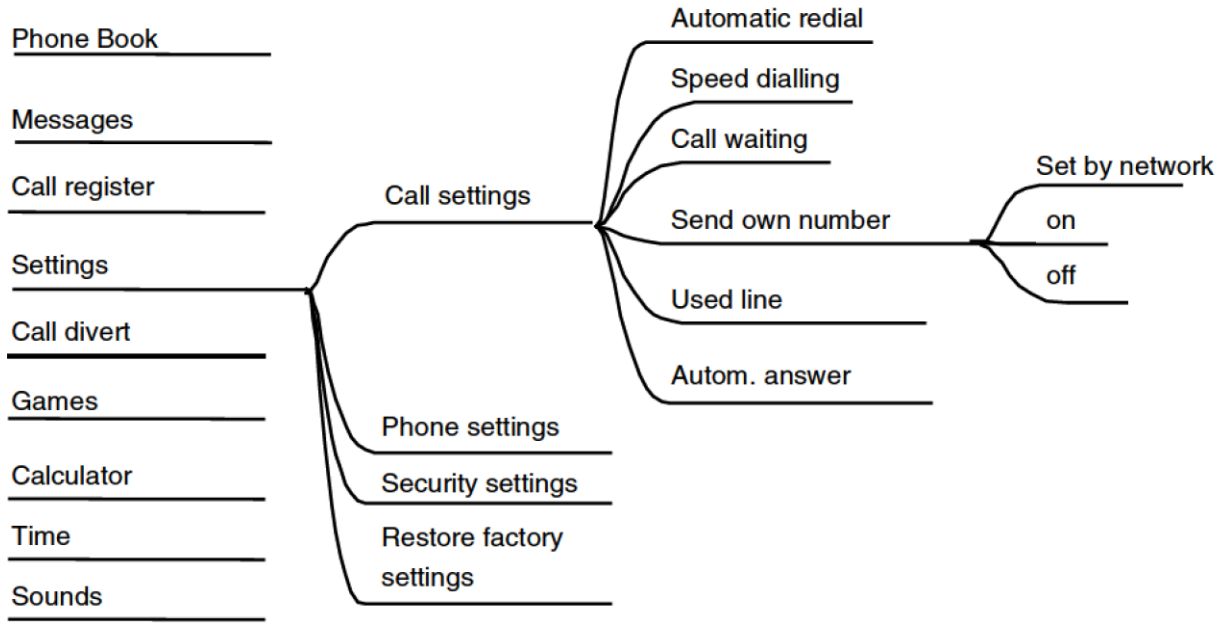

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Fig. 2. Menu branch of the Nokia 3210 as example of the structure to be laid in the card sorting task

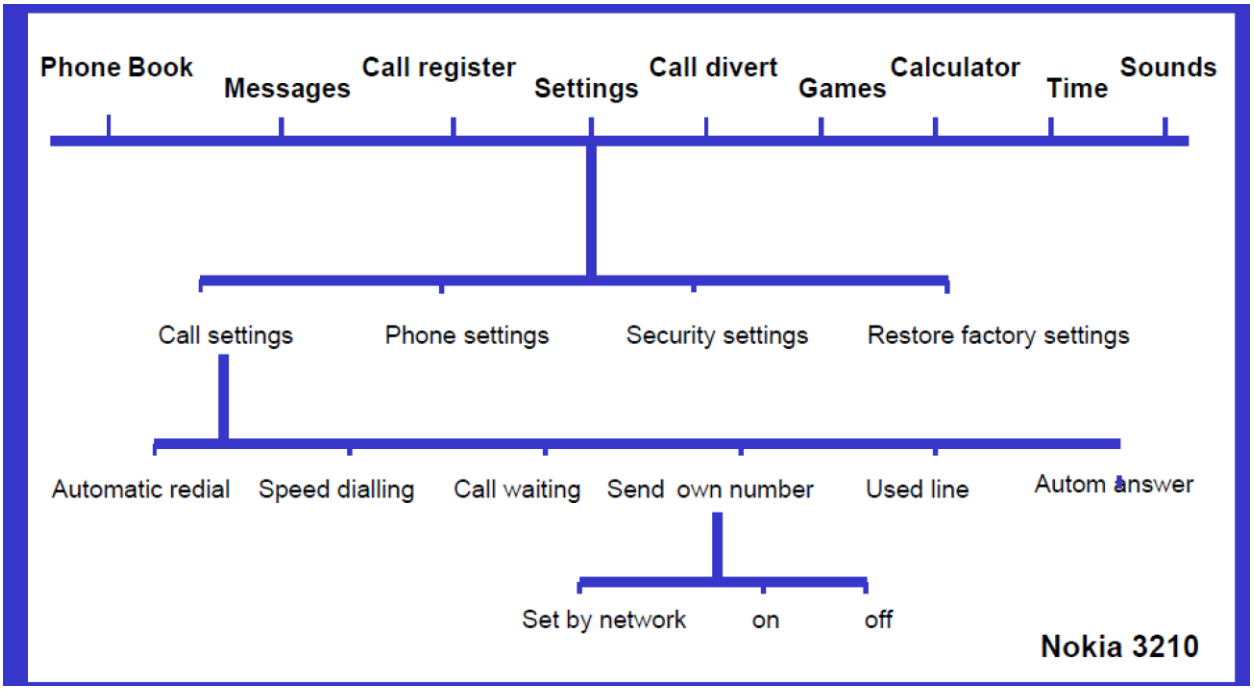
As the whole menu of the phone contains too many functions, only the menu branch where the setting of hiding the own phone number when calling is located was selected for the card sorting task. **Twenty-two cards** with a menu function written on each were randomly spread on the table. The 22 functions corresponded in both phones to the original items on the first level of the menu and the branch used when setting the phone to the status where the phone number is not transmitted.

The participants were asked to arrange the cards on the table according to how they remember having seen them in the menu or, if they did not remember, how it makes most sense to them. When they had finished arranging the cards, the experimenter asked the participant to explain the laid structure in a few words. Figure 2 visualizes the menu branch to be reconstructed (exemplary for the Nokia users).

To conclude this section, the methods of this study are:

1) 16 young and 16 older novice mobile phone users
2) Processing of 4 tasks on a mobile phone simulated on a touchscreen according to menu and navigation keys of the Nokia 3210 or the Siemens C35i
3) Online logging of user actions on keystroke level
4) Cognitive mapping of menu structure through Card Sorting technique
5) 22 cards corresponding to menu items of the branch to be used when solving the task of hiding the own number (Task 3)

For 4) Cognitive Mapping of the menu: Menu branch used when hiding the own number:



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3 Results

The results section will focus on detecting differences between the two age groups regarding their mental representation of the mobile phone's menu and show the relationship between incorrect or incomplete mental representations and the performance actually using the device.

Results always include users of both cellular phones models, since differences between the two phones are not of main interest here. First, the users' survey knowledge is analyzed, then the procedural knowledge, and finally, landmark knowledge.

To conclude this section, the results of this study are:

1) cognitive maps are analysed regarding the three types of knowledge relevant in spatial orientation:
   a) survey knowledge
   b) route knowledge
   c) landmark knowledge
2) Interrelations between correctness of mental model representation and performance using the mobile phone are reported:

3.1 Did Participants Have a Correct Representation of the Overall Structure of the Phone Menu? Survey Knowledge

Analysis of the card sorting task revealed that 4 of the older subjects did not arrange the cards in a hierarchical structure. Instead, one subject arranged the cards in groups of three, without an interconnection between the groups, possibly, because he simply mirrored the arrangement of menu functions he had seen on the display (always three menu items were presented at a time).

Two participants had no idea at all of how to arrange the cards because they could not imagine what was meant with the functions on the cards or how a menu could be organized.

In the younger group, all participants laid a hierarchical menu structure (Table 1).

Table 1. Number of users who laid a hierarchical and a non-hierarchical menu structure in the card sorting task

	Mental representation of cellular phone menu	
	hierarchical	non hierarchical
20-32 years ($N = 16$)	16	0
50-64 years ($N = 16$)	12	4

To analyze the impact of having a mental representation of the menu's tree structure on the ability to effectively and efficiently interact with the device, the performance of those who laid a hierarchical structure in the card sorting task and those who did not is compared.

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Taking only the older subjects, it was shown that the 12 users with a mental representation of the tree structure solved on average 80.2% of the tasks (3.2 out of 4 tasks) while the others solved only 65.6% (2.6 tasks). This difference yielded statistical significance ($t(14) = 2.43$; $p < .05$). When considering all 32 participants, the difference between the two groups was even somewhat bigger with users who had a correct mental representation solving on average 89.7% of the tasks (3.6 tasks), thus 24.1% more tasks than the users who were not aware of the tree-structure ($t(30) = 3.96$; $p < .001$) (see Figure 3, left).

The awareness of the hierarchical structure of the menu also had an effect on the time users needed to process the task (Figure 3, right), though not yielding statistical significance.

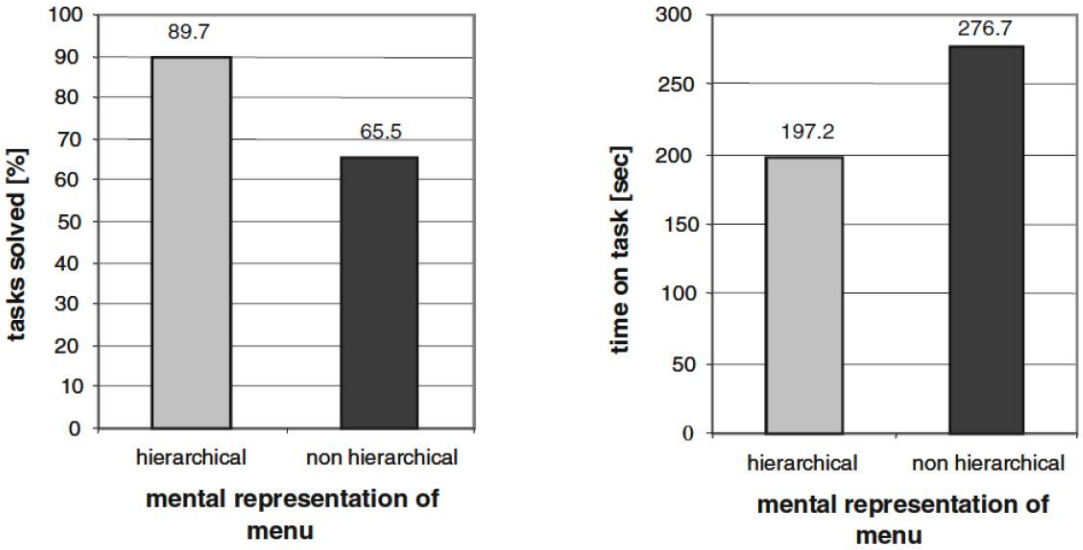

Fig. 3. Performance using the cellular phone depending on a hierarchical mental representation of its menu; N=32 participants (16 between 20 and 32, 16 between 50 and 64 years)

The correctness of the mental representation of the menu structure – the survey knowledge of the menu can also be expressed in the number of levels the participants used to structure the cards. The branch of the menu, which had to be grouped, consisted in fact of four levels in both phones. Of the older participants, only one arranged the cards in four levels, while in the younger group 6 persons did so (Table 2).

Table 2. Number of users who laid 0 to 5 levels in the card sorting task

	Number of levels in the mental representation of the menu				
	0-1 level	2 levels	3 levels	4 levels	5 levels
20-32 years ($N = 16$)	0	3	5	6	2
50-64 years ($N = 16$)	4	9	1	1	1

Comparing the group with a correct mental representation of the depth of the menu with the rest of the participants regarding their performance solving the phone tasks, it is shown in Figure 4 that they not only

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solved more tasks (96.4% compared to 84%, (30) = 2.24; $p < .05$), but also needed less time to process these tasks (109.9 sec compared to 234.4 sec, $t(30) = 2.95$; $p < .01$).

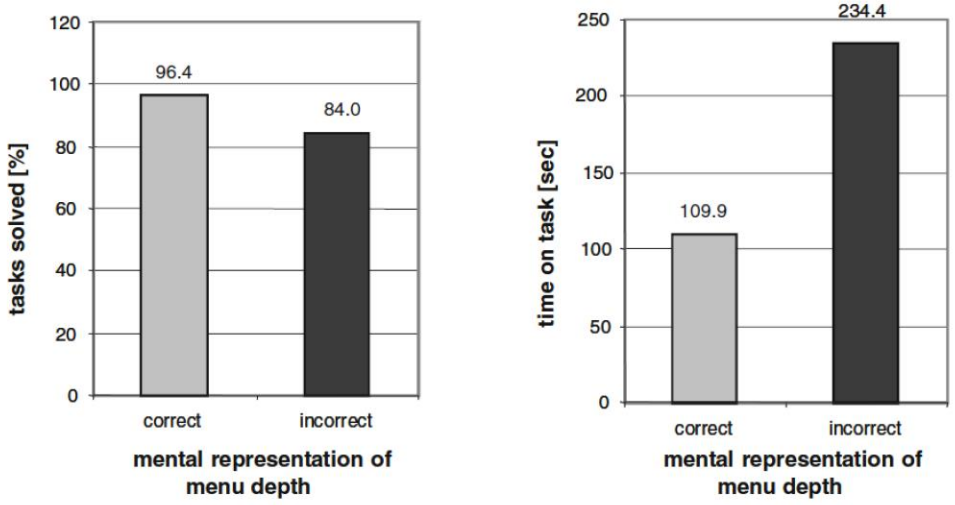

Fig. 4. Performance depending on the correct mental representation of the cellular phone menu's depth; N=32 participants (16 between 20 and 32, 16 between 50 and 64 years)

The one person in the older group with a correct mental map of the menu depth solved 100% of the tasks and needed 140.5 seconds for that, while the remaining older participants solved only 75% ($t(14) = 2.29$; $p < .05$) and needed double the time to process them (281.1 sec, $t(14) = 1.7$; $p = .1$). This person with a correct mental representation of the menu depth thus met the performance of the younger participants using the mobile phone who solved on average 96.9% of the tasks in 142.1 seconds.

Older participants arranged the cards in general in a much easier structure (see Table 2), on average 2.1 levels, while younger subjects structured on average 3.4 levels ($t(30) = 3.6$; $p < .01$), thus being much closer to the correct depth of 4 levels. With a less strict criterion of the correct menu depth – 4 +/- 1 levels - users can be divided into two groups of equal size. 16 participants had a mental representation of the phone's menu consisting of 3, 4 or 5 levels, 16 subjects thought the menu consisted of only two levels or did not think of a hierarchical structure at all. Only three older participants had met this criterion of laying 4 +/- 1 levels. Again, it could be shown that even with this less strict criterion meaningful performance differences can be found. Participants laying 3, 4 or 5 levels solved 94.5% of the tasks taking 167.4 seconds, while the participants who structured the cards in 2 or less levels solved only 78.9 % ($t(30) = 3.84$; $p < .01$) and took 246.9 seconds for the processing of the 4 phone tasks ($t(30) = 2.15$; $p < .05$).

The task of hiding their own number when calling, which was the most difficult and the one relevant for the card sorting task, was only solved by 5 of the 16 participants who structured less than three levels, while of the subjects with a more accurate mental model of the menu depth, 13 persons solved the task ($t(30) = 3.20$; $p < .01$).

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In summary, older participants showed to have an inferior survey knowledge of the phone menu than younger users, with not only more shallow notion of the menu's depth, but sometimes not even a hierarchical representation. It could be shown that this inferior mental model was indeed associated with a poorer navigation performance.

3.2 Is the Path to Be Taken Represented in User's Mental Model?

Route Knowledge

The correct route from "Settings" to the point in the menu where the function of hiding the phone number has to be set "on" was only structured correctly by two participants, both belonging to the younger group (see Table 3). These two persons solved 100% of the tasks correctly while the rest solved on average only 85.8% ($t(29) = 5.61$; $p < .001$).

When taking a less rigid criterion, namely that at least three of the four functions of the path to be structured are correct, still only 2 of the 12 persons who accomplished it are older subjects.

Again, it could be shown that those with a nearly correct mental map of the route were able to solve more tasks correctly (95.8%) than the others (81.3%, $t(30) = 3.33$; $p < .01$) and needed significantly less time (139.8 sec compared to 247.6 sec, $t(30)=3.0$; $p < .01$) (Figure 3).

Table 3. Number of users who laid the correct route in the card sorting task

	Correct mappings in the mental representation of the route				
	0	1	2	3	4
20-32 years ($N = 16$)	0	1	5	8	2
50-64 years ($N = 16$)	6	4	4	2	0

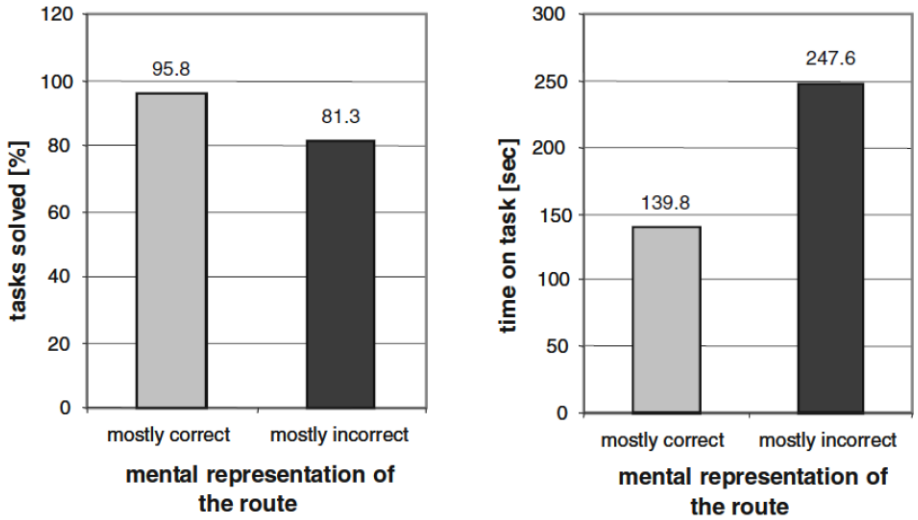

Fig. 5. Performance of users depending on their route knowledge; $N = 32$ participants (16 between 20 and 32, 16 between 50 and 64 years)

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Restating, it was demonstrated that route knowledge of the path in the phone menu to be selected is distinctly less represented in older participants' mental model than in the younger participants. This may explain older users' inferior performance as it was shown that better representations of the route go along with the higher ability to solve tasks on the phone in a shorter period of time.

3.3 Are Main Features of the Menu Branch Mentally Represented?

Landmark Knowledge

Landmark knowledge is defined here as the total number of correct mappings in the card sorting task. That is, the number of functions that have been correctly assigned to the corresponding parent item or to the first-level menu. Apart from the right route to be taken these landmarks are also important for orientation as they can further indicate which way *not* to take in order to solve a specific task.

Regarding landmark knowledge, older adults once again turned out to be inferior to the younger adults. The older group allocated on average only 4.5 of the 22 functions correctly, while in the younger group 11.4 cards were arranged to the right position within the menu. This difference is highly significant ($t(30) = 5.8$; $p < .001$).

The importance of landmark knowledge, or which function is to be found under which category within the mobile phone menu, for successful interaction with the device was further demonstrated in the study: Correlations between the number of functions assigned to the right parent item and the percentage of tasks solved was $r = .78$ ($p < .001$), with time on task $r = -.65$ ($p < .001$). This means that the better the users' landmark knowledge of the menu structure, the more tasks they solved and the less time they needed.

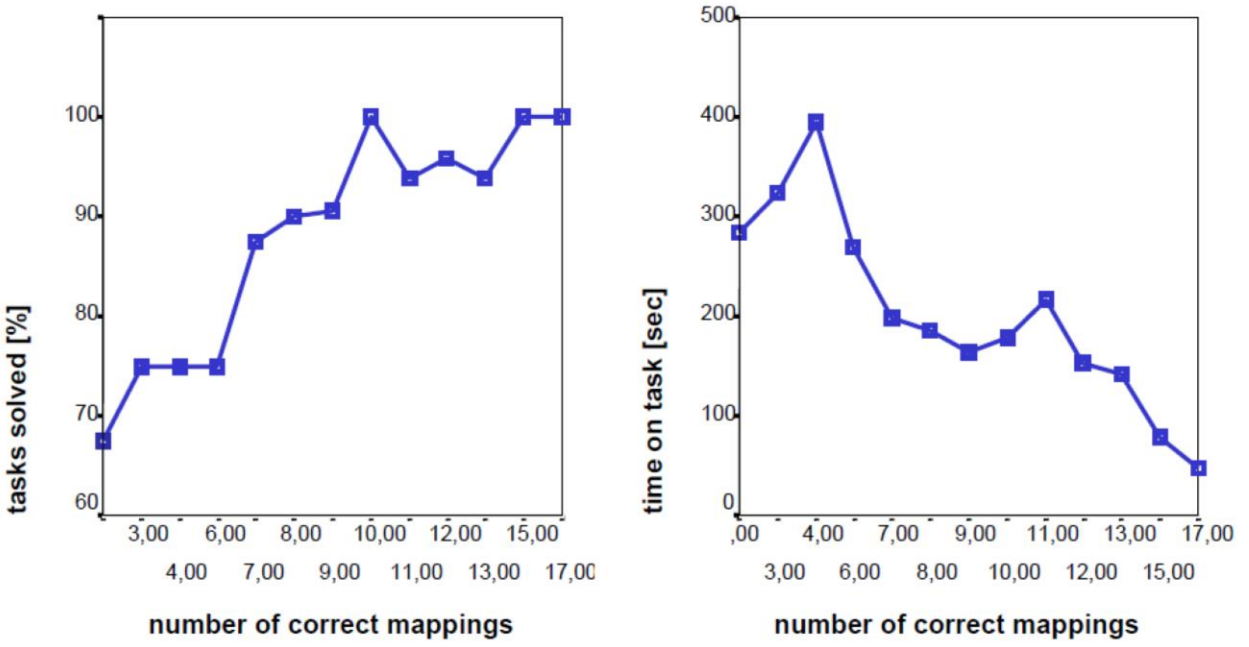

Fig. 6. Performance of users depending on their landmark knowledge; $N = 32$ participants (16 between 20 and 32, 16 between 50 and 64 years)

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4 Discussion and Conclusion

In the present study it was demonstrated that users' mental model of how a mobile phone menu is structured significantly influenced their navigation performance. Crucial for the performance using a mobile phone is the knowledge that functions are arranged hierarchically (survey knowledge), the representation of the menu depth (route knowledge), as well as memorizing under which superordinate term each function is located (landmark knowledge). Thus, the three types of knowledge involved in spatial orientation in the natural environment [10] are also of importance for successful interaction with a cellular phone possessing a hierarchical menu structure. Further, it was corroborated that younger and older users' mental models differ substantially. Older adults' mental model of the menu was not always hierarchical, but instead linear or functions were arranged in clusters without any interconnection. Moreover, seniors showed to have more shallow representation of the menu and allocated fewer functions correctly to superordinate terms. The specific attributes of older users' mental representation resulted in inferior navigation performance compared to the younger group.

In fact, the difficulty of building an appropriate map of the hierarchical menu structure is found not only in older people but also in the very young generation, which has grown up with technology from. The fact that we did not encounter this problem in our young adult group may be ascribed to having a sample of university students taking part in this study (and many other usability studies). Findings gathered with this user group should not be simply generalized for the broader population.

The findings presented here may have implications for the design of cellular phones in general. First, the inherent menu structure seems not to be transparent to older users – even if they are used to working with programs such as Windows Explorer, which is organized in the same fashion as our sample. One way of overcoming problems associated with hierarchical menu structures which was proposed in a recent study [8], is to use only **one long alphabetical list of functions,** where users can search by initial letters. This was evaluated with students. It is to be questioned whether this really helps users less experienced with mobiles as they often have no idea of the functions' naming in the menu and simple recognition of functions and categories.

The fact that, especially in older participants, landmark and route knowledge of the cellular phone's menu is rather poorly mentally represented may, as already mentioned, be ascribed to the large memory load imposed on the user by the current design realizations of the devices. Therefore, it is especially important for this user group to have unambiguous naming and allocation of functions to submenus and categories in order to decrease memory load. This issue is currently under study.

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To conclude this section, the conclusions of this study are:

1) Parallels between mental maps of a mobile phone menu and natural environment can be drawn.
2) Different types of knowledge –landmarks, routes and survey knowledge -seem to be relevant for effective and efficient interaction with the device.
3) The implications for the design of mobile phones is: the spatial nature of the mobile phone menu needs to be made more transparent by:
    a) Including spatial maps of the menu in the manual
    b) Providing graphical hints on the phone's display

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