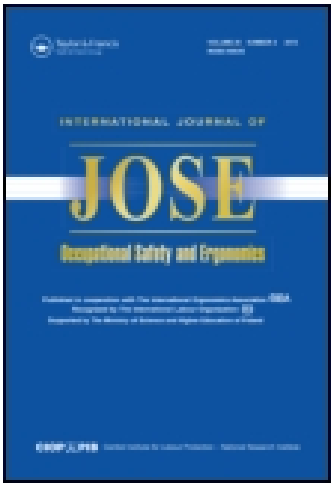

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Understanding Expectations of Different User Groups of a Sophisticated Fall Detection System

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Understanding Expectations of Different User Groups of a Sophisticated Fall Detection System

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The evaluation in technical invention is important because it tests functionality of the intervention and it forms an overall point of view of a user. This study aims to introduce an approach for collecting user expectations with Q methodology in Safe Private Home for Elderly Persons (CARE), which is a new development in ambient assisted living. CARE is a sophisticated fall detection system used in elderly homes to monitor elderly people and the staff. Expectations of elderly people and the staff were collected with Q sorting. Requirements of examined groups were explored successfully on the basis of the sorting and the differences in their opinions were appointed.

bathroom safety elderly users fall detection trust and confidence Q methodology

1. INTRODUCTION

The evaluation in technical invention or development is important because it tests the functionality of the intervention and it forms an overall point of view of a user. The evaluation cannot contradict with needs, expectations or the basic ethical considerations of participants. This study aims to introduce an approach for collecting user expectations with Q methodology in Safe Private Home for Elderly Persons (CARE)[1], which is a new development in ambient assisted living. CARE is a sophisticated fall detection system used in elderly homes. The system consists of a sensor module and the telecommunication system of the institution, to which the sensor module sends a message indicating the problem and its location in the case of an alarm. Because the system is monitoring the lives of the elderly, they were identified as primary users, caregiver staff receiving alarms became the secondary users and service providers responsible for residents are the tertiary users. Therefore, while collecting expectations all three groups had to be taken into consideration and their requirements should be explored.

2. METHODS

Users' expectations were explored with Q methodology, which is a qualitative-quantitative directed questioning methodology for grouping people's feelings and opinions. This methodology, on the basis of many factors, can identify attitude groups by quantifying data that is hardly measurable otherwise [1, 2, 3, 4, 5]. Q methodology works with all previously collected factors, which affect the judgment of CARE, such as cultural and social factors or subjective feelings [1, 3]. The first step of Q methodology was the formulation of 34 relevant statements related to the use of CARE. The statements were based on the factors collected by various organizations and on

[1] http://www.care-aal.eu

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the factors that were phrased concerning basic ethical requirements. The different user groups might have different opinions and preferences, which were taken into consideration when formulating the statements. Consequently, the statements may have different consequences [3]. The factors influencing the expectations are very hard to measure, especially in CARE, as it is a system used in health care where the role of individual differences is great and therefore the decision to be made, the behavior/reaction are not so clear-cut [1].

All statements were grouped into topics with different ethical issues such as autonomy, justice, affordability. In the European Union's legislation these main points appear side by side with pervasiveness of technology, lack of transparency, respect of privacy and confidentiality, security and shared personal data, and geographical inequalities. These topics involve all possible considerations while dealing with a system made for health services [6].

Therefore, in the case of CARE, main ethical considerations require that appropriate information should be provided for users and operators, and the transparency of the system should be assured. Furthermore, the question of obtrusiveness, stigmatization and effect on users' life should be examined. The importance of user consent is highlighted, therefore, an agreement on recording and handling the gathered information should be signed in all cases, nevertheless it can be withdrawn by the users any time.

Table 1 shows 34 statements which were formulated after mapping the topics. The statement categories can later help to reveal tendencies between the topics, showing whether it was important or not. The statements are organized according to four main topics such as safety, efficiency, comfort and social acceptance [7].

2.1. Application of Q Methodology

Data collection in Q methodology can start after formulating proper statements for areas involved in the evaluation [4, 7]. Most studies aim to identify groups of users with Q methodology, however, CARE's aim was to gain information on the expectations of the user groups: elderly/cared (end users), caregiver staff and service providers [1, 2, 3, 8]. The representatives of the three user groups were family members (or guardians) from the end user side and caregiver staff and managers from the service provider side. The end users were not decision makers because of their mental capacities; some of them had dementia and for the others it would be too hard task [5]. Therefore, their family members were the representatives. Very often family members were the real decision makers but they had a huge effect on the decision virtually made by the elderly. Managers (the side of the service providers) were asked because they would propose to work with a system like CARE and they also know the circumstances in the institutions.

The participants sorted the statements on the basis of how important they are in regard to their expectations [3]. In every round, the participants chose the *most* and the *least important* statements. These statements were removed and the task was repeated with the remaining statements. The statements received scores on the basis of the sorting. The *most important* statements received +3, while the *least important* received –3, the other statements were scored between those extremes on the basis of their importance. The answers were recorded on a grid with a 7-point scale (Figure 1) [4, 7].

2.2. Data Collection

CARE was tested in Germany and Finland. These two countries were selected because it was important to choose places where elderly care has high standards and people may be familiar with technical inventions like CARE. The similar living standards of the two countries was also a factor as it was assumed that high living standards mean better social services and higher level of technical support. Germany and Finland were also selected because of the limitations of the consortium partners in the project. The participants from Germany were seven caregiver staff members from the two care homes, two family members of the participants and three people from management (two of them are responsible for a building and the third is from the staff). The participants from Finland were eight caregiver

TABLE 1. Statements Used in Q Methodology

Topic	Statement
Safety	
	1. To data gathered by CARE only authorized person can get access.
	2. The person receiving the alarm knows what to do in any case.
	3. If a caregiver arrives in time when there is an alarm that suggests safety for the similar cases that may occur in the future.
	4. The recognition of the elements of CARE has a primary importance for the user.
	5. In case of even a false alarm the caregivers' fast response means safety for the user.
	6. It means safety for the users that appropriate devices guard their lives.
	7. It is better to have a false alarm than omitting a true one.
	8. In case of an alarm, should it be false or true, the caregiver staff has always to arrive quickly and act properly.
	9. The sensitivity of CARE practically makes it impossible to leave the user without alarm when alarm is needed.
Efficiency	
	10. The system's decision making is of proof so it can be trusted in.
	11. The use of CARE elements is easy and unambiguous.
	12. The presence of CARE causes inhibition.
	13. The response protocol is efficient and transparent.
	14. The response protocol is easy to learn for any cases.
Comfort	
	15. The information gathered is to be stored in a safe place.
	16. CARE doesn't record images by which users could be identified so their personal rights wouldn't be injured.
	17. After the installation only small adjustments are needed (e.g., change of battery).
	18. The presence of the elements of CARE in the flat/apartment is disturbing.
	19. The presence of device in the flat/apartment may suggest that the user has no full control of his/her own life.
	20. The presence of device in the flat/apartment suggests that in case of emergency he/she can count on help.
	21. The cost-benefit ratio of CARE is good, it is worthy.
	22. The use of CARE has minimal interference with the user's life.
	23. For the user depending on technology is disturbing.
	24. If others are satisfied with CARE that means confirmation and confidence towards the system.
	25. The operation of CARE should be introduced to the users in an easy, jargon-free language.
	26. The decision on use of CARE shouldn't be rushed or forced.
	27. The image and the video produced should be shown to the user before the decision on use is to be made.
Social acceptance	
	28. It is important that the users of CARE can share their experiences about the use.
	29. The opinion of well-known people (family, friends, caregivers, etc.) has a great effect on the decision to be made on the use of CARE.
	30. The presence of CARE may be labeling for the user in front of friends and relatives.
	31. The use of CARE promotes the possibility of living a life the cared is used to.
	32. The person responding to the alarm should be known by the user.
	33. Open communication between users and caregivers improves the feeling of safety.
	34. If the flat/apartment should be reordered/redesigned because of the installation of the device that decreases CARE acceptance.

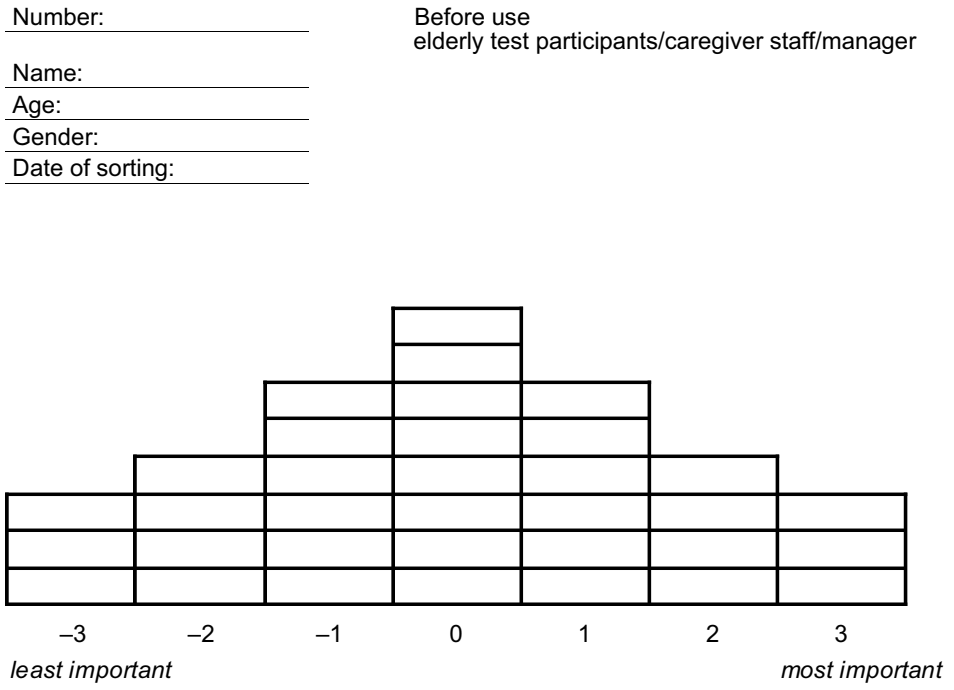

Figure 1. A grid used to record statements in Q methodology.

staff members, three management persons including the director of the care home and four family members. The participants were chosen on the basis of their role at care homes and their relation with the elderly. Gender and age were not significant. The aim of the evaluation was to collect preferences concerning CARE and its methods. The tests were performed in small groups to explore possible differences between groups of users based on their nationality and role. Firstly, data from the German participants were compared to the Finnish to explore the differences that may occur depending on nationality or culture, therefore, their differentiation was important. Secondly, differences in priorities between different user groups were compared.

The sorting took place at the elderly homes. Caregiver staff and managers did their sorting during their shifts, family members did the sorting when they were visiting their relatives. The participants were informed about the features of CARE and they saw the equipment before the sorting, some of them were present during the installation. The participants received the same instructions: to make their choices on the basis of their expectations to get comparable information.

Evaluation of data was done according to five steps:

1. factor analysis of the gathered data,
2. selecting significant factors,
3. sorting statements in a descending order for every participant by their factor score (done only for significant factors)
4. recording in the order of importance ordered statements on the grid,
5. interpreting and describing factors [9].

3. DATA ANALYSIS

3.1. German and Finnish Results

The comparison of results from different nations was important because of possible international sale of CARE. CARE should suit as many nationalities as possible. Differences between users of different nationalities should be examined to adjust improvements of CARE to possible expectations. Results from the German (12 answers) and Finnish (15 answers) participants were analyzed and compared to explore differences.

German sorting results can only be cautiously evaluated because their Kaiser–Meyer–Olkin measure (KMO) was over .5 (.520) at a significance

level of $p = .000$ at Bartlett's test. Finnish results were valid and their KMO was .812 at a significance level of $p = .000$ in Bartlett's test. In both cases first components were strong. The first German component explains ~27% of the total variance while the first Finnish component explains ~50% of it. In the case of the German results a second component could be taken into consideration adding an explanation ~14% to the total variance (Table 2; Appendix A, p. 237).

TABLE 2. Results of Kaiser–Meyer–Olkin Measure (KMO) and Bartlett's Test for All Respondents

Test	Germany	Finland
KMO	.520	.812
Bartlett's test		
χ^2	120.440	314.841
df	66	105
p	.000	.000

At least two components of the German results had to be evaluated to get better understanding of the total variance gained from the results of their sorting. A greyscale represented the main difference between the two components. The first and strong component of German results did not emphasize the topic with a primary importance. Efficiency statements belonged to the neutral zone which means that no specific opinion was formed. Safety statements, which were the second component, were placed rather on the positive side of the greyscale and could be the important topic. The Finnish results showed, on the basis of the earlier greyscale visualization, that the safety statements seemed to be important and that there were no strong opinions on social acceptance statements. According to the three greyscale grids (Figures 2–4), safety was a topic of high importance.

A deeper analysis identified the main motives. For Germans, the relatively strong first component could be interpreted as an attitude in which the feeling of safety has a primary importance compared to the technical components of achievement. In this component an emphasis was put on the importance of the feeling of safety by choosing statements 7, 8, 20. However, statements on the technical implementation (1, 27, 18) were also chosen. The component left statements in the neutral zone to decide if CARE is proper or not. Only participants with technical background took part in the study.

The second component had a matching end with the first one as the feeling of safety also appeared as the main topic of importance. Statements describing situations of discomfort were chosen as unimportant, however, they are completely different from unimportant at the first German component. The component is an attitude describing the importance of the feeling of safety even at the cost of some disturbing factors that had to be dealt with.

The first component of the Finnish sorting is strong. It can be described as the feeling of safety

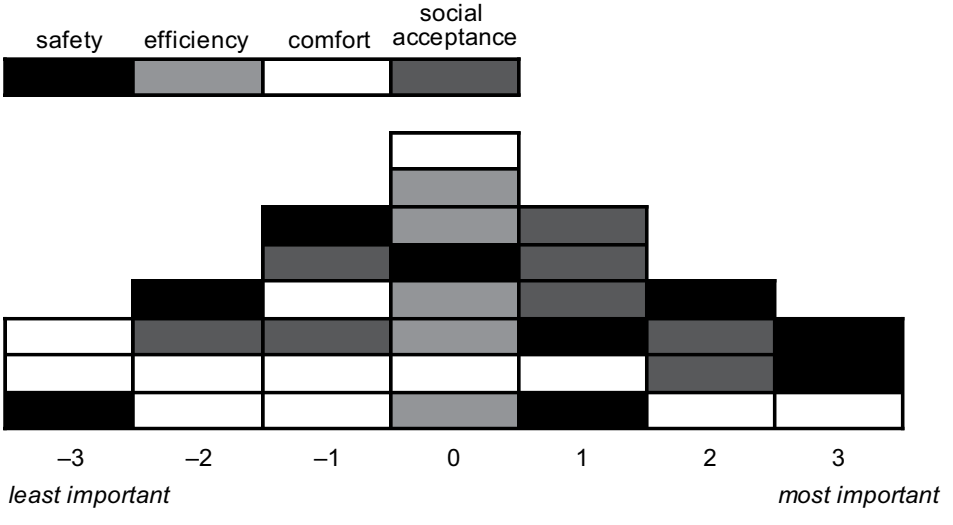

Figure 2. Importance of each topic on the basis of the first component (Germany).

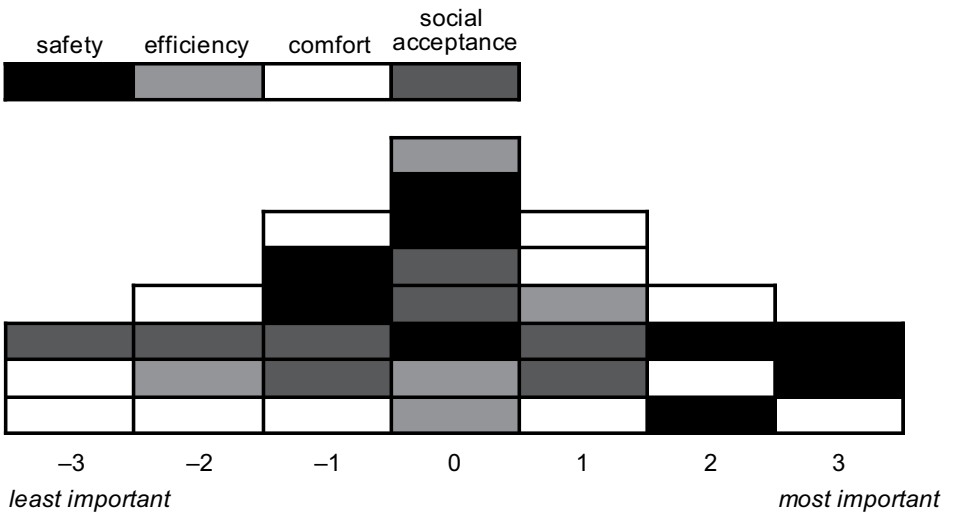

Figure 3. Importance of each topic on the basis of the second component (Germany).

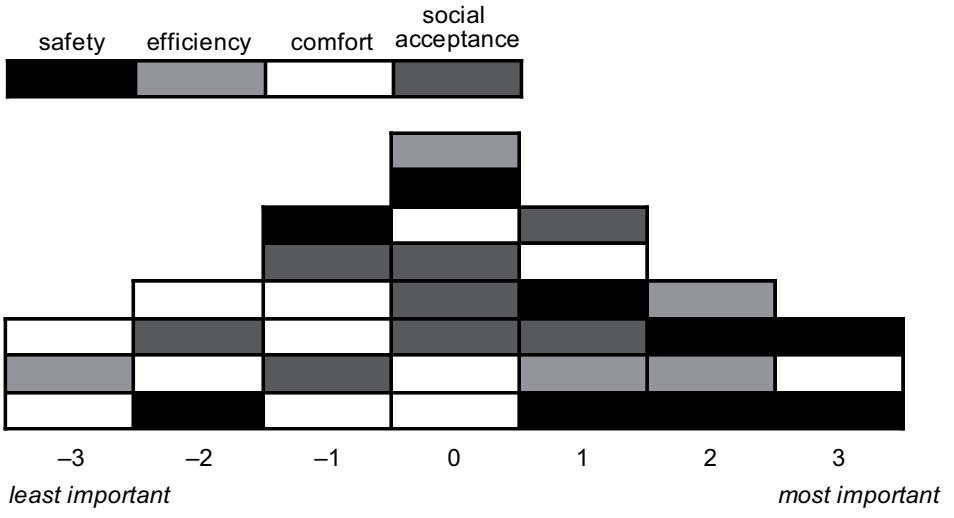

Figure 4. Importance of each topic on the basis of the first component (Finland).

for the participants' disturbance caused by CARE which can be tolerable; a conclusion of important (2, 20, 5) and unimportant (16, 12, 27) statements.

3.2. User Groups' Results

The second evaluation examined differences between the participants on the basis of the groups they belonged to. Because the system is monitoring the lives of the elderly, they were identified as primary users, caregiver staff receiving alarms became the secondary users and service providers responsible for residents are the tertiary users.

The participants were managers of the institutions, caregiver staff and family members of the elderly. Because the family members had a great share in the decision making, their opinion can count as if the elderly themselves would have done it. This evaluation focuses on the differences in the expectations of different user groups.

3.2.1. Family members

Two German and four Finnish family members were asked to choose the statements based on their expectations. The results were valid with KMO of .752 at a significance level of $p = .000$ at Bartlett's test (Table 3).

TABLE 3. Results of Kaiser–Meyer–Olkin Measure (KMO) and Bartlett's Test: Family Members

Test	Family Member
KMO	.752
Bartlett's test	
χ^2	42.575
df	15
p	.000

Two components were formed during the factor analysis. The first component was stronger than the second, describing ~45% of the total variance (see Appendix B, p. 238), therefore, it could be the main motive of the family members' expectations. The first component was analyzed in details. The statements in the first component were ordered on the basis of the factor scores. The statements with the highest and lowest factor scores explained the component. The statements were ordered on the basis of their factor score. The greyscale was done with the previously defined topics. On the basis of the greyscale grid it can be stated that safety questions were the *most important* for family members. Those safety statements had the strongest relation to physical components. However, comfort factors appeared to be unimportant and included some of the statements dealing with the feeling of safety (Figure 5).

The analysis of the first component justifies the results on the greyscale. The family members wanted safety for their relatives at the expense of their comfort using all possible human or technical resources to reach the aim. Having an alarm and checking on elderly has a primary importance. These statements belonged to safety but to some extent they belonged to efficiency as well. The comfort statements (unimportant on the greyscale grid) described factors which prove that the system is working. Conditions to get the system working like cost-value ratio or features of the response protocol, described by the family members as not their responsibilities, were neutral.

3.2.2. Managers

The managers were the representatives of the service providers. The German participants were two house leading managers and the head of caregivers as they were responsible for acquiring such equipment for the elderly home. The Finnish participants were the director of the elderly home and two of her managers as they were the leading personnel. The results were valid with KMO of .705 at a significance level of $p = .000$ at Bartlett's test (Table 4).

TABLE 4. Results of Kaiser–Meyer–Olkin Measure (KMO) and Bartlett's Test: Managers

Test	Manager
KMO	.705
Bartlett's test	
χ^2	45.569
df	15
p	.000

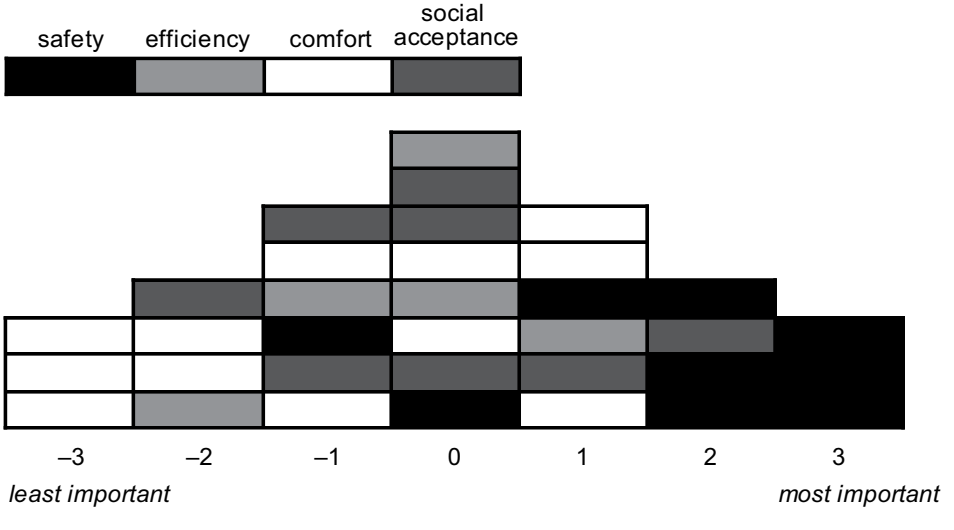

Figure 5. Importance of each topic on the basis of the first component (family members).

The results of sorting formed two components. The first component could be a main motive explaining ~42% of the total variance and the second component was negligible (see Appendix C, p. 238). The managers' expectations were very similar to the family members'; safety played an important role in their evaluation (Figure 6).

The first component was about the importance of legal security of the institution on the expense of the comfort factors of the users. Their concerns on safety were from the institution's point of view as they done everything for the safety of their residents. The statements, supporting the component, with the most importance described services/duties of an assisted living facility. The comfort factors were unimportant.

The analysis of the first component showed that the statements with high importance were the ones dealing with safety as a factor, for which the institutions could be blamed as they are legally responsible for their residents. The statements of primary importance were dealing with an alarm, reacting on an alarm and protecting the human rights of residents. The managers thought that certain inhibition might be caused by the system but the overall adjustments in the apartments and other unpleasant consequences of the decisions showed that the results were not significant but could be a minor nuisance. The neutral items were the ones not directly corresponding to the work of managers such as the learnability of protocol or the technical components of the equipment.

3.2.3. Caregivers

Caregivers were the secondary users of CARE as they used it as a support in their daily work. Seven German and eight Finnish participants took part in the study. The results were valid with KMO of ~.7 at a significance level of $p = .000$ at Bartlett's test. The results of sorting formed four components. The first component explained ~42% of the total variance (see Appendix D, p. 238). This component could explore the main motivation of caregivers (Table 5).

TABLE 5. Results of Kaiser–Meyer–Olkin Measure (KMO) and Bartlett's Test: Caregivers

Test	Caregiver
KMO	.692
Bartlett's test	
χ^2	291.605
df	105
p	.000

The unimportance of the social acceptance can only be emphasized. The evaluation of the first component could be done with a brief analysis. The first component was about high importance of safety factors concerning the work of caregivers at the expense of the factors of comfort and social acceptance. The statements on safety

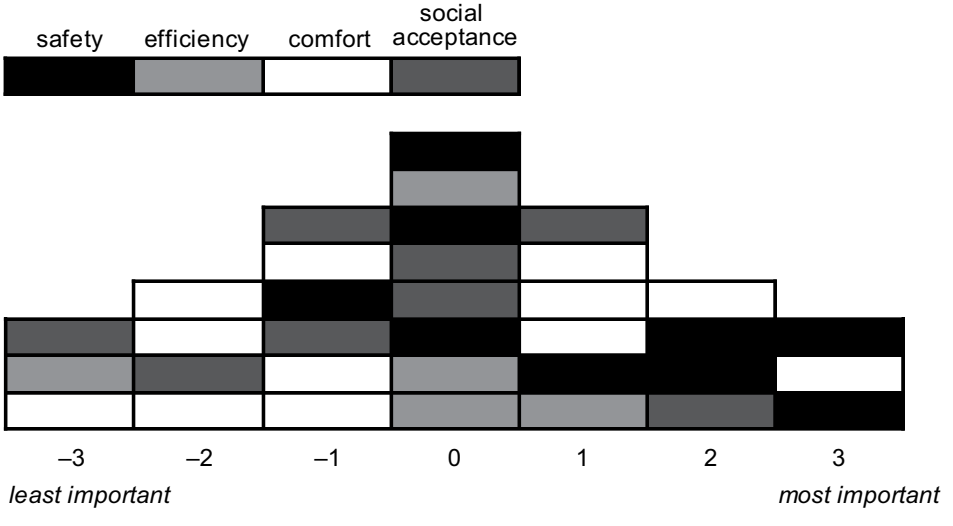

Figure 6. Importance of each topic on the basis of the first component (managers).

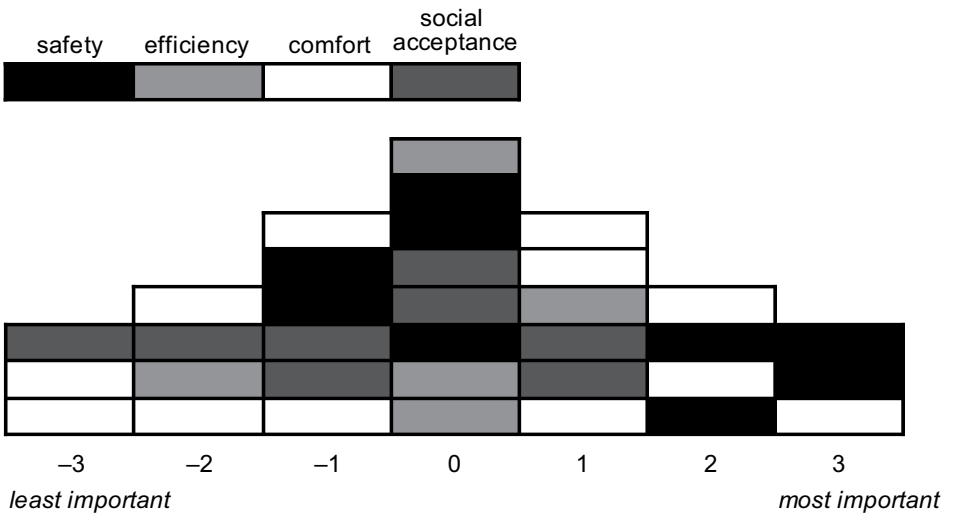

Figure 7. Importance of each topic on the basis of the first component (caregivers).

were important for the caregivers. Statements emphasizing the physical safety of participants not the feeling of safety were important. These factors also referred to the responsibility of the caregivers' work. The statements that might mean disturbance for the elderly were unimportant. The social aspects like opinions of other people were neutral (Figure 7).

4. RESULTS

4.1. Comparison of German and Finnish Results

The first components from German and Finnish results were similar. There was significant correlation between the first components (p = .01). There were no differences between German and Finnish participants' expectations of CARE. There were no differences in different nations or cultures expectations.

4.2. Comparison of User Groups Result

The results showed that safety was important for all participants, while comfort was unimportant. The analysis of the first factor showed that there were connections between the user groups. The opinion of family and caregivers were very similar and there were similarities between the opinion of managers and family. There was no correlation between the opinion of managers and caregivers (Table 7).

5. CONCLUSION

Q methodology helped to identify differences between the opinions of CARE users. Several similar components were identified from German and Finnish results which proves the reliability of this method. Directed asking method helped to collect preferences. The categories of statements (safety, social acceptance, efficiency and comfort)

TABLE 6. Correlations of Components (N = 34): German and Finnish Participants

Component		1 (German)	2 (German)	1 (Finnish)
1 (German)	Pearson correlation	1	.000	.526**
	p		1.000	.001
2 (German)	Pearson correlation	.000	1	.260
	p	1.000		.138
1 (Finnish)	Pearson correlation	.526**	.260	1
	p	.001	.138	

Notes. ** p (2-tailed) = .01.

TABLE 7. Correlations of Components (*N* = 34): User Groups

Component		1 (Manager)	1 (Family)	1 (Caregiver)
1 (Manager)	Pearson correlation	1	.378*	.198
	p		.028	.263
1 (Family)	Pearson correlation	.378*	1	.590**
	p	.028		.000
1 (Caregiver)	Pearson correlation	.198	.590**	1
	p	.263	.000	

Notes. * *p* (2-tailed) = .05, ** *p* (2-tailed) = .01.

helped to identify important topics for different user groups. All groups prioritized safety at the expense of comfort. The greyscale representation of factors indicates similar results in the distribution of topics on the scale of importance. Deeper understanding of motivations can assume that safety and the feeling of safety should be differentiated and that there is a difference in their level of importance. Therefore, these two areas have a very high importance and attention should be paid to them.

Safety should be provided when using CARE. The feeling of safety should be also taken into consideration. Whole flats should be equipped, not just rooms, to avoid the area without sensors of detection. Special attention should be paid to the alarm level and the action of caregiver staff in case of an alarm.

The limitations of this study was the small number of countries involved in CARE. Further research should be completed with the participation of Eastern European and Western European countries.

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APPENDIX A. Total variance explained with factor analysis: (a) Germany, (b) Finland

(a)

	Initial Eigenvalues			Extraction *SS* Loadings			Rotation *SS* Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.201	26.677	26.677	3.201	26.677	26.677	2.278	18.982	18.982
2	1.733	14.438	41.114	1.733	14.438	41.114	2.224	18.537	37.519
3	1.724	14.370	55.484	1.724	14.370	55.484	1.885	15.704	53.223
4	1.341	11.176	66.660	1.341	11.176	66.660	1.612	13.437	66.660
5	0.967	8.062	74.722						
6	0.738	6.150	80.872						
7	0.675	5.622	86.494						
8	0.521	4.338	90.832						
9	0.439	3.660	94.493						
10	0.288	2.399	96.892						
11	0.211	1.759	98.651						
12	0.162	1.349	100.000						

(b)

	Initial Eigenvalues			Extraction *SS* Loadings			Rotation *SS* Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.519	50.129	50.129	7.519	50.129	50.129	3.844	25.629	25.629
2	1.366	9.109	59.238	1.366	9.109	59.238	3.298	21.989	47.619
3	1.201	8.003	67.241	1.201	8.003	67.241	2.943	19.623	67.241
4	0.948	6.322	73.563						
5	0.879	5.857	79.420						
6	0.697	4.646	84.066						
7	0.513	3.419	87.485						
8	0.493	3.289	90.775						
9	0.364	2.427	93.202						
10	0.288	1.917	95.118						
11	0.208	1.384	96.502						
12	0.197	1.314	97.816						
13	0.141	0.941	98.757						
14	0.108	0.723	99.480						
15	0.078	0.520	100.000						

APPENDIX B. Total variance explained with factor analysis: family members

	Initial Eigenvalues			Extraction *SS* Loadings			Rotation *SS* Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.661	44.350	44.350	2.661	44.350	44.350	2.417	40.289	40.289
2	1.109	18.476	62.826	1.109	18.476	62.826	1.352	22.537	62.826
3	0.788	13.136	75.962						
4	0.608	10.130	86.092						
5	0.457	7.609	93.702						
6	0.378	6.298	100.000						

APPENDIX C. Total variance explained with factor analysis: managers

	Initial Eigenvalues			Extraction *SS* Loadings			Rotation *SS* Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.540	42.337	42.337	42.337	42.337	42.337	2.003	33.389	33.389
2	1.374	22.907	65.244	65.244	22.907	65.244	1.911	31.854	65.244
3	0.770	12.840	78.084						
4	0.512	8.528	86.612						
5	0.432	7.194	93.806						
6	0.372	6.194	100.000						

APPENDIX D. Total variance explained with factor analysis: caregivers

	Initial Eigenvalues			Extraction *SS* Loadings			Rotation *SS* Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.231	41.537	41.537	6.231	41.537	41.537	4.841	32.275	32.275
2	2.000	13.334	54.871	2.000	13.334	54.871	2.472	16.478	48.754
3	1.273	8.486	63.357	1.273	8.486	63.357	1.715	11.436	60.190
4	1.115	7.436	70.793	1.115	7.436	70.793	1.590	10.603	70.793
5	0.928	6.184	76.978						
6	0.759	5.057	82.035						
7	0.678	4.519	86.554						
8	0.573	3.821	90.375						
9	0.398	2.657	93.031						
10	0.282	1.881	94.913						
11	0.254	1.695	96.608						
12	0.199	1.324	97.932						
13	0.165	1.102	99.035						
14	0.094	0.623	99.658						
15	0.051	0.342	100.000						