University of Ljubljana Faculty of Social Sciences

CENTRE FOR SOCIAL INFORMATICS

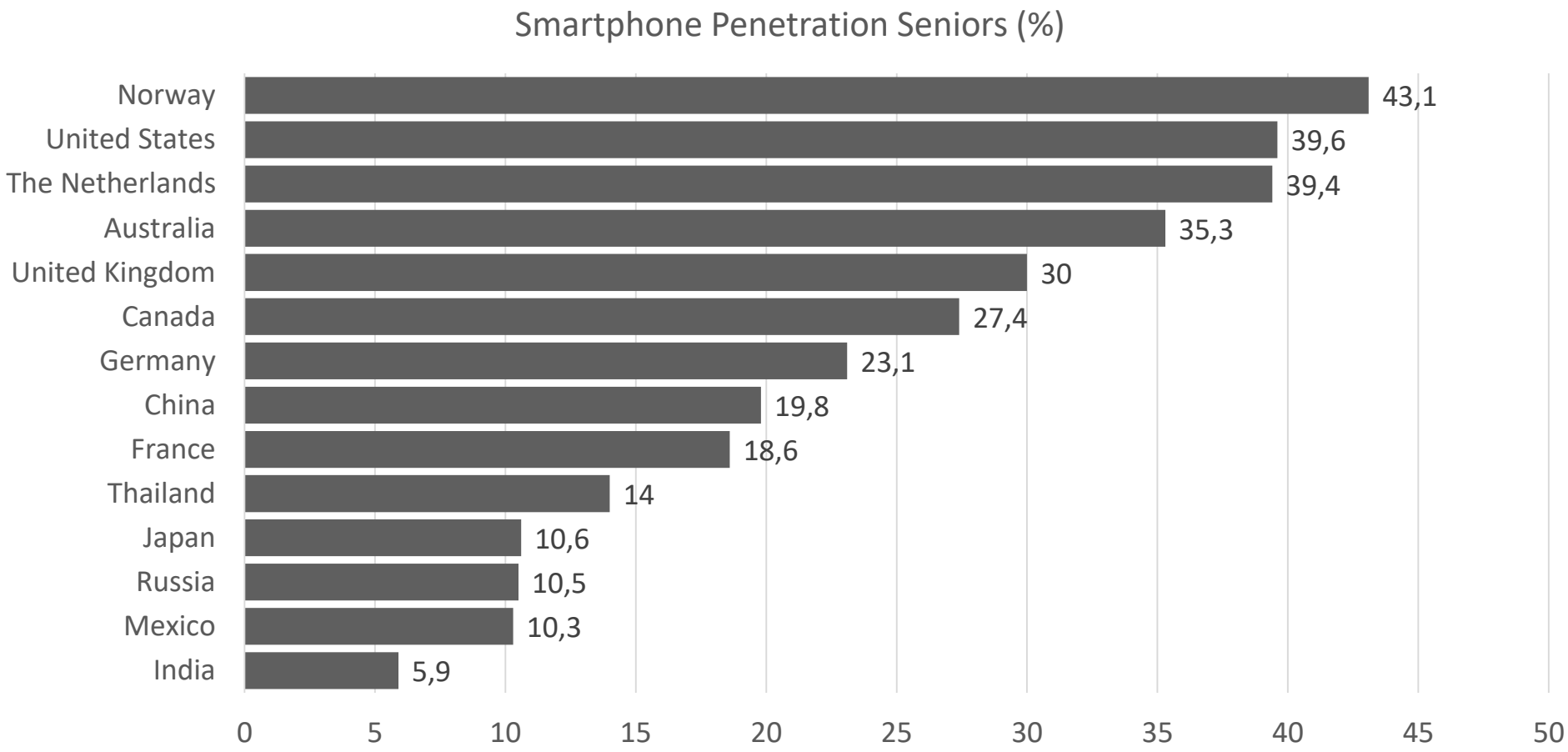
Andraž Petrovčič, PhD, Assistant Professor
University of Ljubljana, Faculty of Social Sciences, Centre for Social Informatics

Age-Friendly Design of Smartphones
A must or an option today?

Outline

- Smartphone penetration among older adults.
- Reasons for low/non-acceptance.
- Age-friendly design for better user experience with smartphones among older adults.
- Empirical findings from two studies at CSI.
- Conclusions (lessons learned).

Smartphone adoption worldwide (I.)

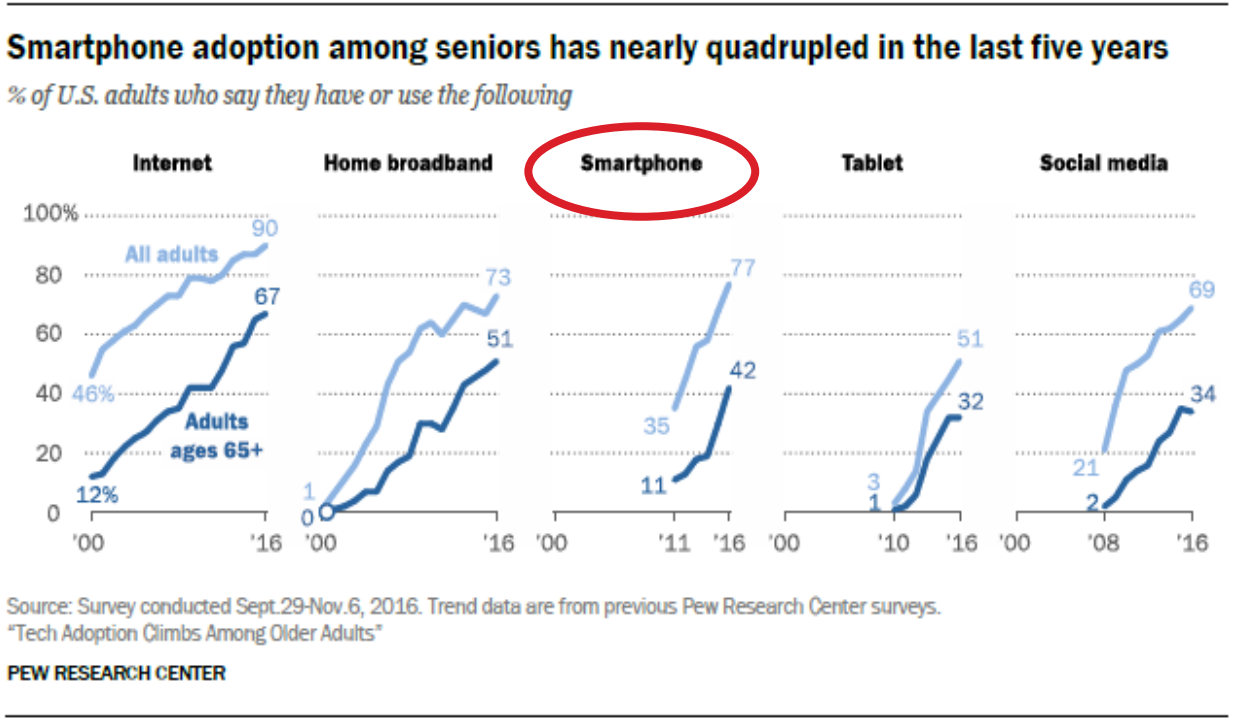


Adapted from Berenguer el at. (2017)

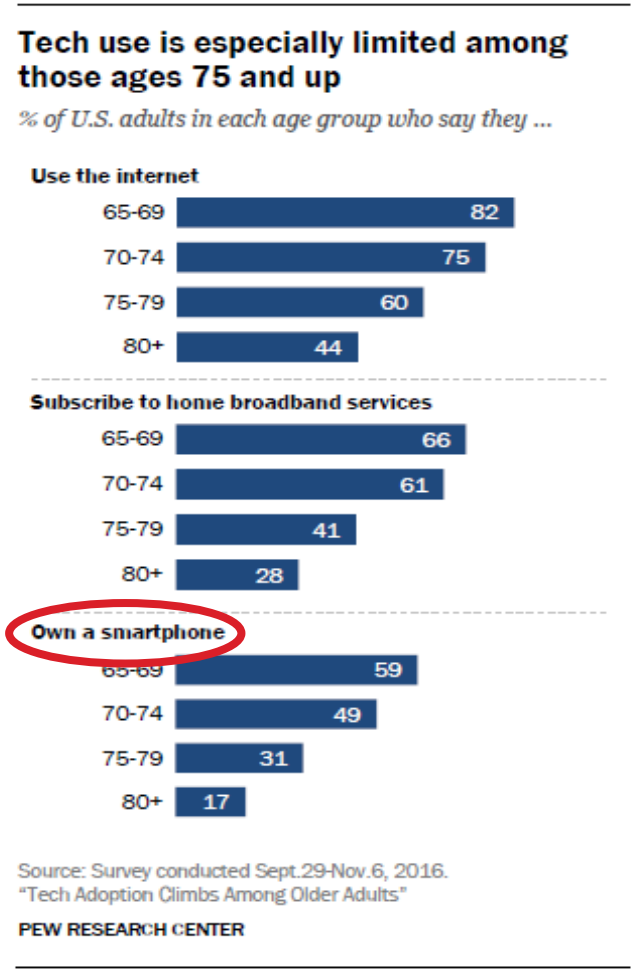
Smartphone adoption worldwide (II.)

- Deloitte Global (2018) penetration of smartphones among adults in developed countries will surpass 90% by 2023 – a 5 percentage-point increase over 2018.
- **Smartphone sales** will be **1.85 billion per year in 2023**, a 19% increase over 2018 and equivalent to over **5 million units sold per day**.
- The **main driver of growth** will be **take-up by the ageing population**. We would expect ownership among 55-to-75-year-olds to reach **85% in developed countries in 2023**, a 10-percentage-point increase over 2018 (Deloitte Ireland, 2018).

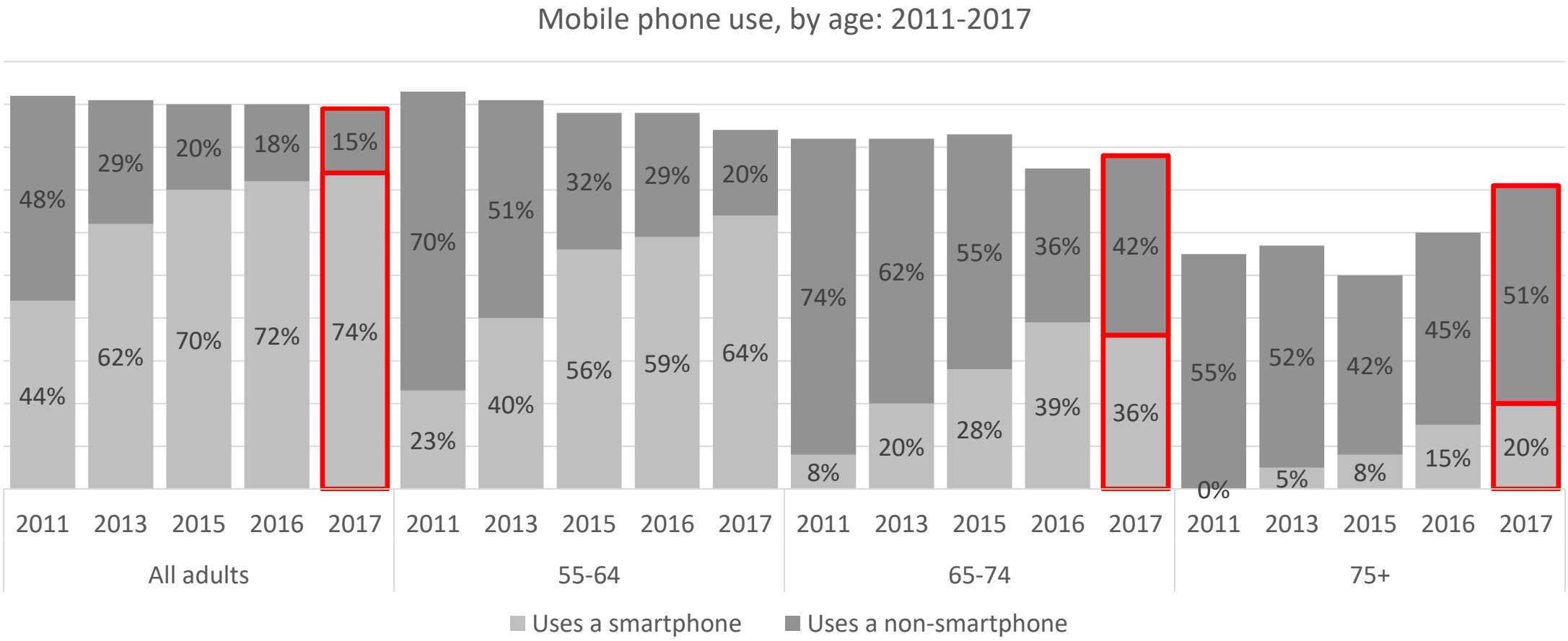
Smartphone adoption in the US



(Pew Research Center, 2017)



Smartphone adoption in the UK



Adapted from Ofcom Adults' Media Literacy Tracker (2017)

Smartphone usage patterns of older adults

- This age gap is more pronounced in the use of social networking services (SNSs): in 2013, data from 11 developed countries (BE, FI, FR, DE, JP, NL, SG, KR, ES, UK, and US) showed that just **below a third of 55+er's use a smartphone for SNSs**, unlike younger age groups (Deloitte, 2014).
- **25%** of smartphone owners aged 55+ **have never downloaded an app** to their mobile device (Deloitte, 2014).
- Many older users of smartphones also **tend to use smartphones as feature phones** (Berenguer et al., 2017; Petrovčič et al., 2018).

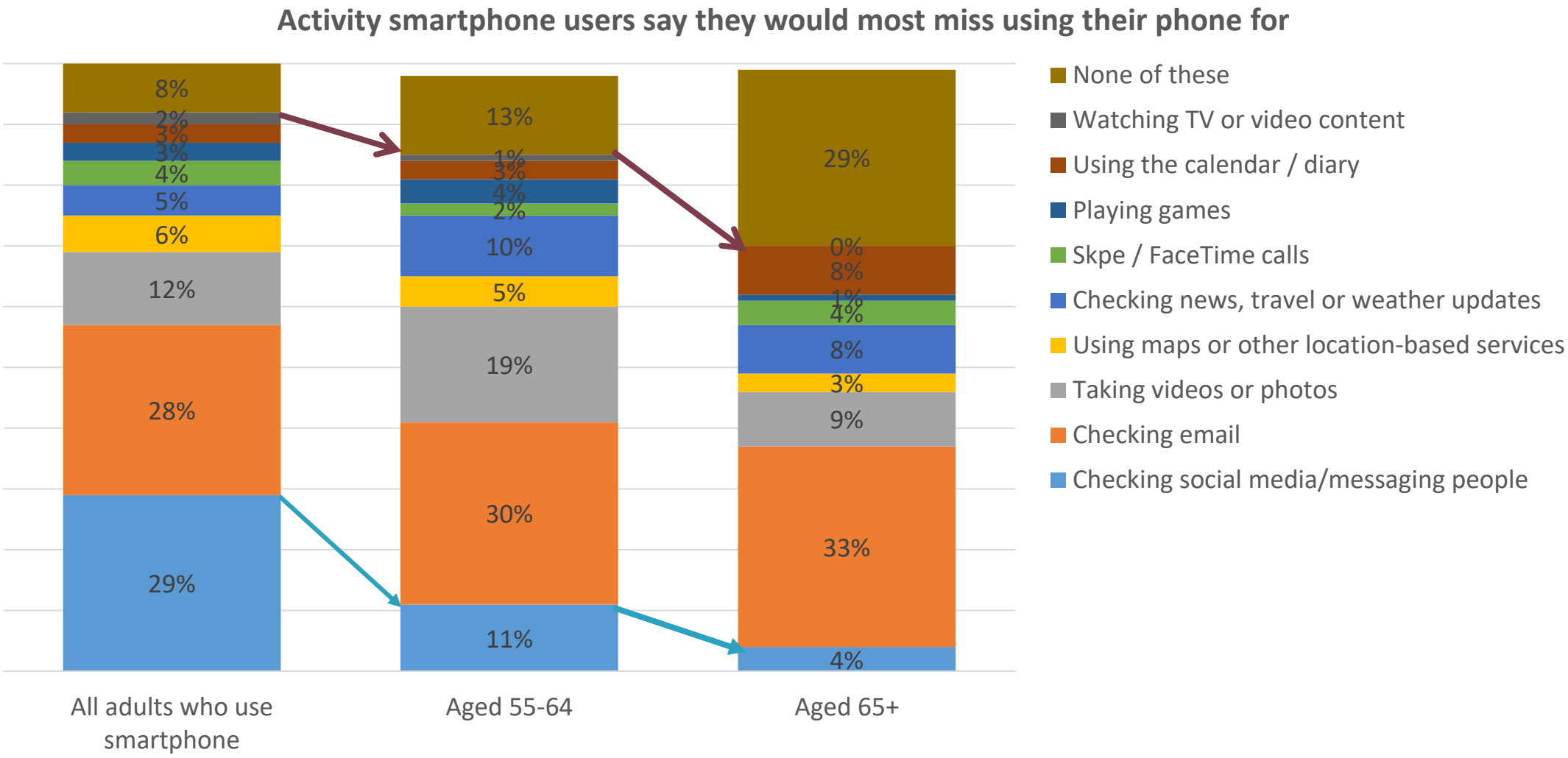
Smartphone utilization

Figure 3. Device preference for various activities, UK (2016 versus 2017)
Question: Which, if any, is your preferred device for each of the following activities?

Weighted base: Smartphone owners in 16 developed markets (22,929 respondents). The figure is the average of 16 countries in our study, namely Australia, Belgium, Canada, Denmark, Finland, Germany, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Spain, Sweden, UK and USA
Source: Deloitte's Global Mobile Consumer Survey, developed markets, May–July 2017

(Deloitte Ireland, 2018)

Smartphone utilization in the UK



Reasons for low acceptance

- A number of studies investigate why older adults remain reluctant in adopting smartphones.
- Pang et al. (2015) suggest **three groups** of factors:
  - **subjective barriers** (e.g. human factors, motivations and attitudes, socio-economic conditions),
  - **situational barriers** (e.g. economic costs, mobile market maturity, network and service infrastructure, social support),
  - **technological barriers** (e.g. ergonomics, user interface design, usability concerns).

Smartphone services for active and healthy ageing

- Smartphones represent an opportunity for improving the **active and healthy ageing** of older adults (Plaza et al., 2011) through an integration of a range of services:
  - **mHealth** (measuring vital signs, teleconsultation, rehabilitation)
  - **mCare** (remote care for independent living at home)
  - **smartCities** (public transportation)
  - **eGoverment** (access to public administration services)
  - **Ambient Assistive Living** (AAL) environments (smart homes)

Usability and design of smartphones for older adults

Human factors in interface design

Term	Definition	Constructs	Examples
Sensation	The awareness of simple properties of stimuli such as color; activation of sensation cells (e.g., retinal cells).	Taste and smell, haptics, audition, vision.	Seeing the color red; hearing a high-pitched sound.
Perception	The awareness of complex characteristics of things in the environment; the interpretation of information that results from sensation.		Recognizing a red object as an apple or determining that a sound is an alarm.
Cognition	Processes by which the brain takes sensory information from the ears, eyes, etc. and transforms, reduces, stores, recovers, and uses that information.	Working memory, semantic memory, prospective memory, procedural memory, attention, spatial cognition, language comprehension.	Thinking, problem solving, reasoning, decision making.
Movement control	Carrying out an action based on perception or cognition; requires coordination of muscles for control of motion of some type.	Perceptual feedback, motoric declines, different motoric and movement strategies.	Steering a car; double clicking a mouse button; grabbing an object from a shelf.

Adapted from Fisk et al. (2009, 15-25)

Principles of optimizing interface design

Principle	Description	Examples
Compatibility	System design should be compatible with user expectations.	A knob turned clockwise results in an increase in something; counter-clockwise results in a decrease.
Consistency	Location of items should be the same across screens; similar functions should act the same throughout the system.	Save or home button should be in the same location on every screen; cancel button should always result in the same action.
Error recovery	Expect users to make errors and make recovery easy.	Provide an "undo" option and meaningful error messages.
Feedback	Results of actions should be clear.	Provide status information such as an hourglass to indicate processing.
Individualization	Enable the user to tailor the system to individual capabilities and preferences.	Flexibility in display characteristics such as size of icons; more than one option to perform a task (e.g., menu versus control keys).
Memory	The user 's memory should not be overloaded; memory aids should be provided.	Do not require multiple meaningless steps to perform an action (CTRL-F-Q-L-R); provide labels to support memory.
Structure	Provide structure to support performance.	System layout chart; site map; organized displays.
Workload	Reduce information processing requirements of user.	Organize displays and highlight critical information to reduce need for scanning.

Adapted from Fisk et al. (2009, 75)

Guidelines for age-friendly mobile phone design

Device-based and screen-based interaction elements

Interaction elements	Findings
Display	High contrasts, options to zoom in and increase the font size are desired
	Prolonged screen dimming to provide more time for completing operations
Graphics	Simple and meaningful icons without decoration and animation
	Appropriate/conservative colors with high contrast
Form factors	The device should be big, enable a comfortable grip, and be lightweight
	Audio adjustments should be integrated into the device and hearing aids available
Buttons	Preference for larger keypad buttons
	Favor raised buttons that offer accurate dialing and text writing, providing tactile feedback when pressed
	Feedback should be immediate, visual, auditory, and/or tactile
	The arrangement of buttons (e.g., enough space between buttons; the keypad placed at the bottom of the interface)
	The buttons must be easy to understand and distinguish from one another either visually or by touch
	Scroll buttons should be avoided, minimized in number, or placed on the side of the phone

Adapted from Petrovčič et al. (2018)

Guidelines for age-friendly mobile phone design

Menu and navigation interaction elements

Interaction elements	Findings
Menu	Menu structure must be simple and flattened; nesting of features minimized or avoided
Navigation	Easy-to-use menus should be preferred, as many older adults experience disorientation with menu navigation
	Small size of a phone's display hinders navigation; the full menu cannot be shown at one time
Function naming	Functions should be easy to understand and recall
	Foreign expressions, abbreviations, and technical terms should be avoided in menus
	Terminology should be simplified, consistent, and self-explanatory

Guidelines for age-friendly mobile phone design

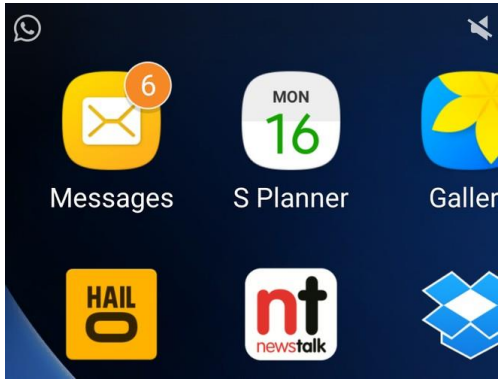
Interaction elements of touchscreen-based smartphones

Interaction elements	Findings
Feedback	Multimodal feedback with auditory and tactile signals enhances older adults' performance and subjective benefits
Target size and position	Pointing performance is increased with larger targets and wider spacing between them
	Pointing performance improves with the targets located in the upper right direction from the screen center point
	Optimal target size is between 14 mm and 17.5 mm
Gestures	Older adults have difficulty in recognizing when a button or target is pressed, which often leads to long taps and pressing of wrong buttons
	Problems with text entry using virtual keyboards
	Additional time needed to comprehend and learn the movements needed for touchscreen gestures
	Difficulties in identifying tappable areas on touchscreen

Examples of UI violations

Decorated icons and inappropriate colours

Small keyboard target size



Unclear naming of the Calendar (S Planner) feature

Potential design solutions for smartphones

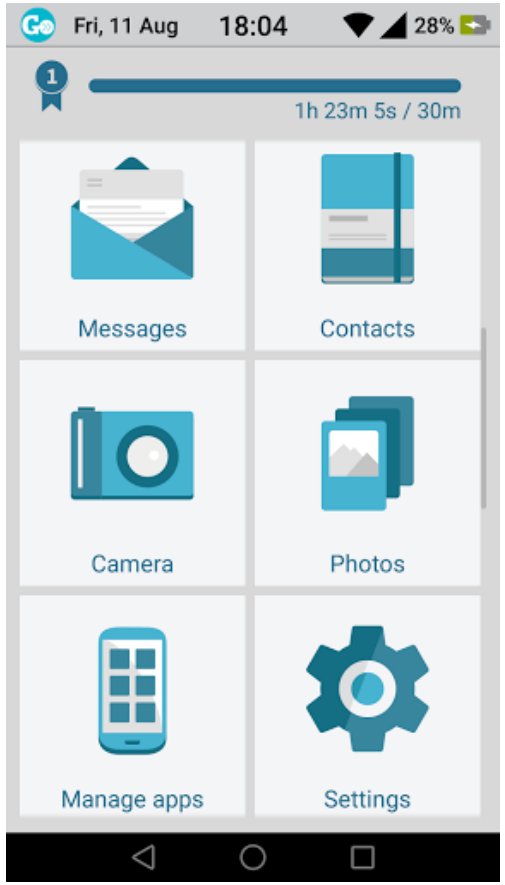
- Smartphone **devices** (Doro smartphones, emporiaSMART)
- Smartphone **launchers** (Golivephone, Koala Phone, Big Launcher, etc.)
- **Adapted generic launchers** (Android, iOS):
  - Accessibility settings in generic OSs
  - Simplified/"light" versions of generic OSs

Example 1 – Adapted smartphone

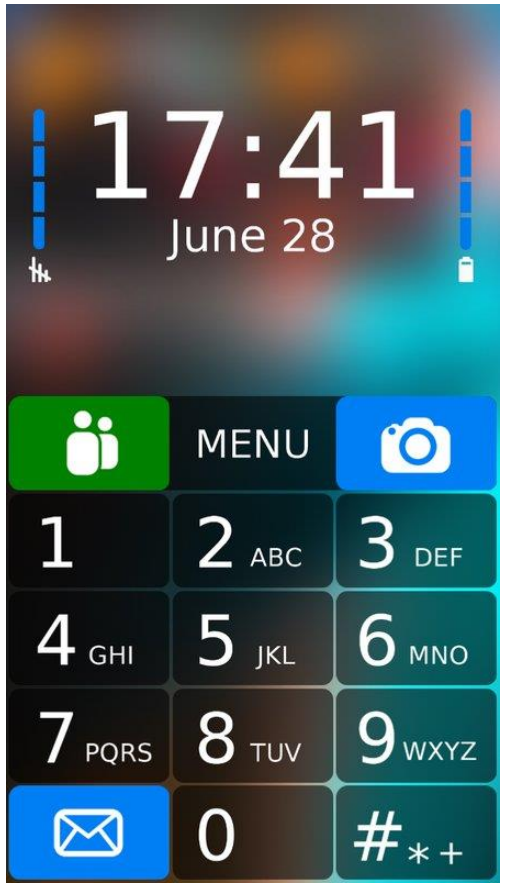
Doro 8035 smartphone

Emporia Smart smartphone

Example 2 – Launcher for older adults



GoLivePhone launcher



Koala Phone Launcher

Example 3 – Adapted generic launcher

Android Easy mode

iOS Easy mode

Video showcase – writing short message

Easily writing and sending message using adapted GoLivePhone Launcher

Issues at writing and sending message using generic Android launcher

Empirical investigations

Study I: Heuristic evaluation of smartphone launchers with an adapted interface and assistive technologies for older adults

Study II: A comparison of the usability of a standard and an age-friendly smartphone launcher

Study I: Heuristic evaluation

Rationale -1st step:

- Applied project: our co-funder/client was undecided between putting on the market adapted devices or/and adapted software (i.e. age-friendly launcher).
- Second decision problem: in-house development or taking/adapting off-the-shelf software.
- As this was **an under-researched area** we took an **explorative research** approach:
  - get an insight into the state-of-art of app market,
  - what does app market offer and how good is what is „out there".

Background and research design

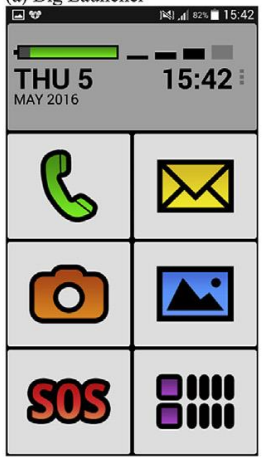
- Limited research on **usability of launchers with an adapted UI for older adults**.
- We compared a set of **12 commercialized age-friendly launchers** with ATs for older adults by means of heuristic evaluation (HE).
- Instrument: Check-list (Silva et al. 2014) with six heuristics: **cognition, content, dexterity, navigation, perception, visual design** (23 items).
- Experts: 4 experienced raters.

Research Questions

- Which usability interface aspects are respected and violated in age-friendly launchers?
- How many and what types of assistive technologies are integrated into age-friendly launchers?
- Are there any differences in the usability problems between age-friendly launchers according to the number of basic functions and assistive technologies?

Home-screens of the evaluated launchers

(a) Big Launcher



(b) BigBig Elderly Desktop

(c) CareZone

(g) Koala Phone

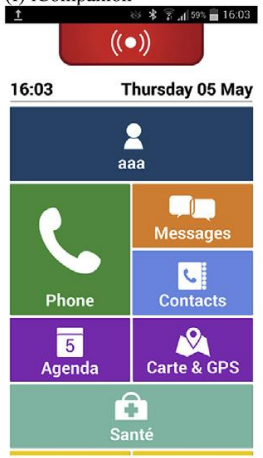
(h) Large Launcher

(i) Necta Launcher

(d) Fontrillo

(e) GoLivePhone

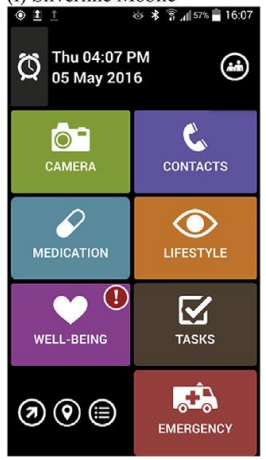
(f) iCompanion



(j) Seniors Phone

(k) Sentizens

(l) Silverline Mobile



Results – Heuristics violations

Heuristic	Total	
	M (%)	SD (%)
Cognition	52,1	22,5
Content	39,6	29,1
Dexterity	75,0	20,7
Navigation	62,5	22,6
Perception	34,7	21,9
Visual design	64,6	27,1
TOTAL (Mean)	54,7	24,0

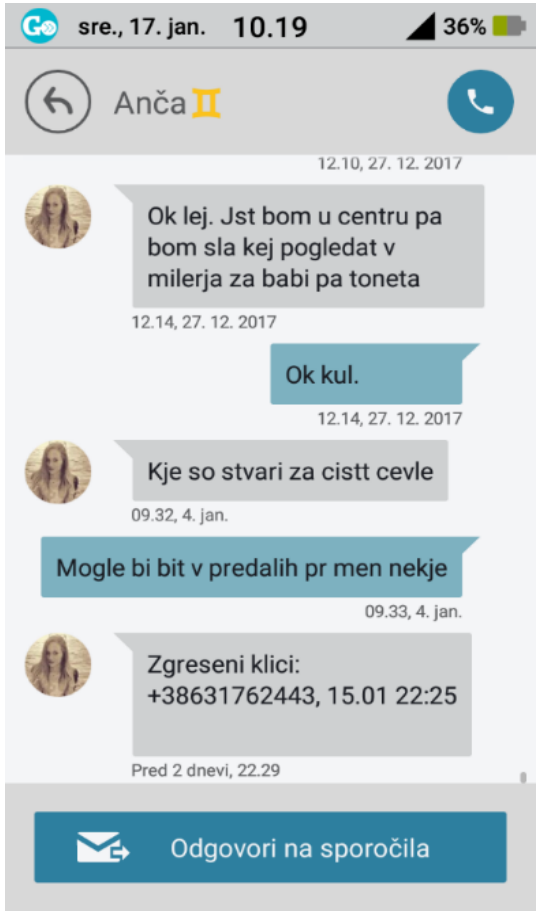
- Heuristic **dexterity** yielded the **lowest** average number of **violations**.
- The frequency of **violation was above the total average** for the heuristics addressing **cognition, content,** and **perception**.

Results – Total heuristic score (THS)

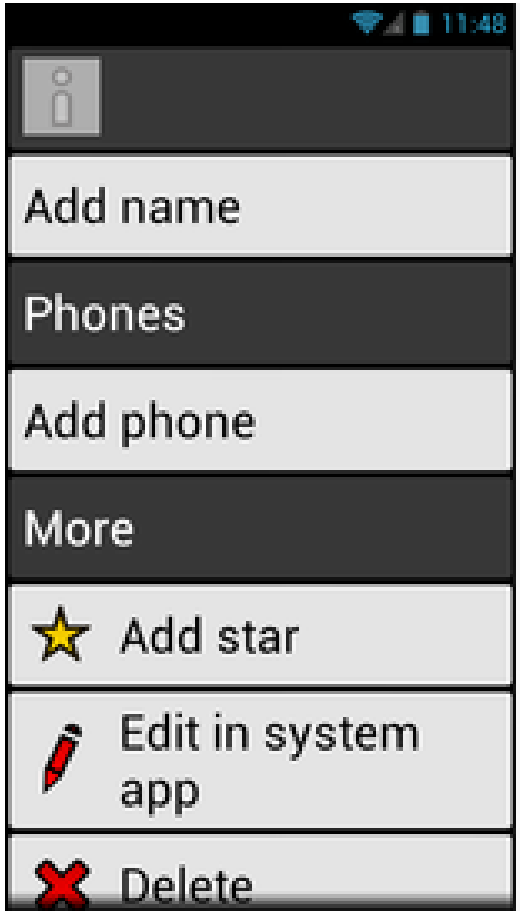
Name	OS	Features	ATs	THS (%)
Koala Phone Senior Launcher	Android	8	1	TOP 86,1
GoLivePhone	Android	11	7	77,8
Big Launcher	Android	5	1	66,7
Necta Launcher(for senior)	Android	9	2	61,1
Fontrillo	Android	8	1	58,3
Silverline Mobile	Android	7	2	58,3
Sentizens	iOS	7	1	47,2
iCompanion Senior Launcher	Android	12	3	45,8
Seniors Phone	Android	4	1	41,7
BigBig Elderly Desktop	WP	6	1	38,9
Large Launcher Senior Phone	Android	7	1	38,9
Care Zone Family	iOS	8	1	36,1

THS was calculated as an arithmetic mean of the six heuristics scores – Cognition, Content, Dexterity, Navigation, Perception and Visual Design

Violated heuristics - examples



GoLivePhone – Font size of sent/received messages is not enlarged (*Visual design)*



Big Launcher – More actions required on the same screen (*Cognition)*

Fontrillo – Scrolling required on the home screen (*Dexterity*), absence of „Back" button *(Navigation)*

Study I: Summary

- In general, good support of „basics" and scarce coverage of advanced features (camera, calendar, navigation, etc.).
- ATs are weakly supported by age-friendly launchers (by and large, limited to the „SOS" call).
- **Overall usability performance below the expected level**: on average only 54.7% of the 23 evaluated sub-heuristics was respected.
- The highest proportion of **violations** was related to the heuristics of **content and perception**.
- A great **variation between launchers** in terms of the total heuristic score (50 percentage points, with a min. 36.1% and max. score of 86.1%.).
- Surprisingly, launchers with more complex UI (i.e., with more features) have performed better in the evaluation.

Study II: Usability test of two launchers

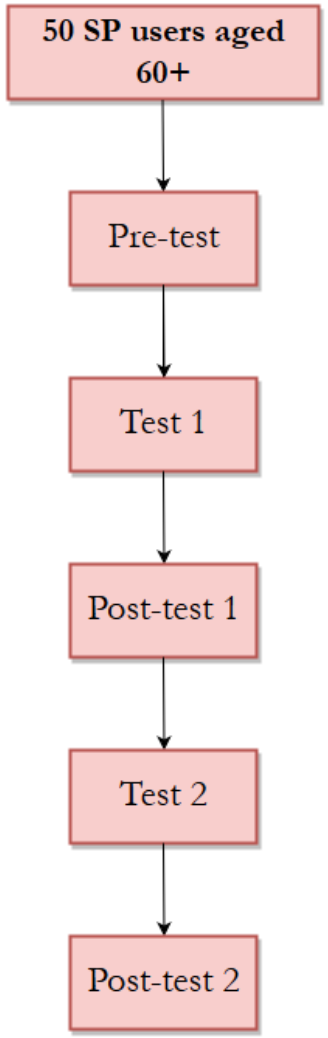
Rationale -2nd step:

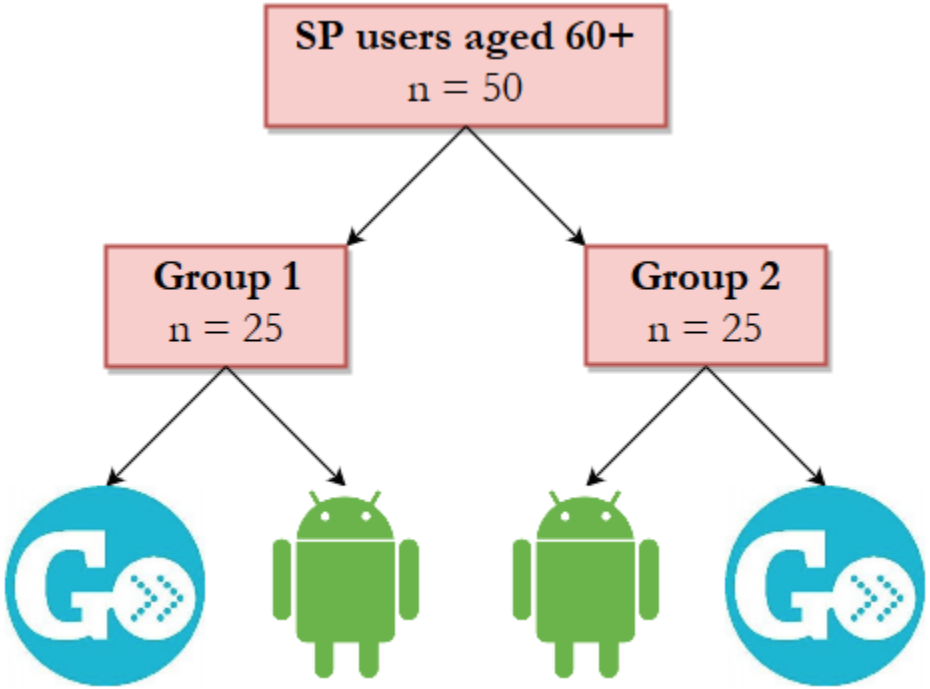
- Applied project: our co-funder/client was concerned about the huge difference between „top-scorers", „laggards" and „low-performers".
- Second decision problem: does it make sense to invest resources into software adaptation (market insiders' projection: sooner or later the age-gap will disappear and everybody will be on „easy"/"light" versions of generic OS).
- Two implications for research design:
  - get „in touch" with users (i.e., usability testing),
  - experimental research design (i.e., *ceteris paribus* which software is better adapted or generic).

Research questions and design

- Research questions:
  - Does **GoLivePhone (GLP) perform better than a standard Android** launcher?
  - What is the **relationship** between **user interface complexity** and **usability performance** of two types of launchers?
- A **randomized crossover experiment** involving 50 **older smartphone users (60+)**.
- Method: **Summative usability testing** – participants solved 10 tasks, all of them on both, generic Android and GLP launcher, but in opposite sequence.

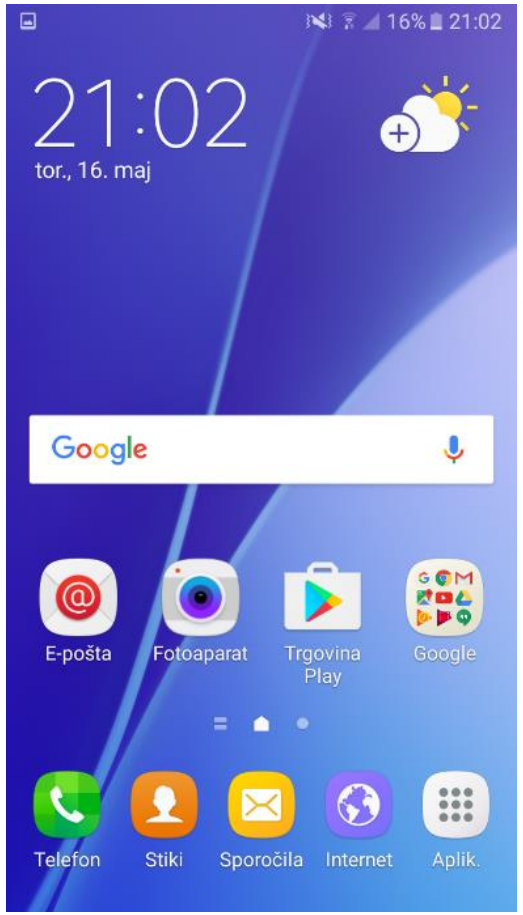
Study design and experimental design



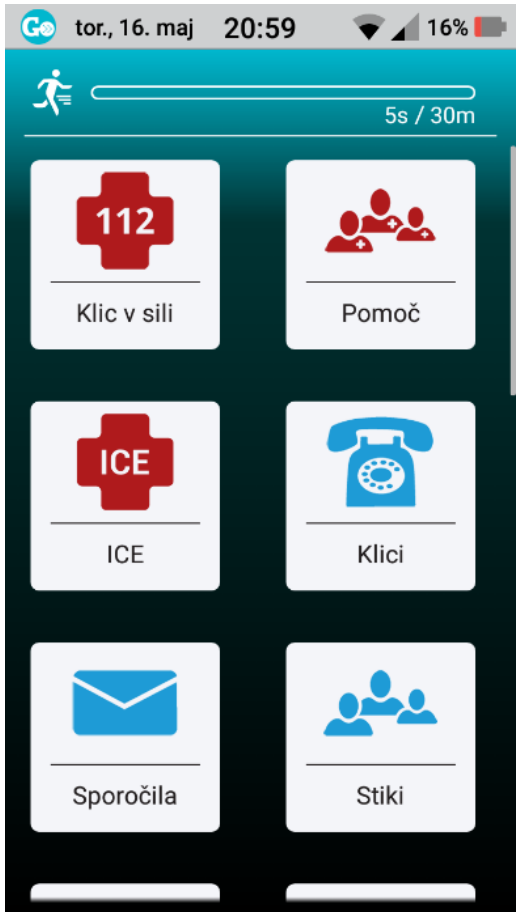


Test setting

Tested launchers



Generic Android launcher v6.0.1



GoLivePhone launcher

Testing scenario tasks

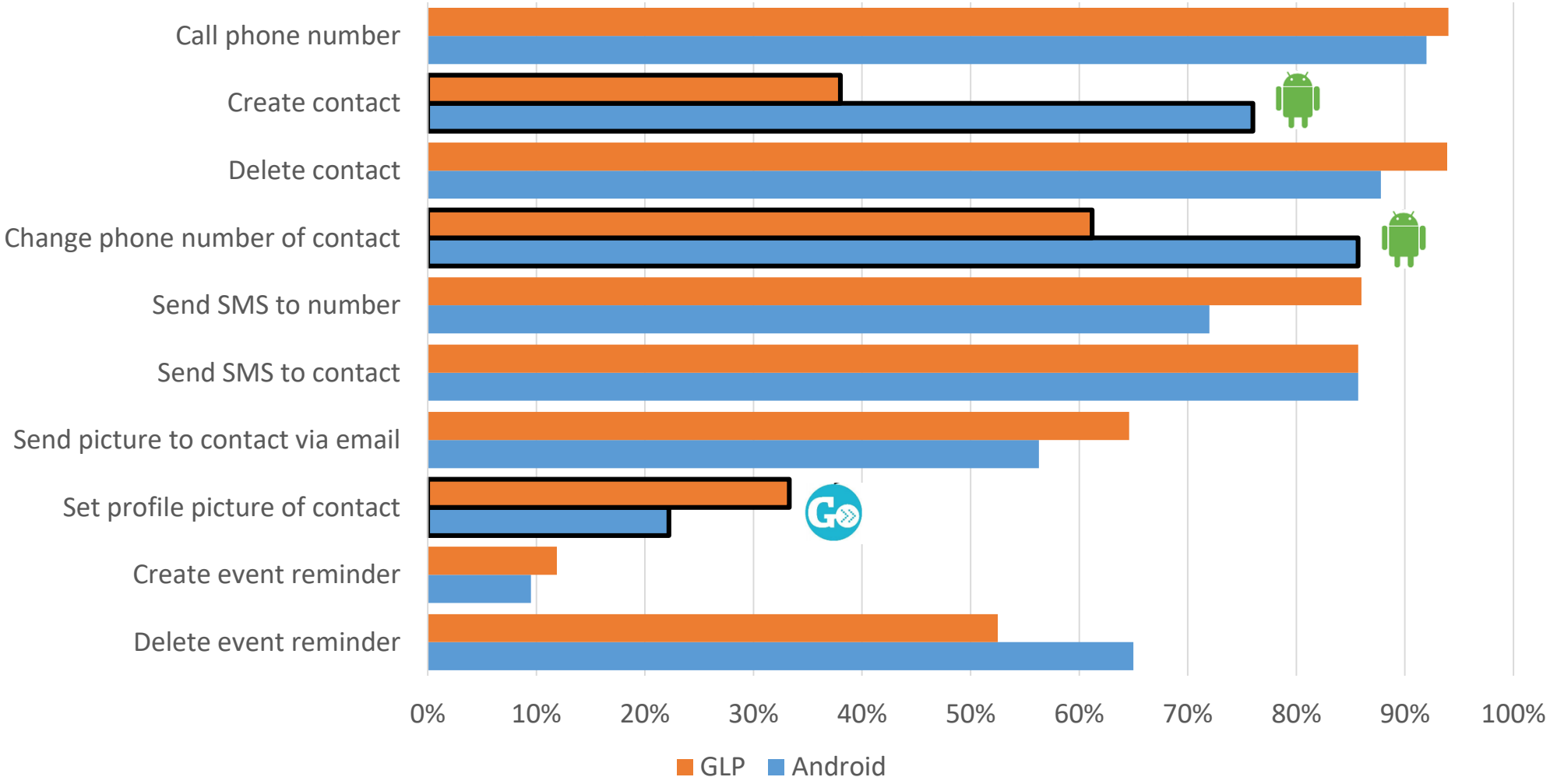
Task	Feature	Task description
T1	Call and contact	Call the phone number 01 580 53 80. When you hear ringing, end the call.
T2		Create new contact Helen Blunt with phone number 030 456 061.
T3		Delete contact Alice Emerson.
T4		Change phone number of the contact Anna Spencer to 030 456 071.
T5	SMS	Send SMS message with content "Ok" to phone number 040 641 177.
T6		Send SMS message with content "I am coming" to the contact Jane Booker.
T7	Gallery	In the gallery, find the photo of house. Open the photo, and send it to contact Martha Davison.
T8		Add photo of a woman from the gallery to the contact Lucy Parker.
T9	Calendar	Create an event "Visit" for Friday 30 June, 3-4 pm, in city centre. Set it as one-time event without reminder.
T10		Find and delete event "Celebration" which should take place on June 28.

Usability metrics

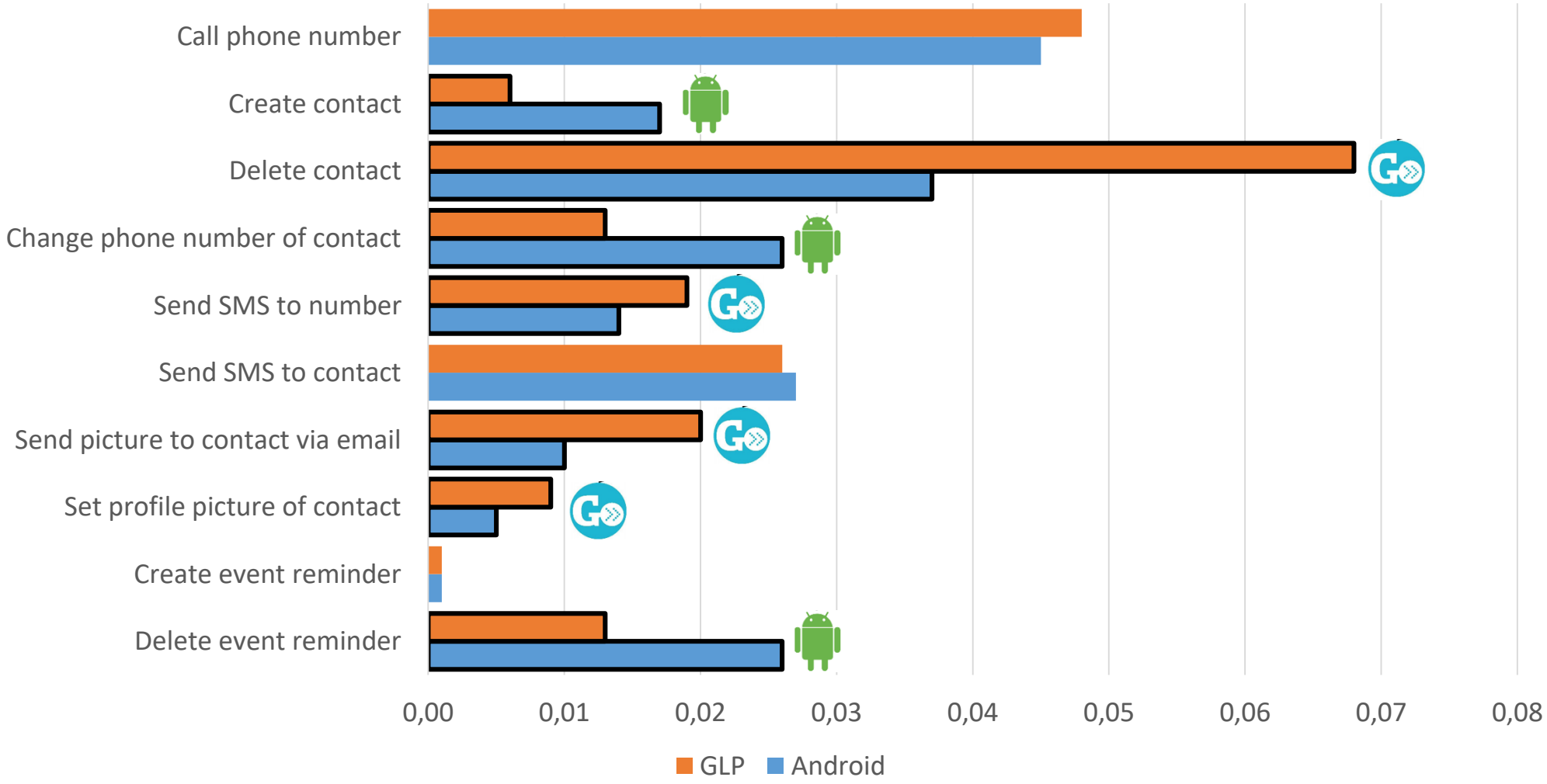
- The usability performance of a launcher was evaluated on the basis of two out of three usability metrics – **effectiveness and efficiency**. Third metric, satisfaction, was not measured (ISO, 2018).
- **Effectiveness** is the accuracy and completeness with which a certain goal is achieved by the user.
- **Efficiency** refers to the amount of resources that a user expends to achieve a certain goal.

Video showcase – changing contact's phone number

Results – Task success



Results – Task efficiency



User interface complexity matrix (UICM)

- The minimum number of actions (taps) that needs to be taken to achieve the goal along the optimal path in the user interface - *production rules* in Cognitive Complexity Theory.
- The presence of multiple potential ways to arrive at a desired end state (i.e. to achieve the goal) in the user interface.

UICM	Number of optimal paths = 1	Number of optimal paths > 1
Length of optimal path ≤ 5	Simple-Simple	Simple-Complex
Length of optimal path > 5	Complex-Simple	Complex-Complex

Results – UICM

Task	UICM Expected Outcome	Observed Outcome TS	Observed Outcome TE
Call phone number	=	✓	✓
Create contact		✓	✓
Delete contact	=	✓	
Change phone number of contact		✓	✓
Send SMS to number	=	✓	
Send SMS to contact	=	✓	✓
Send picture to contact via email		✗	✓
Set profile picture of contact		✓	✓
Create event reminder	=	✓	✓
Delete event reminder	=	✓	

Study II: Summary

- Almost **no difference** in task success and **marginal outperformance** of the age-friendly launcher in task efficiency.
- **High UI complexity, worse performance** – irrespective of the type of launcher:
  - Task success: **9/10** observed outcomes were in line with UICM expected outcomes.
  - Task efficiency: **7/10** observed outcomes were in line with UICM expected outcomes.

Conclusions

- Somehow, the results were little disappointing: the age-friendly launcher didn't make the anticipated „big" difference.
- Yet, the UICM suggests that **the age-friendly launcher had a less complex UI only on two (very complex) tasks!** (that's where it outperformed Android UI).
- Is it worth investing so much resources in developing a system that seems to bring (only) a marginal improvement in usability?
  - **Client**: No, unless it is upgraded with something that brings extra value for users and extra ROI for us.
  - **Public agency**: Depends, it might be that other approaches would work better (e.g., digital skills tutorials and learning sessions).

Thanks for your attention!

Andraž Petrovčič, Ph.D.
Faculty *of Social Sciences*
University *of Ljubljana*
Kardeljeva pl. 5
SI-1000 Ljubljana
andraz.petrovcic@fdv.uni-lj.si
www.cdi.si

CENTRE FOR SOCIAL INFORMATICS

University *of Ljubljana* Faculty *of Social Sciences*

Thank you for your attention!