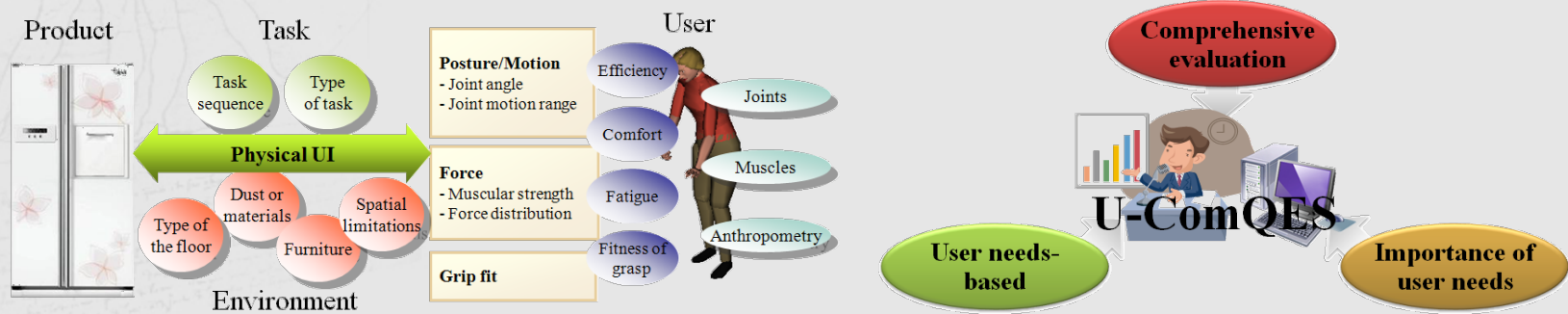# Development of a Comprehensive and Quantitative Usability Evaluation System Based on User Needs

Wonsup Lee, Kihyo Jung, Jangwoon Park, Sujin Kim, Sunghye Yoon, Moonsung Kim, and Heecheon You

Department of Industrial and Management Engineering,

Pohang University of Science and Technology (POSTECH), South Korea

Contents

- Introduction

  - Background

  - Objectives of the Study

- Usability Evaluation System Development

- Application: Refrigerator Usability Testing

- Discussion

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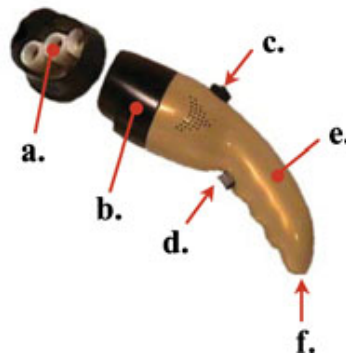
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Usability Evaluation

- Test the degree of efficiency and effectiveness of use for a product (hardware, software, manual) considering users, tasks, and environments (Han et al, 2001; Bennet, 1984; Shackel, 1984).

Usability testing of an operating manual for hair braiding device (You et al., 2008)

Usability evaluation for vacuum cleaner (Lee et al., 2009)

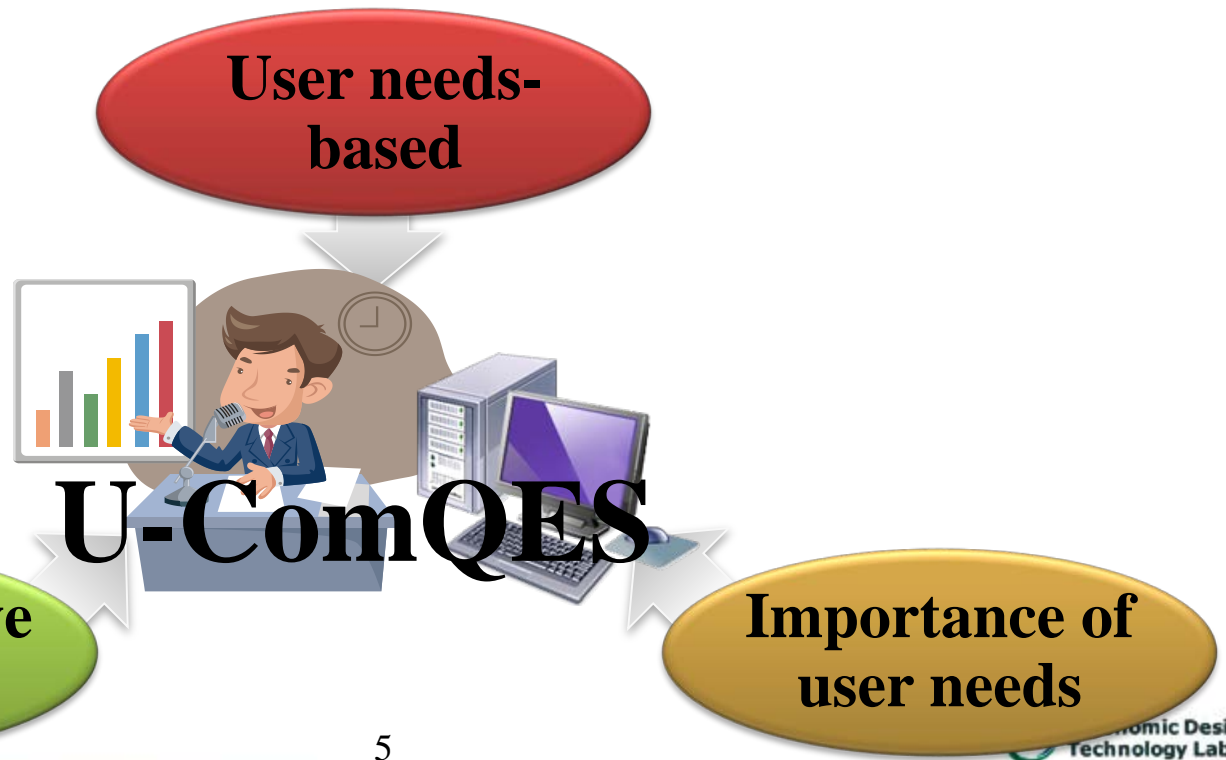# Desirable Usability Evaluation for Practitioners?

Needs of PDD Practitioners	Desirable UE
1. **User-centered design**	$\Rightarrow$ Based on **user needs**
2. **Comprehensive identification of** usability problems	$\Rightarrow$ **Comprehensive** by considering characteristics of product and user
3. **Important design elements** affecting/causing usability problems	$\Rightarrow$ Considering **relative importance of user needs**
4. Identifying **preferred vs. undesirable design features**	$\Rightarrow$ **Quantitative analysis and synthesis**
5. **Efficient analysis and identification** of usability problem	$\Rightarrow$ **Assisted by a computerized system**

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Objectives of the Study

1. Develop a **comprehensive and quantitative evaluation system (U-ComQES)** which is based on **user needs** and incorporating their relative **importance**.

2. Examine the **effectiveness of U-ComQES** by applying to the usability testing of refrigerator.

U-ComQES Development Process

Attributes of Desirable UE

| S1 | **Analysis of Product-User Interface** | → | Comprehensiveness |

| S2 | **Survey of User Needs** | → | User-needs based |

| S3 | **Development of User Needs Hierarchy** | → | |

| S4 | **Survey of User Needs Importances** | → | Relative importances of user needs |

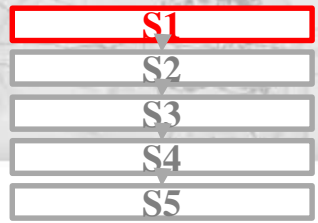| S5 | **Implementation of U-ComQES** | → | Quantitative and efficiency analysis |
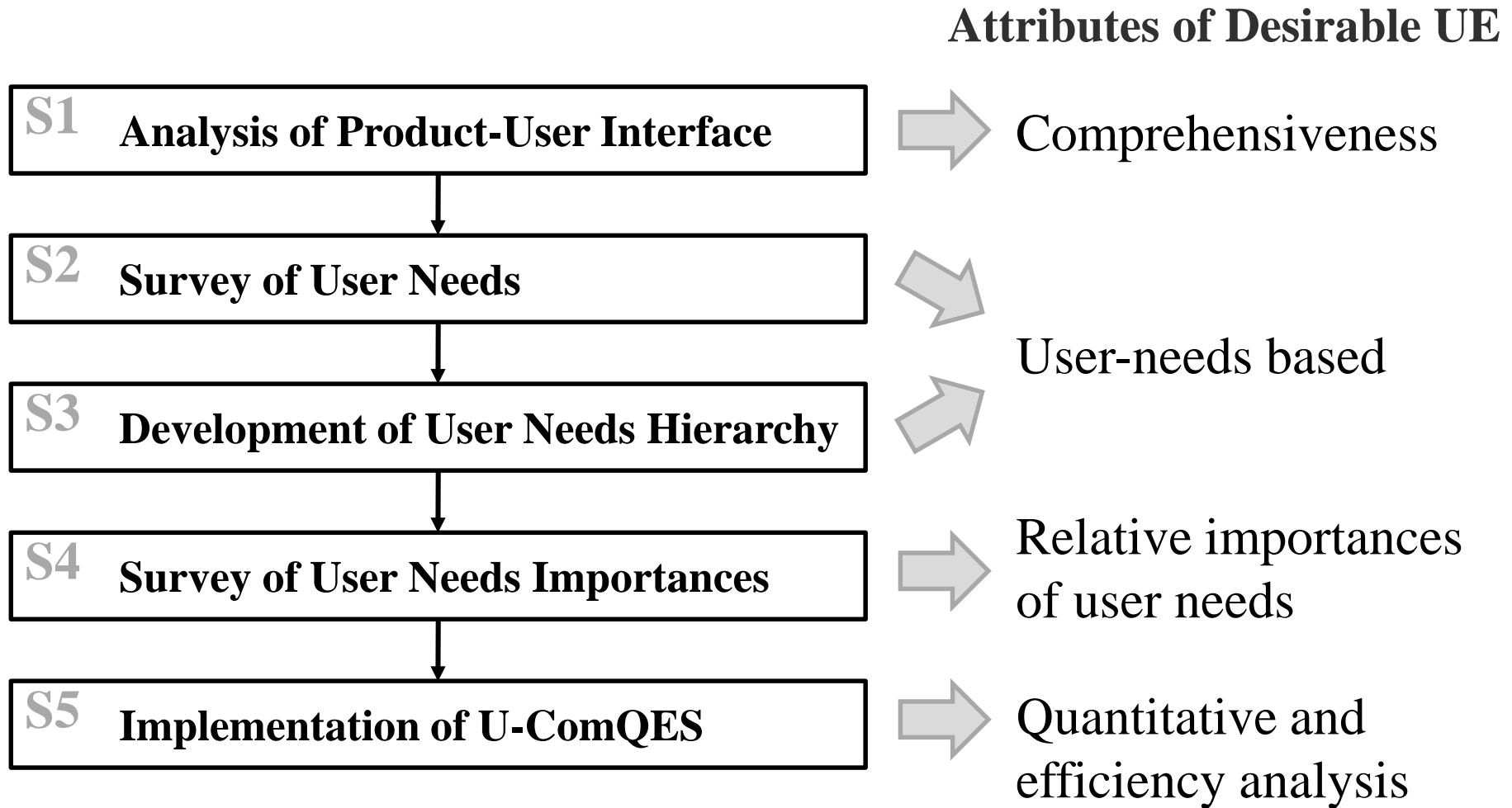
S1. Analysis of Product-User Interface (PUI)

- Analyze the PUI to comprehensively understand the characteristics of the product, user, and their interaction.

Product Components [C]

Task [T]

Task sequence

Type of task

PUI

Dust or materials

Type of the floor

Spatial limitations

Furniture

Environment [E]

Posture/Motion
- Joint angle
- Joint motion range

Force
- Muscular strength
- Force distribution

Grip fit

Usability Criteria [U]

Efficiency

Comfort

Fatigue

Fitness of grasp

Joints

Muscles

Anthropometry

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Characteristics of PUI: Product Components

(e.g.) hierarchy of product components [C]: refrigerator - 38 components

Category	Subcategory	Component
Exterior components	Door	Door panel
		Door handle
	Control panel	Display
		Control buttons
	⋮	⋮
Interior components	Door guards	Dairy guard
		Half guard
		⋮
	Shelves	Sliding shelf
		Folding shelf
		⋮
	⋮	⋮

Characteristics of PUI: Tasks
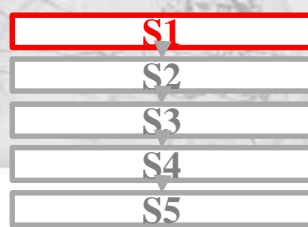
(e.g.) hierarchy of tasks [T]: refrigerator - 42 tasks

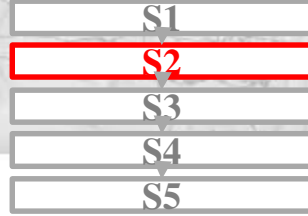| Class	Task
Door open/close	Open and close refrigerator door
	Open and close freezer door
	:
Clean	Clean inside and outside
	Disassemble/Assemble shelves, guards, and boxes
	:
Install	Install shelves at profit height
	Install guards at profit height
	:
:	:

S2. Survey of User Needs

■ Prepare a questionnaire to identify user needs for each product component

Door Handle (related tasks: open, close, clean)

Likes	Dislikes	Improvement Suggestions
1._____ _____ 2._____ _____	1._____ _____ 2._____ _____	1._____ _____ 2._____ _____

■ (e.g.) survey of user needs: refrigerator
- Mail survey: 200 copies
- Respondents: 89 female users (age = 41.7 ± 6.9; range of age: 30s ~ 50s)
- Compensation: $10 ~ $50 depending on the quality and quantity of information

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Interpretation of User Needs

- Interpreted user responses by following the user needs identification guidelines (Ulich & Eppinger, 2008)
    - G1: What, not how
    - G2: Specificity
    - G3: Positive, not negative
    - G4: An attribute of the product
    - G5: Avoid 'must' and 'should'

UN: Sufficient opening range of door

Category		Likes	Dislikes	Improvement Suggestions
Component	**Door panel**	Can be opened with a low force.	Does not open enough.	Make the operating range larger.
	Dairy guard	Its cover can be opened smoothly.	Cannot see inside through the cover.	Make its cover transparent.

UN: Opening door with low force

UN: Transparent guard cover to see contents inside

S3. Development of User Needs Hierarchy

Component		Usability criteria	User needs
Door	Door	Ease of use	Large open range of door
			Open without disturbances
			:
		Ease of control	Smooth open
			Open with low force
		:	:
	Door-handle	Fit to the hand	Good grip fit
			Profit shape to hand
		:	:
Door guards	Dairy guard	Ease of use	Appropriate height
			Transparent guard cover
		:	:
	Half guard	Ease of use	Appropriate size
	:	:	:

S4. Survey of User Needs Importances

S1
S2
S3
S4
S5

- Survey importances for each user need to calculate weighted usability scores.

(e.g.) refrigerator: 72 female users (age = 39.5 ± 4.0; range: 30s ~ 40s)

Component		Score for importance
		Very low ... Very high
Door	Door	① ② ③ ④ ⑤ ⑥ ⑦
	Door-handle	① ② ③ ④ ⑤ ⑥ ⑦
Door guards	Dairy guard	① ② ③ ④ ⑤ ⑥ ⑦
	Half guard	① ② ③ ④ ⑤ ⑥ ⑦
:	:	:

Component		Usability criteria	Score for importance
			Very low ... Very high
Door	Door	Ease of control	① ② ③ ④ ⑤ ⑥ ⑦
		Ease of use	① ② ③ ④ ⑤ ⑥ ⑦
		:	:
	Door-handle	Ease of grasp	① ② ③ ④ ⑤ ⑥ ⑦
	:	:	:

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Calculation of Normalized Weights

- Transform to normalized weight scores for each level of needs hierarchy.

Component			Usability criteria		User needs	
Door	Door	0.52	Ease of use	0.17	Large open range of door	0.26
					Open without disturbances	0.17
					:	$\Sigma = 1$
			Ease of control	0.17	Smooth open	0.53
					Open with low force	0.47
			:	$\Sigma = 1$	:	:
	Door-handle	0.48	Fit to the hand	0.24	Good grip fit	0.16
	$\Sigma = 1$				Profit shape to hand	0.23
			:	:	:	:
Door guards	Dairy guard	0.20	Ease of use	0.17	Appropriate height	0.25
					Transparent guard cover	0.18
	:	:	:	:	:	:

S5. Implementation of U-ComQES

- Developed a system by incorporating user needs and normalized weights.

Component hierarchy

User needs

User needs importance

U-ComQES

Analysis and report

- S company
- L company
- W company
- M company

C 1   C 2   C 3   ...   C 5

Searching causes of usability problem

U-ComQES Application: Refrigerator

S company

L company

- Usability scores by
  - User need
  - Usability criterion
  - Product component
  - Overall
- Comparison between several models

Assessment of usability

Entry of usability scores into U-ComQES

<Usability problem list>

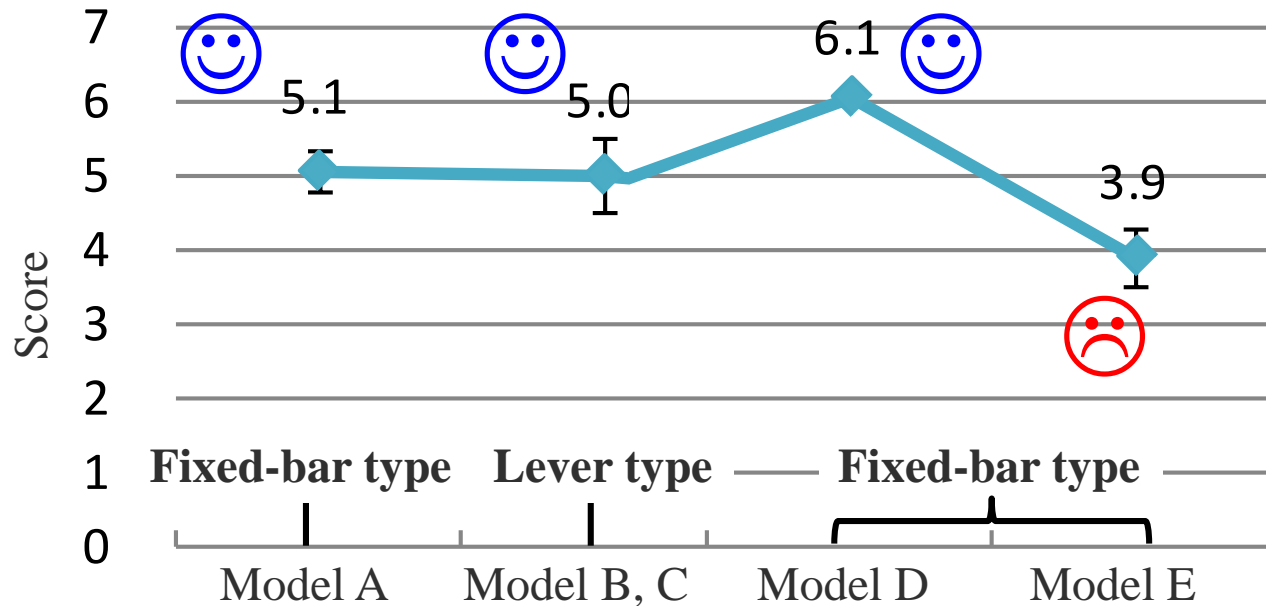Analysis and identification of usability problems

System Application: Evaluation of Refrigerators

- Usability assessment
  - Side-by-side (SBS) Refrigerator models: 5
  - Components [C]: 38
  - Tasks [T]: 42
  - Usability criteria [U]: 16
  - User needs: 228
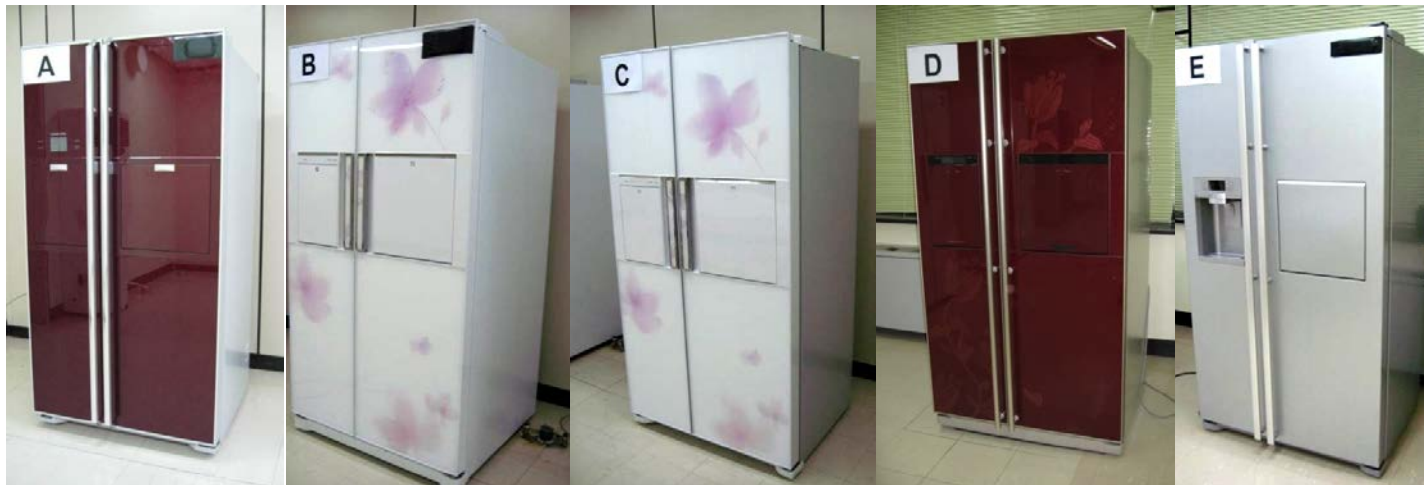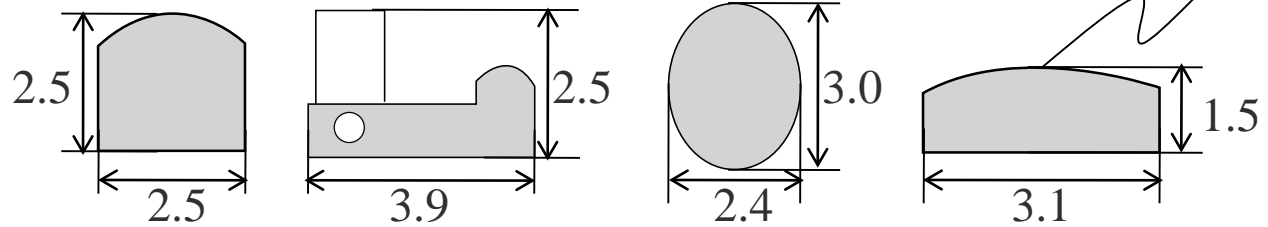
Preferred Designs: Door Handle Type and Shape

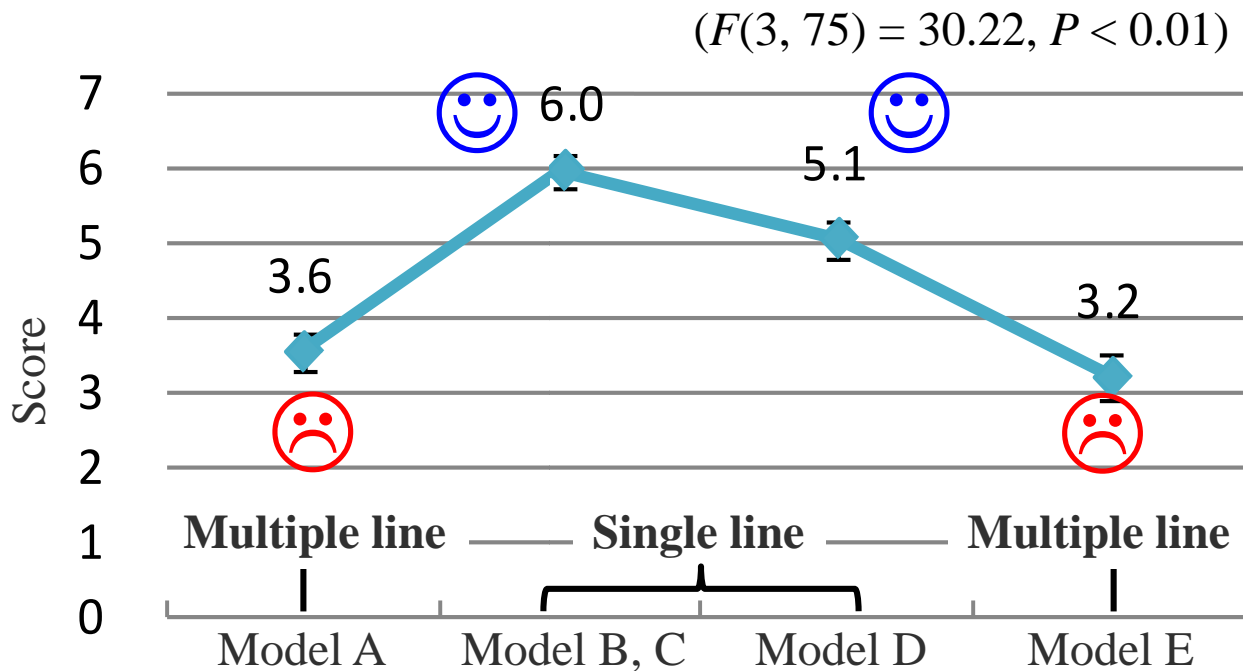$(F(3, 75) = 7.15, P < 0.01)$

Fixed-bar type

Lever type

(Unit: cm)

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Preferred Designs: Display

$(F(3, 75) = 30.22, P < 0.01)$

Score

7
6 — 6.0
5 — 5.1
4 — 3.6
3
2 — 3.2
1 — **Multiple line** —— **Single line** —— **Multiple line**
0

Model A Model B, C Model D Model E

Discussion

- Key features of U-ComQES

  - **User-needs based** evaluation items

  - **Comprehensive** testing

  - Relative **importances**

  - **Quantitative** evaluation

  - **Computerized** system

Benefits for PDD practitioners

$\Rightarrow$ weighted usability testing scores

$\Rightarrow$ preferred design identification based on quantitative comparison

$\Rightarrow$ quick and efficient analysis

- Analysis result

  - Level of **usability scores** (weighted summation)

| User needs | Usability criteria | Product components | Overall product |

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- **Limitation**
  - Time-demanding for evaluation of user needs (228 items for 38 product components)

    ⇒ Developed a simple mode system to evaluate by usability criteria (104 items)

  - Limited data reliability due to use of subjective judgment

Q & A

Thank you for your attention…