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Population Stereotypes as a Perceiver's Cognitive Structure on Manipulating Devices for Daily Use

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Purpose: This study standardizes the position and direction of devices based on general user expectations and stereotypes. Population stereotypes are cognitive structures that contain the perceiver's knowledge, beliefs, and expectations about human groups. In this paper, the stereotypes that people typically expect when manipulating 'cylindrical key-in-knob locks' and 'lever-type water faucet handles' were investigated and data regarding their expectations were collected.

Methods: Two sets of 600 participants, between 13 and over 60 years old, were recruited for the experiment. Each group was evenly subdivided into six age groups. Each participant was presented with cylindrical door locks mounted on a miniature door and actual lever-type water faucet handles mounted on a mockup sink.

Results: If the cylindrical lock was positioned 'vertically,' 59.2% of the participants expected the device to be locked, and if the lever type faucet handle was positioned 'up,' 63.0% of the participants expected the device to be turned on. Thus, daily-use devices should be designed consistent with user expectations of operation. There was a significant difference between genders for manipulating the faucet handle between up and down.

Conclusion: A more general stereotype may be defined by repetitive measurements under the same test conditions with fixed time intervals, as well as accounting for people with cognitive problems.

Key Words: Cognitive structure, Human expectations, Population stereotypes

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I. Introduction

As human beings, we naturally evaluate everything we come in contact with. We especially try to gain insight and direction from our evaluation of other people. Stereotypes are "cognitive structures that contain the perceiver's knowledge, beliefs, and expectations about human groups" (Hoenig et al, 1997).

People have an implicit ability to understand cause-and-effect relations and the meaning of an object's movement in relation to its mechanical usage. In particular, adults automatically anticipate the movement direction of indicators and control devices, such as pointers, dials, scales, knobs, and levers, and operate them accordingly. When several groups respond consistently to the same operation, it constitutes a population stereotype, and when the movement direction of an indicator or control device is consistent with a widely prevalent stereotype, it displays high compatibility (Bridger, 1986). In other words, compatibility shows how close something is to human expectations.A system with a greater degree of compatibility will result in faster learning, faster reaction time, fewer errors, and higher user satisfaction (Granger and Greer, 1976).

Population stereotypes and control-display compatibility have been studied for more than 50 years, including studies on physical control-burner arrangement relationships (Carey and Posavac, 1978; Chapanis and Mankin, 1967; Steadman and Graham, 1970) and on direction-of- motion relationships (Brebner and Sandow, 1976; Brooks, 1972; Courtney, 1994; Hoffmann, 1996; Mandleberg and Brooks, 1975).

The stereotypes regarding the direction of power supplies for electrical switches in the U.S. are: Up (97%) for Up/Down, Right (71%) for Left/Right, and Away (53%) for Away/Toward switch movements. The most preferred is the Up/Down switch (Schwartz, 1995). However, the stereotype expected in the U.K. for Up/Down switches is contrary to that in the U.S.; power is expected to be supplied when the switch is Down. Karpman (1995) found that in Korea, the stereotype regarding On/Off direction of various types of switches is consistent with that of the U.S., but with toggle, slide, and lever switches, Koreans prefer a Left/Right orientation (horizontal motion), whereas North Americans prefer an Up/Down (vertical motion).

The Lundgren and Persechino (1986) study on the orientation of indicators and operation devices showed that the stereotypes of northern and central Africans were more fixed when exposed to new technology or within younger, educated groups. Courtney (1994) found dissimilarities between Americans and Chinese regarding preferences for operation devices and indicators of burners. As such, factors that influence expectations of mechanical operations include technological exposure, and also indigenous culture, letters, and signs (Bridger, 1986). Disparities also exist according to nationality, age, and gender (Shallice and Burgess, 1991).

This study is based on stimulus-and-response patterns, key concepts of cognitive structure, ergonomic design, and human expectations. It offers a design preferred by the majority of users according to stereotypes regarding the locked position of door locks and the open direction of water faucet handles. To this end, we used cylindrical key-in-knob locks (commonly known as cylindrical locks) and the single Hot/Cold lever-type faucet handle (that controls both hot and cold water), which are the most popular type in homes, offices, and public facilities. Stereotypes for the locked and open directions were established to develop design criteria shared by the majority of users.

In general, door lock devices are opened from the outside with a key and with a thumb turn knob (also called a latch knob) on the inside, using a cylindrical knob handle that must be released manually. Does turning the thumb turn knob horizontally or vertically from the inside lock or open the door? At times, people experience difficulty opening the door to someone else's house or office and has had to jostle with the knob before finally getting it right. For example, the comments and responses in 'The old new thing: user interface design for interior door locks (2005)' state that people from many countries, such as Austria, Canada, France, Germany, India, Korea, UK, and the U.S. experience difficulty with predicting the locked and unlocked positions of a door lock.

Sinks are used at home, work, and public washrooms or bathhouses for washing. Numerous water faucets are encountered, of which the most widely used are the single lever-type faucet handles. Which direction should the faucet handle be operated to turn on or off the water? In many cases, the opening directions of water faucets at other houses or public washrooms are not the same as at home. For example, some single lever-type faucet handles are turned 'up' to turn on the water, while others are turned 'down.' This is a typical case of inconsistency because user

Table 1. Mean (SD) distribution of age of participants by age stratification

Gender	Age group					
	10s	20s	30s	40s	50s	Over 60
Male	15.8 (1.6)	24.9 (2.0)	35.2 (2.5)	44.5 (2.6)	54.3 (2.7)	65.3 (3.5)
Female	15.9 (1.3)	24.1 (2.6)	34.2 (2.5)	44.1 (2.6)	54.0 (2.6)	65.2 (3.7)

expectations for manipulating the faucet handles were not considered at the design stage. Inconsistency of manipulating direction occurs in the variety of product lines offered by diverse manufacturers, producing a barrier to product standardization.

Complications can arise from differences in user cognition and expectations of the manipulating position and direction of these locks and water faucets. Furthermore, designs vary according to company and product because of a lack of stereotype standards. Such a nuisance seems relatively trivial compared to the systematic malfunction of power switches, but our daily lives are overly inconvenienced all the same. In particular, emergency situations, such as a fire that requires a speedy exit, are good reasons for establishing consistency in design of door lock devices. Therefore, this study holds significance in that it standardizes the position and direction of devices based on general user expectations and stereotypes.

This study was the assess the manipulative ability in according to cognitive structure of the user.

II. Methods

1. Subjects

This study was a randomized, controlled two sets of 600 participants were selected in Jeonbuk province area. Each group was evenly subdivided into six age groups, with 100 participants each, starting from teenagers to the elderly (over 60 years old). Each group was evenly divided among males and females. The data collection sites were: middle and high schools for teens; college campuses for those in their twenties; churches, a bus terminal, and a train station for various age groups. Parks and nursing homes were visited to collect data for the elderly. Participant age ranged from 10 to 60 years (Table 1). The age distribution of both cohorts was almost identical.

2. Test devices

Figures 1 and 2 show the cylindrical lock and water faucet used in this study. These devices are widely available and prevalent in households and buildings. The door lock devices are opened from the outside with a key and with a thumb turn knob on the inside, using a cylindrical knob handle that must be released manually. For the water faucet, turning the single lever to the left (counterclockwise) provided hot water while turning it to the right (clockwise) provided cold water.

While pencil-and-paper tests are simple to devise and administer (Toglia, 1991), they may not reveal genuine stereotypes sufficiently well to be used with confidence (Murrelle et al, 1992). Chan and Chan (2003) noted that a real hardware test should be used whenever possible for

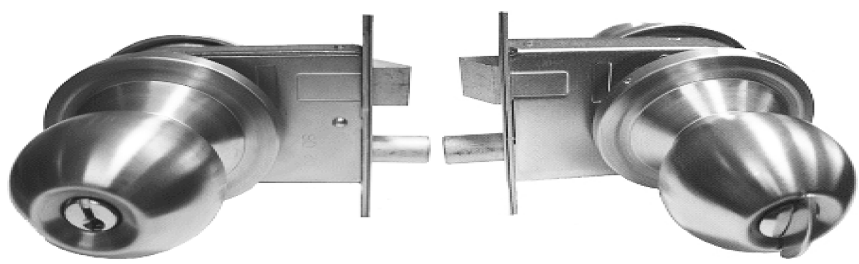

Figure 1. Cylindrical key-in-knob lock (outside and inside view)

Table 2. User expectations by orientation and type of door lock device

Classification	Cylindrical lock		Water faucet handle	
	Vertical	Horizontal	Up	Down
Response	355	245	378	222
Percentage	59.2	40.9	63.0	37.0
95% CI*	55.3~63.1	36.7~45.1	58.8~66.6	33.4~41.2

*Confidence Interval

determination of design parameters of control panels. Therefore, to facilitate participants' understanding and provide a realistic situation, the cylindrical door lock was mounted on a miniature door and an actual lever type water faucet handle was mounted on a mockup sink.

Figure 2. Lever-type water faucet handle

3. Research procedure

The surveyor first recorded the gender, age, and dominant hand (handedness) of each participant, and then asked a question regarding locking position (horizontal or vertical) when using the thumb turn knob from the inside. The first question was, "What is the locking position of the cylindrical lock mounted on the door?" For a better understanding of the study, each participant was asked to operate the lock devices. The next question was, "What is the opening direction of the water faucet handle mounted on the mockup sink?" The water faucet mockup was shown to the participant. Each participant was then asked to turn on the water (operate to 'open' direction) using the water facet mounted on the mockup sink. The surveyor stood by for observation and wrote down one manipulating direction for each response.

4. Data analysis

Descriptive statistics using SPSS 10.0 for Window on frequency analysis and 95% confidence interval analysis were generated using integrated data, gender, age stratification, and dominant hand. Furthermore, a Chi-squared test was administered to verify independence among expected value distributions and to analyze expectation characteristics of stereotypes by gender, age stratification, and dominant hand. The level of significance was 5% for all statistics.

III. Results

1. Overall user expectations

Data on door locks was collected by visiting 186 residences and offices. Most (59.0%) locks required vertical positioning to lock the locking thumb turn knob. In other words, the vertical locking position of the thumb turn knob was used more than the horizontal locking position (Table 2). This percentage is about the same as respondents expectations—59.2%. The vertical position of the thumb turn knob is a stronger stereotype than the horizontal position. A stereotype is operationally defined to be stronger towards a response of 100% and weaker towards 50%.

For faucet handles, 63% responded lifting the lever Up for turning the water on, a stronger stereotype than Down (Table 2). To inquire about the application status of water faucets, product research was conducted in about 50 households, public washrooms, and bathhouses along with dealers, distributors, and manufacturers, indicating that 78% of the lever type handles are operated with the Up direction turning the water on.

Brooks (1972), Carey and Posavac (1978), and Evans (2007) reported that the generalizable stereotype for conventional faucets (i.e., cross taps) is 'counterclockwise for on' and is 'up for on' for the lever type, which is consistent with our study, user expectations, and other

Table 3. User expectations (%) by age stratification

Manipulating position & direction		Age stratification					
		10s	20s	30s	40s	50s	Over 60s
Cylindrical lock	Vertical	63.5	62.0	63.0	61.5	58.5	46.5
	Horizontal	36.5	38.0	37.0	38.5	41.5	53.5
Water faucet handle	Up	63.0	57.0	61.0	64.0	68.0	65.0
	Down	37.0	43.0	39.0	36.0	32.0	35.0

Table 4. User expectations by gender

Classification		Cylindrical lock		Water faucet handle	
		Vertical	Horizontal	Up	Down
Male	Response	178	122	209	91
	Percentage	59.3	40.6	69.7	30.3
	95% CI	53.8~64.9	35.1~46.2	64.5~74.9	25.1~35.5
Female	Response	177	123	169	131
	Percentage	59.0	41.0	56.3	43.7
	95% CI	53.4~64.6	35.4~46.6	50.7~61.9	38.1~49.3

studies.

2. User expectation by age stratification

It is important to analyze expectation patterns according to age stratification. User expectations of the locking position showed little difference by age stratification (Table 3). However, responses in the over 60 group were opposite to the stereotype. Our senses and physical capacity as well as the ability to process information deteriorate with age (Salthouse and Somberg, 1982; Strayer et al, 1987). This study demonstrates a general stereotype fluctuation in conjunction with increased age. All age groups showed a stereotype for faucet handle direction, but the direction was inconsistent.

3. User expectation by gender

User expectation by gender were consistent with overall stereotypes for door locks (Table 4) and water faucets. Gender did not influence the faucet stereotype direction, but the degree of expectation was stronger in males than in females.

According to Evans (2007), males and females did not show different stereotypes for both conventional and lever-operated faucets. However, Guyatt et al (1987) found differences between males and females. Evans (2007) noted that the difference between these findings might be due to the higher degree of standardization in Australian plumbing, and a correspondingly stronger stereotype for both sexes.

4. User expectation by dominant hand

Left-handed (including both-handed) participants accounted for 6.3% or 8.8% of the total count for the two sets of 600 participants. This is lower than 13.2% (including both-handed) that were studied by Jung et al (2007). Among those, men were more common (52.8%-73.0%) than women (27.0%-47.2%), and younger participants in their teens and 20s preferred their left hand.

Handedness did not influence overall user expectations of the locking position (Table 5) or faucet position--Up was the stereotype, but the degree of expectation was a little higher for right-handed than left-handed participants.

5. Verification of independence among expected value distributions

A Chi-squared test was used to verify independence of the expected value distributions (Table 6) for youth (20s and 30s) and the elderly (50s and over 60s), male and female, and right-handed and left-handed, for both measurements.

Table 5. User expectations by dominant hand

Classification		Cylindrical lock		Water faucet handle	
		Vertical	Horizontal	Up	Down
Right-handed	Response	339	236	348	199
	Percentage	59.0	41.0	63.6	36.4
	95% CI	54.9~63.0	37.0~45.1	59.6~67.7	32.3~40.4
Left-handed	Response	15	10	30	23
	Percentage	60.0	40.0	56.6	43.4
	95% CI	44.7~81.2	18.8~55.3	43.3~69.9	30.1~56.7

Table 6. Chi-squared test verification of independence among expected value distributions

Classification	Age distribution (Youth vs. Elderly)			Gender (Male vs. Female)			Dominant hand (Right vs. Left)		
	Value	DF	p-value	Value	DF	p-value	Value	DF	p-value
Cylindrical lock	5.415	1	0.011	0.007	1	0.868	0.055	1	0.815
Water faucet handle	2.406	1	0.121	11.440	1	0.001	1.020	1	0.312

The distribution of age stratification was significant for lock position, but gender and dominant hand were not. No significant difference was found for faucet position in youth and elderly or dominant hand, but gender was significant.

IV. Discussion

Devices and tools used in our daily environment should be user-friendly and designed and installed in an easy-to-understand and failsafe manner. Understanding user expectations and preferences, such as how people generally approach and use daily implements and objects, what types of mistakes are frequently made, and preferences, can help achieve these goals.

Although fairly clear-cut population stereotypes do exist for certain control display relationships, these are by no means universal (Zencius et al, 1998). When there is no strong population stereotype or when relevant principles are in conflict, a designer still needs to make a design decision. One approach is to design control-display relationships to match existing relationships found in other systems likely to be used by the intended population. That is, standardization can substitute for a population stereotype. Another approach is to select a relationship that is logical and explainable. At least then it will be easier to train people to use the system even if the logic was not apparent to them before training. When there is no clear-cut stereotype to adopt, there is no previous experience to follow, and there are no logical principles to use, then empirical tests of possible relationships should be performed with the intended user population to serve as the basis for a design decision.

We conducted a survey regarding user expectations of the locking direction of cylindrical locks and the opening direction of water faucet handles that are used daily in homes, offices, and public facilities, to determine stereotypes:

1. The vertical locking position was preferred with a cylindrical lock. A significant difference exists by age distribution (youth vs. elderly), but not gender or handedness. Female stereotypes were generally stronger than males.
2. For faucets, the strongest On stereotype was to lift the handle up. As for locks, gender influenced stereotype strength, but age and handedness did not. Therefore, these factors do not need to be include in design studies.

This study provides useful guidelines for door lock designs that are consistent with user expectations of locking

position and also for designing water faucet handles that operate consistently with prevalent user expectations. Usually, design specifications are repeated from one source to the next, with minor modifications, rather than from a single empirical study. In addition, these conclusions are culturally specific and may be of little relevance to other cultures.

The open position and manipulating direction should be manifested in the design itself from its inception. Visibility is the most valued principle in designing any device. In other words, key parts of operation should be laid out in a clear and easy to comprehend fashion, with appropriate instructions (Baddeley and Wilson, 1994). Unfortunately, locking position and opening direction lack operational visibility and appropriate instructions. Future designs should enhance visibility, be in accordance with strong stereotypes, and standardized. Moreover, attaching a redundant code to the door lock device and the water faucet handle, such as a Lock/Unlock label and an Open/Close label, respectively, or some other appropriate mark or sign, may reduce trials-and-errors. Such labels should act as design factors to enhance overall aesthetics.

V. Conclusion

User expectations and preference surveys should be conducted prior to the design and application of devices in the future. Furthermore, the stereotype threat occurs when individuals, believed to be intellectually inferior, perform badly on cognitive tests they perceive to confirm stereotypes about them (Cole et al, 2006). Therefore, a more general stereotype may be defined by repetitive measurements under the same test conditions with fixed time intervals, as well as accounting for people with cognitive problems.

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