# Effect of Perception-Compatibility, Learning-Factor, and Symbol-Carrier on Single LED Symbol System Recognizing

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**Abstract.** This study investigated effect of perception-compatibility, learning-factor, and symbol-carrier on single LED symbol system recognizing. A total of 48 subjects aged between 19 to 53(M=28.6, SD=9.49) participated. Subjects were asked to interpret target LED symbols and match with product status. A 2 (perception-compatibility) × 2 (learning-factor) × 2 (symbol-carrier) mixed design was used in this study. Analysis showed that the effect of perception-compatibility on recognizing accuracy was significant. However, no significant effects on accuracy were associated with learning-factor and symbol-carrier. The result showed that perception-compatibility play an important role in recognizing symbols.

**Keywords:** symbol carrier, semantics, product status.

## 1 Introduction

Single LED symbol was applied on products extensively. It's an easy way to present the product status, like a battery charger, electric grill, and electric iron… etc. Usually, every product applies symbols for presenting product status, and user has to interpret the symbols. It's a process of symbols coding and decoding in Semiotics: the product engineer coding each product status into the LED symbol, and users try to decoding them. However, semantics of LED symbols were different among each brands and products, and sometimes it confused users on matching with product status. That's because the symbol grounding problem had happened (Harnad, 1990). Users could not match the semantics (product status) with symbols in their mind. This study surveys and discusses this issue of symbols' property, and correlative theories as follows.

### 1.1 Saussure's Semiology

In semiology, Saussure deemed that a symbol includes a signifier and a signified (Eco, 1976). The signifier is the appearance of the signal, it might be a figure, a word,

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or a sound-image… etc.; signified is the meaning of the signal, it might be a concept, an object, or a thought… etc. Scilicet, a symbol includes a sign and what it represents. For example, a world 'tree' is a sign, and it represents a real tree out of the door (figure 1). This is the basic theory of the semiology.

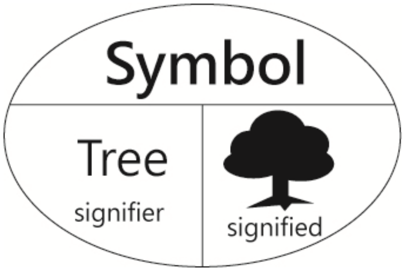


**Fig. 1.** Saussure's theory on semiology: signifier and signified

Besides, Saussure also described important characters of symbols: synchronic and diachronic. He pointed that people connect a signifier with a signified in the same space-time, it's a convention. But the relationship between signifier and signified is not eternal, it might changed in different space-time. For example, "the White House" means the government of U.S.A., it is well knows. But 200 years ago, "the white house" might just be a name of cowboy's house, that the effect of diachronic. It means people might have a consensus on a symbol, but this consensus might change in different space-time.

## 1.2 Peirce's Symbol-Triangle Theory

Subsequently, the symbol-triangle theory of Peirce defined that a symbol includes three parts: representamen, object, and interpretant(Eco, 1976). To comparing the symbol-triangle theory with Saussure's theory, this study found that representamen was defined the similar as signifier, and object as signified. The particular of symbol-triangle theory is interpretant, it's the explanation of the symbol which exist in user's mental. Peirce believed that a meaningful symbol should integrate these three (figure 2).

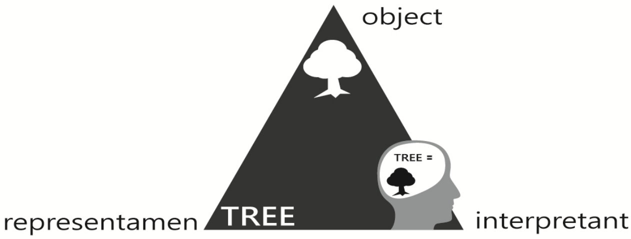


**Fig. 2.** Peirce's symbol-triangle theory

### 1.3 Jakobson's Functions of Language

Even this theory was defined for philology, it also be applied in semiology extensively. Influenced by Saussure, Roman Jakobson(1960) defined 6 functions of language: addresser, context, message, contact, code, and addressee. Based on Jakobson's theory, semiology was defined into a communication process. In this process, 'addresser' send 'message' to 'addressee', 'message' was combined from 'code' and transferred by 'contact'. 'Addressee' decodes the 'message' according to 'context' (figure 3).

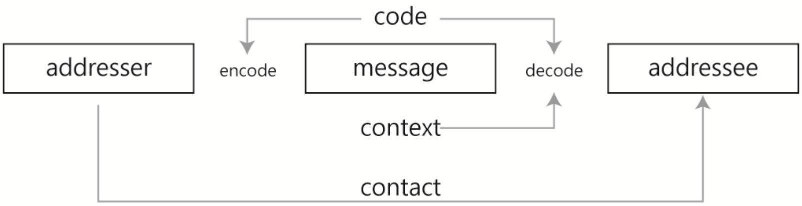


**Fig. 3.** Roman Jakobson's Functions of Language

### 1.4 Morris' TSrichotomy: Semantics, Syntactics, and Pragmatics

Morris classified Semiotics into Semantics, Syntactics, and Pragmatics (Eco, 1976). Semantics is the well-known in Semiotics which discuss about meaning of symbols. Syntactics discuss the relationship between symbols, it often applies on grammar of language. The most important of Morris' theory is Pragmatics. Pragmatics discusses the effect of "context" on meaning of symbols. Morris believed "context" is necessary when people try to understand a symbol. For example, a flashing red LED means nothing, but it means "something wrong" when it was placed on a machine. It coincides with Jakobson's theory: people (addressee) decode the symbol (message) according to situation (context).

## 2 Method

In conclusion, symbol recognizing was effected by cognition (mental) of user, situation of symbol (context), and compatible between signal and semantic. This study investigated the effect of perception-compatibility, learning-factor, and symbol-carrier on single LED symbol system recognizing by experimental method.

This study includes a pilot study and an experiment. Thirty-two subjects in the pilot study were asked to map 4 LED symbol with 4 product status. The outcome of the pilot study was used in experiment. Details of pilot study and experiment as followed.

### 2.1 Pilot Study: Compatibility of Perception on Single LED Symbol

**Subjects.** Seventeen female and 14 male between 20 and 56 years old (M=32.4, SD=10.93) served as participants. All reported 16/20 corrected visual acuity or better.

**Stimulus Materials and Design.** Participants were grouped into battery-charger group and electric-iron group. Stimulus were dynamic images, stimulus showed 4 identical product images with 4 LED symbols. Each product had 4 product status (charging error/ heating error; charging/ heating, standby/ standby, charging complete/ heating complete.) Symbols were appearing 4 combinations of colors and frequencies: quickly blinking red light, slowly blinking orange light, solid orange light, and solid green light. The frequencies of symbols as figure 1, and the RGB of colors as table 1.

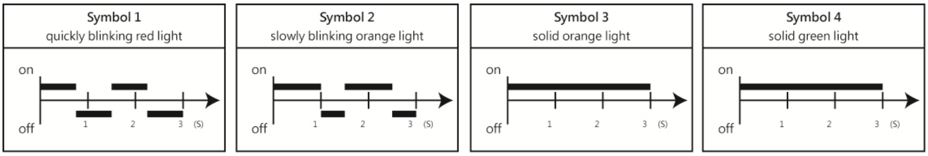


**Fig. 4.** Frequencies of the symbols

**Table 1.** RGB of Three Colors Used in Present Study

| | Color | | |
|---|---|---|---|
| | **Red** | **Orange** | **Green** |
| **R** | *255* | *255* | *0* |
| **G** | *0* | *120* | *255* |
| **B** | *0* | *0* | *0* |

Stimulus was displayed on a screen with random sequence (figure 2). After explaining the test, participants were asked to look on the stimulus and mapping symbols with product status. The answers were recorded by Visual Basic .NET.

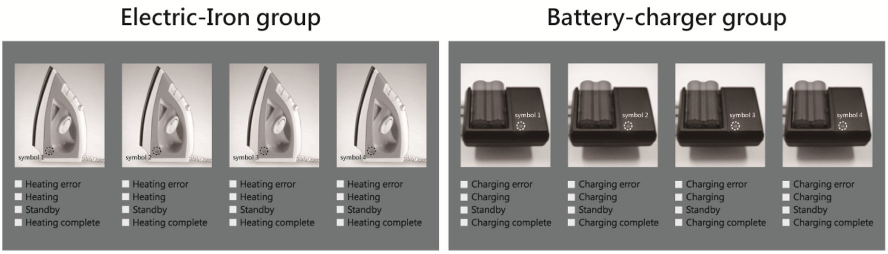


**Fig. 5.** Schematic Diagram of Stimulus in Preliminary Test

**Result.** The result of pilot study shows as followed (Table 2):

- Electric-Iron Group

The symbol quickly blinking red light had 100% mapping with heating error; slowly blinking orange light had 100% mapping with heating; solid orange light had 93.75% mapping with heating complete; and solid green light had 93.75% mapping with standby.

- Battery-Charger Group

The symbol quickly blinking red light had 100% mapping with charging error; slowly blinking orange light had 87.5% mapping with charging; solid orange light had 100% mapping with standby; and solid green light had 87.5% mapping with charging complete. The result was applied in the followed experiment.

**Table 2.** Result of Preliminary test

| | **quickly blinking red light** | **slowly blinking orange light** | **solid orange light** | **solid green light** |
|---|---|---|---|---|
| **Electric-iron** | | | | |
| Heating error | *16* | *0* | *0* | *0* |
| Heating | *0* | *16* | *0* | *0* |
| Heating complete | *0* | *0* | *15* | *1* |
| standby | *0* | *0* | *1* | *15* |
| **Battery-charger** | | | | |
| charging error | *16* | *0* | *0* | *0* |
| charging | *0* | *14* | *0* | *2* |
| charging complete | *0* | *0* | *0* | *14* |
| standby | *0* | *2* | *16* | *0* |

## 2.2 Experiment

**Subjects.** Twenty-four female and 24 male between 19 and 53 years old (M=28.6, SD=9.49) served as participants. All the participants have not participated in preliminary test, and reported 16/20 corrected visual acuity or better. The subjects received a payment of NT 100 dollars for their participation.

**Stimulus Materials and Design.** The independent variables were perception-compatibility, learning-factor, and symbol-carrier for stimulus. The stimulus were dynamic images, each stimulus presented a single LED symbol system which was placed on a product. The single LED symbol system contained 4 symbols, which are the same as preliminary test: quickly blinking red light, slowly blinking orange light, solid orange light, and solid green light.

Two levels of perception-compatibility between symbol-semantic were used, high-compatible symbols were the same as the result of preliminary test, and low-compatible were permuted the mapping (Table 2). Two type of symbol-carrier were used, a battery charger and an electric iron were applied the symbol system. Two type of learning-factor were used, half of participants had read the instruction for mapping symbols and product status before test, and others were not. Table 2 shows mapping of symbols/product-status in each subjects. dynamic image of stimulus presented a product (a battery charger or an electric iron) with a flashing single LED in the middle of the monitor, the size of the product was600×600 pixel and flashing single LED was 20×20 pixel (figure 2).

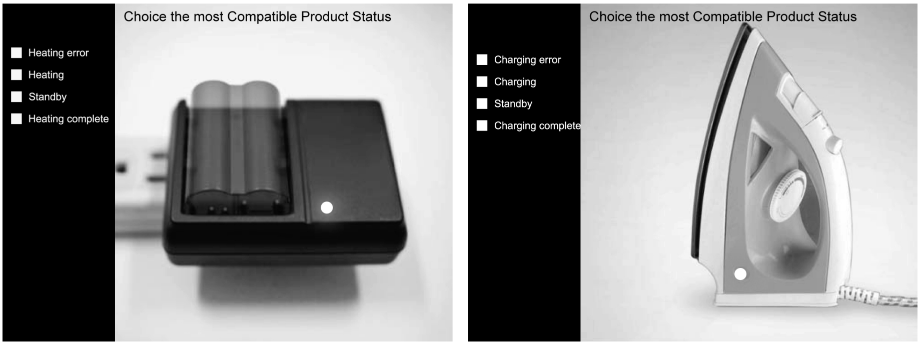


**Fig. 6.** Schematic Diagram of Stimulus

**Table 3.** Mapping Table between Product Status,Symbol-Carrier, and Perception-Compatibility

| | Semantics (Product Status) | | | |
|---|---|---|---|---|
| | **Symbol 1** | **Symbol 2** | **Symbol 3** | **Symbol 4** |
| | **quickly blinking red light** | **slowly blinking orange light** | **solid orange light** | **solid green light** |
| **Electric-iron** | | | | |
| high-compatible | *Heating error* | *Heating* | *Standby* | *Heating complete* |
| low-compatible | *Heating complete* | *Heating error* | *Heating* | *Standby* |
| **Battery-charger** | | | | |
| high-compatible | *Charging error* | *Charging* | *Charging complete* | *Standby* |
| low-compatible | *Standby* | *Charging error* | *Charging* | *Charging complete* |

A 2 (perception-compatibility) × 2 (learning-factor) × 2 (symbol-carrier) mixed design was used. All the variables were designed in between-subjects. Each participant was asked to mapping a single LED symbol system with product-status for 4 symbols.

**Procedure.** At the beginning of the test, the executor of experiment explained the mission, and half of participants were asked to read the mapping table for1minutes. Then participants were asked to mapping the single LED symbol with a product status by click mouse. The answers were recorded by Visual Basic .NET.

**Data Analysis.** Recognition performance was analyzed in accuracy rate (percentage of correct) using a repeated measures analysis of variance, which was carried out using SPSS (SPSS Inc., Chicago, IL).

## 3 Results

Table 3 shows means and standard errors of accuracy for each symbol.

**Table 4.** Means and Standard Errors of Accuracy (%) for each symbol (N=48)

| Independent Variable | Accuracy | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Symbol 1 | | Symbol 2 | | Symbol 3 | | Symbol 4 | |
| | M | SE | M | SE | M | SE | M | SE |
| **Perception-Compatibility** | | | | | | | | |
| high-compatible | *79.17* | *9.5* | *83.33* | *8.64* | *75.00* | *9.317* | *91.67* | *6.46* |
| low-compatible | *37.5* | *9.5* | *29.17* | *8.64* | *50.00* | *9.317* | *25.00* | *6.46* |
| **Learning-Factor** | | | | | | | | |
| prior learning | *70.83* | *9.50* | *66.67* | *8.64* | *70.83* | *9.32* | *58.33* | *6.46* |
| without prior learning | *45.83* | *9.50* | *45.83* | *8.64* | *54.17* | *9.32* | *58.33* | *6.46* |
| **Symbol-Carrier** | | | | | | | | |
| battery charger | *54.17* | *9.50* | *50.00* | *8.64* | *50.00* | *9.32* | *58.33* | *6.46* |
| electric iron | *62.50* | *9.50* | *62.50* | *8.64* | *75.00* | *9.32* | *58.33* | *6.46* |

*multiply by $10^{-2}$

### 3.1 Perception-Compatibility

The main effect of the perception-compatibility on accuracy was significant ($F_{4,37}$ = 120.24, p=0.00). It showed that the accuracy for perception-compatibility with high-compatible was significantly greater than under low-compatible conditions.

### 3.2 Learning-Factor and Symbol-Carrier

However, no significant effect on accuracy was associated with learning-factor and symbol-carrier, $F_{4,37}$ = 2.31, p=0.76 and $F_{4,37}$ = 1.54, p=0.21, respectively. No interactive effect on accuracy was observed. There were no two-way interactive effects, neither.

## 4 Discussion

### 4.1 Perception-Compatibility

The results demonstrated that perception-compatibility significantly affected participants' accuracy when they mapping product-status with symbols, but learning-factor and symbol-carrier didn't. These results were similar to several researches: a compatible symbol makes better performance for user, no matter on learning or recognizing the symbol (Mitsch & Dubberly, 1990; Sanders &Tashner, 2005; Jo & Han, 2006). It verified that human have a interpretant in their minds Peirce's theory, that's the reason why perception-compatibility effect accuracy more than learning-factor or symbol-carrier.

### 4.2 Learning-Factor

Learning-factor didn't significantly affect participants' accuracy. The result did not comply with some studies. Lesch etc. (2011) pointed that performance of recognizing graphic signals were upgraded by learning. The reason of this result might be effected by memory system of human. Participants were asked to prior-learn the substitute symbol system, but the learning effect stayed in short-term memory. Lesch etc. (2011) accounted that human recognizing signal by their experience which stored in long-term memory. Participants of experiment might recognize symbols by their experience, not by the mapping table. The result verified that a prior learning doesn't convince user's cognition- the intrinsic user experience.

### 4.3 Symbol-Carrier

Symbol-carrier didn't significantly influenced participants' accuracy. This result was consistent with McClelland and Rumelhart's (1981) interactive-activation-model. In which they accounted one of the cognitive processes of recognizing symbol is mapping features with other symbols in human's long-term memory. In other words, participants interpret the LED symbols intensively according to their experience in which, red denotes dangerous, green denotes safe, orange denotes warm, while slowly blinking implies working and solid light implies stable. That is why the identical single LED symbol applied on different symbol-carriers didn't significantly persuade participants' accuracy.

In conclusion, designing a single LED symbol system should followed the experience of users; semantics of an identical symbol does not always apply to different product. Instructions of any make do not convince an incompatible single LED symbol system.

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