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The Appropriateness of Feed Forward and Feedback Mechanisms in Alerting Less Conscious Response

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Abstract— **Currently, most products are designed to support their users using them consciously. In fact, there are four stages of learning according to the relationship of consciousness and competency: 1) unconscious incompetence, 2) conscious incompetence, 3) conscious competence, and 4) unconscious competence. The third stage is considered the most perfect due to users' competency and consciousness whilst a task is being performed. As a consequence, products are designed by using feed forward, a signal sent from products to users, to a different sense other than the one engaged in a current task. This is deemed wholly suitable for users of the third stage. However, after having continuously performed a task, users eventually proceed to the fourth stage, that of unconscious competence user. Products designed to use feed forward signals at this point, might not be the most effective means of alerting unconscious competence users.**

This study, then examines whether feedback or feed forward is better suited - in terms of speed - to alert user response to signals. The methodology of this study uses subject performance measurement. Subjects are asked to perform two tests - the first was one normally done unconsciously, that of simply seating oneself. The second task requires, through the performance of a repetitive act, (that of moving two red beans per time using chopsticks) drawing away the attention as much as possible, from subjects in their seats. The assumption is that subjects would adjust their posture accordingly (draw nearer to the red beans) when improved concentration was needed to move them and not to pay attention to whether they are seated correctly or not.

During the test, both feedback and feed forward signals alerted subjects to control distance between their eyes and the beans themselves. Results reveal feedback was better in alerting subjects when controlling distance and returning back to the original posture, in terms of speed of response.

The explanation is that response to feedback signal happens immediately. With feedback, the subject reacts physically at the body part, later sending a message to the brain explaining what has just occurred. Meanwhile, response to feed forward occurs only after the brain has sent commands to the body part it wishes to move. The objective of this study is neither to provide nor to confirm the appropriate use of the feedback signal, only to establish certain factors and their intricate relationship, which can be used to inform the design of feedback as a signal within products. Feedback signals themselves cannot completely alert unconscious competence users; however, kinesthetic ability of the tasks should be taken into consideration.

Keywords- Unconscious Competence User; Feed Forward-Feedback Control; Motor Skill

I. INTRODUCTION

Nowadays, many products in the market have been developed to achieve more effectiveness and efficiency. Success in using products needs users to have enough understanding of how they work. Norman [1] defined the word "conceptual model". The brief explanation is "how the product works". To understand the conceptual model of products, users will create their mental model of using the products which help users know how physical system works [2] and shape the conceptual model of products that they are using.

Users also learn and develop their skill of using products all the time. US Gordon Training international Organization developed "conscious competence learning model" in the 1970's. The model presents four stages of leaning as 1) unconscious incompetence, 2) conscious incompetence, 3) conscious competence, and 4) unconscious competence, as cited in [3].

Normally, products have to be designed to meet their users in the third stage. Using products in the third stage, users form their mental model to understand products. Moving from the third stage to the fourth, basically, depends on practicing. After gaining adequate amount of times of using products, users will use the products more easily and better in terms of its performance. Using products by creating mental model will be transformed to using it unconsciously.

Unconscious competence can be known in terms of "motor skill", a learned series of movement producing smooth and efficient actions or sometime called "motor performance", which basically means "to create and use muscle-related motor programs" [4].

In the third stage, users receive the information from products then use it to consider what they have to do in the next step. It can be seen that consciousness is very important because users have to examine what the meaning of information is. This kind of process of sending information was defined as feed forward, the process of how users receive information from outside by their perception then the brain examines the meaning of information and sends a

command to a part of body to respond to that information. In the fourth stage, the way to use consciousness is changed. Instead of focusing on execution, users will focus on the objectives and goals of what they are doing. The execution is functioned by motor skill or automatic behavior. The interesting point is "whether users still receive the signal or information (feed forward) sent back from products well as in the third stage".

II. Problem Statement

From theoretical background, feed forward has been confirmed that it is an appropriate signal to use in the third stage because users in this stage still use products consciously. Although many event shows that feed forward is not good enough for using products in the fourth, where users mostly use products unconsciously, feedback theoretically, is likely to be used for the signal of products in the fourth stage.

III. Research Questions

In the unconscious competence stage which sometime is called automatic behaviors or motor skill, error comes in slip form. Slips mostly result from automatic behavior when subconscious actions are intended to satisfy our goals get way laid en route. To focus on the effectiveness of the consequence of the actions and to avoid errors in the fourth stage, therefore the research questions are:

A. Can feedback alert users to react in the unconscious competence stage?

B. Do users respond to feedback faster than feed forward?

IV. Methodology

The methodology of this study is the anthropometric. It is the basic working tools for analysis and development of engineering design requirements by human factors and ergonomics professional. This methodology has been used to measure capabilities of human sensing and performance as well [5]. It was divided into two parts. One was the test by assigning tasks whereas the other one was a retrospective interview. Testing was aimed to find whether subjects can respond faster to feedback or feed forward signals. There are two tasks assigned to subjects. The first was a task that is normally done by using gross motor skill. Theoretically, this type of task should be the second nature of subjects as they have ability to complete this task unconsciously. The second was one that can draw the most of the attention from subjects. It means that if subjects have to do the multitasking, most of their attention has to focus on the second task.

In the test, subjects were requested to start with their proper posture of sitting before start moving red beans. When time passed, subjects started paying more attention on moving red beans than sitting; normally, the subjects' sitting posture was declined from its original position. In this case, the concerning point of declining was the distance between subjects' eyes and the movement of red beans. The observation showed that the more attention subjects gave to the red bean moving activity, the less distance between their eyes and red beans occurred. From the observation, a part of body functioned to reduce distance was subjects' necks. Therefore, the mechanism making subjects' neck move, was considered the acting part of body. Theoretically, the feedback signals from outside were sent directly to this mechanism. If the distance between subjects' eyes and red beans being moved, has been reduced, two types of signal, feed forward and feedback signals, would be sent randomly to alert subjects to stretch or bend their neck backward to the original position. Feed forward signal was the signal that subjects received from their perception. Visual and audio signals were selected because these two kinds of signal are used generally in products. In the test, red-light visual signals, installed around the tray, were used to alert users of their usage in many products. Audio signal was the sound "Beep", also used in general products. On the other hand, feedback is the signal sent directly to the acting part of body. In this case, flicking subjects' neck was enabled as signal alerting subjects.

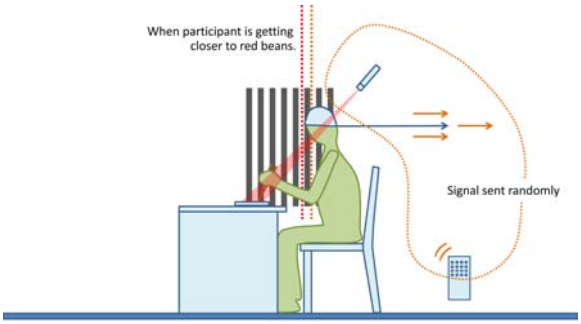

Figure 1: Criteria of sending signals

Testing was divided into two tests. The first was the comparison between audio signal and flicking signal. The second was the testing comparing visual and flicking signal. In each test, signals were sent randomly to subjects. In this study, the focus was more on feedback than feed forward. The proportion of feedback signals outnumbered that of feed forward signals by a rough 2:1 ratio.

V. Result

All tests were recorded by VDO camera then assessed by Noldus software where the number of responding and time spent for each task were counted.

From the comparison of all types of signal, figure 2 shows the comparison of the average time, subjects spent to respond to each signal. It can be noticed that the time they spent for flicking signal in two tests are not critically different.

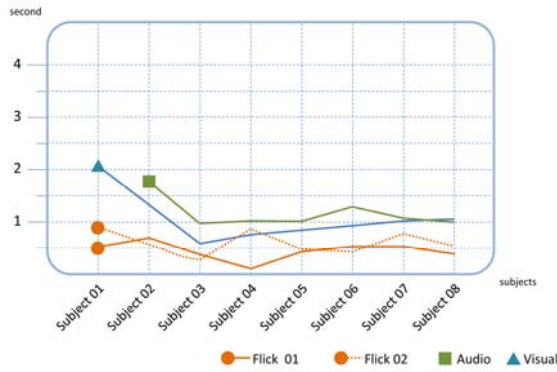

Figure 2: Average time of each subject for responding in testing 1 and 2

The lines of audio and visual are almost parallel but the responding to audio signal seems to need more time than the one to visual signal. Time that subjects spent for audio and visual is very close; the averages are 1.11 seconds and 0.93 second respectively. On the other hand, average time spent for flicking signal is only 0.48 second. It is two times less than that of audio and visual (see figure 3).

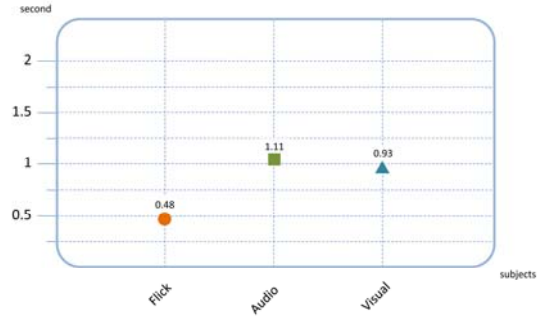

Figure 3: Average time for responding to signals

For the percentage of the responding time to each signal, flicking is still the highest. Subjects responded 77 out of 85 times of sending. From figure 4, there are just 9.40 % of times that users did not respond to the signal, while audio and visual are responded just only 78.10% and 70.80% successively.

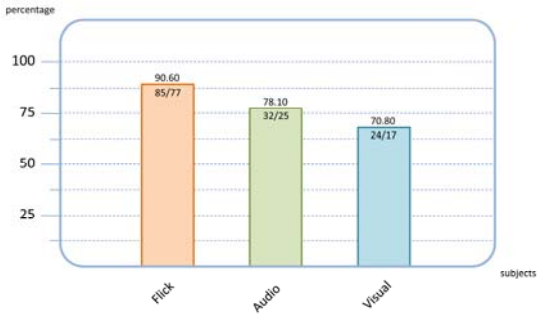

Figure 4: Percentage of responding to signals

All subjects were interviewed as soon as finishing the test. They were asked to describe what they felt when receiving the signal and give the score for the ability of signal alerting them to stretch or move heads backward and the level of disturbance in the second activity which was moving red beans. They were asked to give the score from 1-3 (see figure 5). Score "1" represents the lowest ability level of alerting and disturbing while score "3" represents the highest.

	Level of reminding			Level of disturbing		
	Audio	Visual	Flick	Audio	Visual	Flick
Subject 1	2	1	3	1	3	3
Subject 2	1	3	3	2	1	3
Subject 3	1	2	3	1	2	3
Subject 4	2	1	3	1	2	3
Subject 5	1	2	3	1	2	3
Subject 6	1	2	3	1	2	3
Subject 7	2	2	3	2	1	3
Subject 8	2	1	3	2	2	3
	12	14	24	11	15	24

Figure 5: Result of score given by subjects after testing

From the interview, all subjects gave the highest score to the flicking signal (feedback) for alerting them to stretch or move their heads backward, along with the ability to disturb while moving red beans. On the other hand, for feed forward, five from eight subjects felt that visual is better than audio in terms of alerting which is correspondent with the disturbing level. The total score in figure 5 shows that if the signal's ability of alerting users to stretch or move their heads backward increases, its ability to disturb the action of moving the red beans is expectedly expanded as well. Similarly, the signal that has less ability to alert the controlling main activity might not disturb the second task much.

VI. DISCUSSION

According to the testing result, the feedback which has potential to help controlling the result of task is done automatically. From the learning model of using a product, the key success of how to shift from the second stage (conscious incompetence) to the third stage (conscious competence) seems to be an ability to create the mental model of using the products. Feed forward signal is considered the key signal of communication from products to users because the third stage users still use products consciously; users know exactly what being done and what have to be done in the next step. That is why literature suggests that the consequence in the third stage is the best.

In the fourth stage of being unconscious competence users, the kinesthetic mechanism of the acting part of body normally memorizes the movement of task. This is the main reason why people can perform some tasks unconsciously. The test result shows that feedback signal is better than feed

forward signal, regarding the speed of responding, to alert users to adjust the task errors. Not only muscle memory but also the kinesthetic mechanism, as suggested in this study, is the factor of how to use feedback signal well. There is some relationship of the human learning stage; the types of signal used for communicating from products to users, and also the mechanism of kinesthetic of the movement of using products.

In terms of the products possibly used with less consciousness, feed forward signal may not be an appropriate one because to perceive and understand the meaning of feed forward signal need user's consciousness. However, feed forward is accepted as a proper signal for conscious competence users while the other one for unconscious competence users. The key factor of using feedback signal well is the ability of kinesthetic of acting movement, causing the avoidance of making errors especially slip ones. Finally, the consequence of the task in unconscious competence stage is probably close to that of conscious competence users. Figure 6 shows the conclusion of the benefit of this study. It is the answer of how to complete the quality while users use products or do the task in the unconscious competence stage.

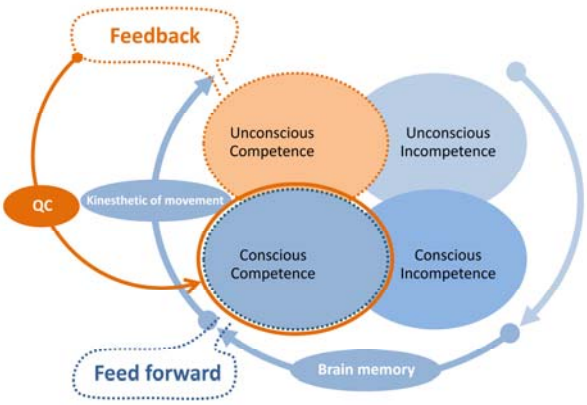

Figure 6: Key success factors in unconscious competence stage

The real situation is not exactly same as the model shown in figure 6, even though users already reach the fourth stage, they always switch between the fourth and the third. For example, focusing on controlling a car direction, in the general situation, fourth stage users can control the car automatically. In a very narrow road, they may automatically leave other tasks to pay all attention to control the direction. However, in the next seconds they may focus more on the speed then their attention moves to the force given to the accelerator. In this case, it is very clear that users always switch the stage of each task all the time. Therefore, the conclusion of this study is not the complete answer of using feedback signal. It needs more study and experiment to support such implementation.

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