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(Original article)

Efficiency of semantic process for children's interface
ประสิทธิภาพกระบวนการที่มีความหมายสำหรับอินเตอร์เฟสของเด็ก

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ABSTRACT: This research is an examination of the concept of process semantics representing the meaning of tasks, time, space, and navigation. In assessment of this concept, children were tested with an existing typical office mail application comparing the mailman program with the Process semantics. The office mail was the regular mail used in commercial software, while the mailman was designed for hypothesis testing. Sixty subjects did the usability testing of six tasks. When interacting with both programs, the completion times of three tasks in mailman program are faster than those in the office mail. Moreover, the number of errors with the mailman program is less than that with the office mail for all tasks. The result reflected the process semantics with the operational transparency in conjunction with the metaphor of mailman agent significantly improving children's understanding.

Keywords: Semantic; Interface; Children; Agent; Metaphor

บทคัดย่อ: งานวิจัยนี้เป็นการตรวจสอบแนวคิดของกระบวนการที่มีความหมายสามารถแสดงถึงงาน เวลา สถานที่และการนำทาง เพื่อที่จะประเมินแนวความคิดนี้ กลุ่มเด็กถูกทดสอบด้วยซอฟต์แวร์อีเมล์สำนักงานเปรียบเทียบกับอีเมล์บุรุษไปรษณีย์ที่มีความหมายของกระบวนการ อีเมล์สำนักงานเป็นซอฟต์แวร์ที่จำหน่ายในตลาดทั่วไปในขณะที่อีเมล์บุรุษไปรษณีย์ถูกออกแบบมาเพื่อทดสอบสมมุติฐาน ผู้เข้าทดสอบที่เป็นเด็กจำนวน 60 คนทำการทดสอบความสามารถในการใช้งานจำนวนหกงาน ผลปรากฏว่าเด็กสามารถทำงานด้วยอีเมล์บุรุษไปรษณีย์เสร็จเร็วกว่าอีเมล์สำนักงานได้ถึงครึ่งหนึ่งของงานทั้งหมด มากไปกว่านั้นปริมาณความผิดพลาดของอีเมล์บุรุษไปรษณีย์ยังมีความผิดพลาดน้อยกว่าอีเมล์สำนักงานทุกงาน ดังนั้นกระบวนการที่มีความหมายเป็นการแสดงการปฏิบัติงานที่เห็นชัดเจนซึ่งต้องใช้ร่วมกับการอุปมาโดยใช้ตัวแทนบุรุษไปรษณีย์ทำให้เด็กมีความเข้าใจได้เป็นอย่างมาก

คำสำคัญ: ความหมาย; อินเตอร์เฟส; เด็ก; ตัวแทน; การอุปมา

1. INTRODUCTION

Though the word "product semantics" is coined by Krippendorfff for Industrial Design, it could be used for software interface as well. Typically, product semantic is concerned with human interface[1]. It is a layer of cognition in which users may experience how they interact with their environment. It shows how they understand their own practice and why they engage in what they do. The human errors are considered as arising largely from an inability to make sense, from a mismatch of meanings and affordances. This human error is the knowledge-based mistake which is the gap between knowledge in the world and users' knowledge. Any given has his or her own mental model that could differ from the designer's model[2]. The product semantic hence bridges the knowledge gap of both models. When users make sense on product or its interface, they could work with better efficiency with less error can be expected.

Fig. 1 Semiotics of an office email

Semiotics is the study of signs such as icons and symbols. For the office e-mail, the icons are designed with an office metaphor. For example, the tray represents the mail inbox, while the paper clip depicts the attached file (Fig. 1). The folder is designed for keeping files. In addition, the product semantics, a metaphor has been used in the user interface design community. In the early eighties when the first Graphical User Interface had been introduced by XeroxStar 8010 with a desktop metaphor. Metaphors allow the transference or mapping of knowledge from a source domain (familiar area of knowledge) to a target domain (unfamiliar area of situation)[3]. Although the uses of the office or desktop metaphor has been such a widespread success, it is not comprehended to children and marginal people in unfamiliar environments[4]. Children 5 to 6 years can use pull-down menus to launch program, negotiate complex menus and use the computer for simulations and art project[5]. They did not have the knowledge and experience much on the office metaphor such as the document trays, paper clips, and folders. The metaphor shows the abstract levels not the physical thing. The document was represented by a file kept in the folder, while the attached mail was represented by the paper clip with a letter. Such high-level concept makes an inexperienced user such as children confused with their own interpretation.

Druin and Solomon[6] said that children have their own likes, dislikes, curiosities, and needs that are not the same as their parents or teachers. For children, interacting with the computers should be fun like playing with friends, the computers should also develop children's intelligence in school. They presented that children around 10-16 years old have a difficulty in using traditional software. The way they use interface design is different from adults. For instance, icons and symbols are designed to represent meanings for children instead of being designed to represent the command. There are several research studies on the icons and metaphors for preschoolers. The results of an investigation indicate that failing to recognize the icons might be caused by violation of invisible, visible resemblance, and conceptual resemblance[7]. The computer literacy may be another issue for children. The researcher suggested to avoid design a complex user interface and clear navigation paths, since they have the problem to understand the abstract concepts and the limitation in term of cognition.

From the observation at school, the researcher found that 10-year-old children make numerous mistakes in three consecutive findings. 1) When they input the name of the site by typing the syntax address. They have a problem with incorrect spelling and typing. The long typing website address is a major problem for them. 2) Children prefer to communicate with the people outside by using the network on-line. The social contact with teachers, friends and parents makes children enthusiastic. 3) Children have less attention to wait for the computer processes such as

downloading and copying files, frustration occurs while they wait. This shows how the process of using the computer is important as product. Besides the product semantics, this study focuses on the process semantics. The definition of the process semantics can be seen clearly on the transaction of information or file such as progress bar. The progress bar shows many processes such as copying files, transferring files, and loading time. The operation of these transaction is still questionable since the process in the digital world is not the same as the physical world. Users do not know what is going on in the operation.

There is a question how children understand the operational transparency such as the progress bar. This issue had not been addressed besides the product semantics and its metaphor. In the past, the slow internet causes users to put effort on waiting for e-mail software to retrieve the file from the server. This issue had been addressed with the labor illusion[8]. Although the current technology has the fastest transaction service without waiting time, several applications still have the progress bar such as the antivirus program and the file transfers from one place to another. Children may not understand the meaning of the progress bar which signifies the progress in both time, and space. They might be confused with the concept of file transactions from one place to another place in digital space. One study reveals the replacement of the progress bar with a running tally of the tasks being performed can help increase the perceived value. For example, the subjects searched the online ticket in the blind condition comparing to transparency condition[8]. The example of blind condition in the on-line ticket is the progress bar without telling what the system is working. On the other hand, the transparency condition is the progress bar with the system showing the result of airline search. The subjects preferred the result of airline search while waiting rather than seeing the progress bar alone. This research addressed the value that the subjects had appreciated on the labor intensive of the computer system that carries the task of search. Nevertheless, the study did not mention on the process that has more meaningful or semantics. Since there is no literature revealing how the meaningful process increases the users' performance, the animated progress bar with time and space had ever been an issue for the study. Process Semantic is proposed. For an instance, it had been addressed in many user interface design guidelines such as Microsoft UX design desktop for application[9] and Human Interface Guideline for Apple Developer[10] respectively. The animated indicator shows how much progress had been made, how much time remained and how to stop it.

Norton disk doctor is another good example of explanation (Fig. 2). The doctor inspects the hard disk to represent the virus scan tasks. Moreover, the software promotes the operational transparency by telling the current task. This is an analogy for what was going on behind the scene. The study found that subjects prefer websites with a longer waits to those that return instantaneous results[11]. Although the Norton disk doctor is a good example that shows how the process work, it cannot do much in term of task. As a result, the concept of agent was introduced in the process semantic. Agents provide expertise, skill, and labor. Being capable of understanding our needs and goals in relation to them, the agents then translate those goals into an appropriate set of actions, perform those actions and deliver the results in a form that users can use[12]. Several researches had been conducted the use of agents for children especially the autism child in the

past. One of those researches indicates that children with autism can learn new language within an automated program centered allowing the computer animated agent[12]. For this research, the questionnaire was sent to children grades 2-4 to find out which types of agents match their conceptual model among the bird, the mailman, and the robot. There were 47 males and 25 females in this sample. Many subjects were familiar with robot (M=2.69, SD=0.59), mailman (M=2.2, SD=0.546) and bird (M=1.93, SD=1.07) respectively. When asking which stuffs that three agents can carry. The subjects answered that the mailman and the bird can carry mail, while the robot carries a thumb drive. As a result, the mailman agent was selected since he can carry mail, video file, and thumb drive. The role of agents for this research can do more than receiving and sending files. It must prompt subjects the action for further step such as checking or sending mail.

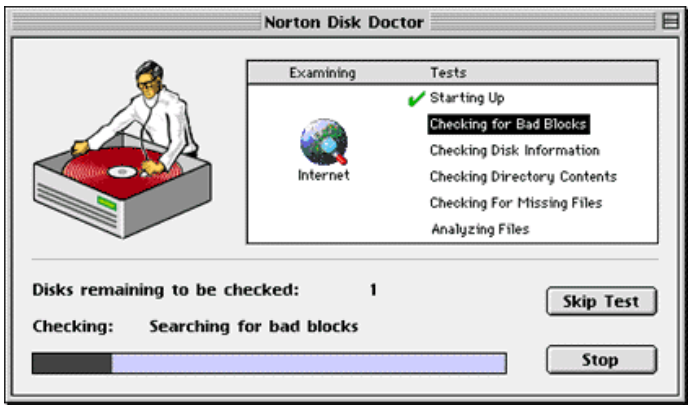

Fig. 2 Norton disk doctor performing task of virus scan

The investigation is of this research is on two premises. First is the process semantic. The concept of semantic should suggest the time and space. Subject should be able to identify the location of the transaction such as the digital file. Unlike the physical object and environment, the digital file is difficult to understand. The process should have the meaning, so children can make sense of the system status. The investigation issue is to check whether an animated indicator affects how children understand time and space in term of navigation. The mailman is an agent that replaces the progress bar and showing the current task by delivering the mail from one house to another house. This reveals time, space, and current tasks.

H1: Is there any significant difference between operation transparent and blind condition interface?

Second premise is an integration of product and process semantic that supports the mental model. The designers' mental model must match the users' mental model. Do children understand an unfamiliar icon in the traditional software (office metaphor) comparing to the experienced icon (mailman metaphor) designed for children? Although this study is on the process

semantics, the process itself cannot work without product semantics. Users need to interact with an icon or object in order to carry on their processes.

H2: Subjects prefer the familiar icon instead of an unfamiliar icon.

2. METHOD

2.1 Participants

Sixty students around 5-10 years old participated in this research. They have basic knowledge in computers (both operation and activation such as select, click, and drag & drop). All of them can read the text with no problem of legibility.

2.2 Measures

Human performance is a method used for this research since it shows how subjects perform based on the interpretation. If they interpret the icon the wrong way, they will take more time and error(s). They were assigned to play with the software and were measured in terms of completion time and number of errors.

Both office email and children's mailman are simulated e-mail software. The office mail is a simulation of the Eudora program. The experiment time was 10 minutes for each program. To avoid transitive learning among two types of software, half of subjects started with the mailman first and the other started with the office email. The measurement was done by counting the time and number of errors. The data were compared with the pair-sample T-test.

2.3 Procedure

Table 1 shows six tasks for testing and objectives for this study. Tasks 1 -3 are the checking email and task 4 -6 are sending e-mail. They have time to familiarize themselves with both programs before the test approximately 5 minutes.

Fig. 3 shows the office mail program with the feature of checking mail. The quick access toolbar of office mail contains a variety of icon types such as in-box tray, check mail, new mail, attach file and printer. The progress bar will show up when subjects press the check mail button (Fig. 3a). To read the mail, subjects must click on the inbox mail and double click on the message to open (Fig. 3b). When sending the movie file, subjects must select the paper clip for the file attachment (Fig. 3c). Then the system will prompt a window for choosing and attaching the file to the message. Subjects click the send button cites on the right corner of new message window. Subjects must select an attached clip file by clicking the paper clip icon on the quick access toolbar, then a new window will show up the destination folder.

Table 1 Six tasks for testing and objectives

Tasks	Objectives
1. Open mail	When new mail arrives, subjects open it. The semantic process shows users where the new mail is.
2. Close mail	Locate and press the closed button. This shows how children know about the existing standard of interface.
3. Reopen mail	This task was used to test whether children understand the semantic process in term of space. If they can locate where the message it, it is successful in term of navigation.
4. Create or send a new message.	For the office mail, the task is to create a new message by selecting the new message icon. For the mailman, the agent will ask subjects to select either checking mail or sending mail.
5. Attach a clip file	Attach the movie file as a new mail. For the office mail program, the pre-ready fill-in address and the content provided for subjects. They can select the clip file from the folder. On the other hand, subjects can send the clip file without typing any message in the mailman program. If they would like to write the message, they can click on the writing message icon below the big house.
6. Send mail	Select the mail receivers and send. This is a concept of semantic process should the users know where the senders mail will go.

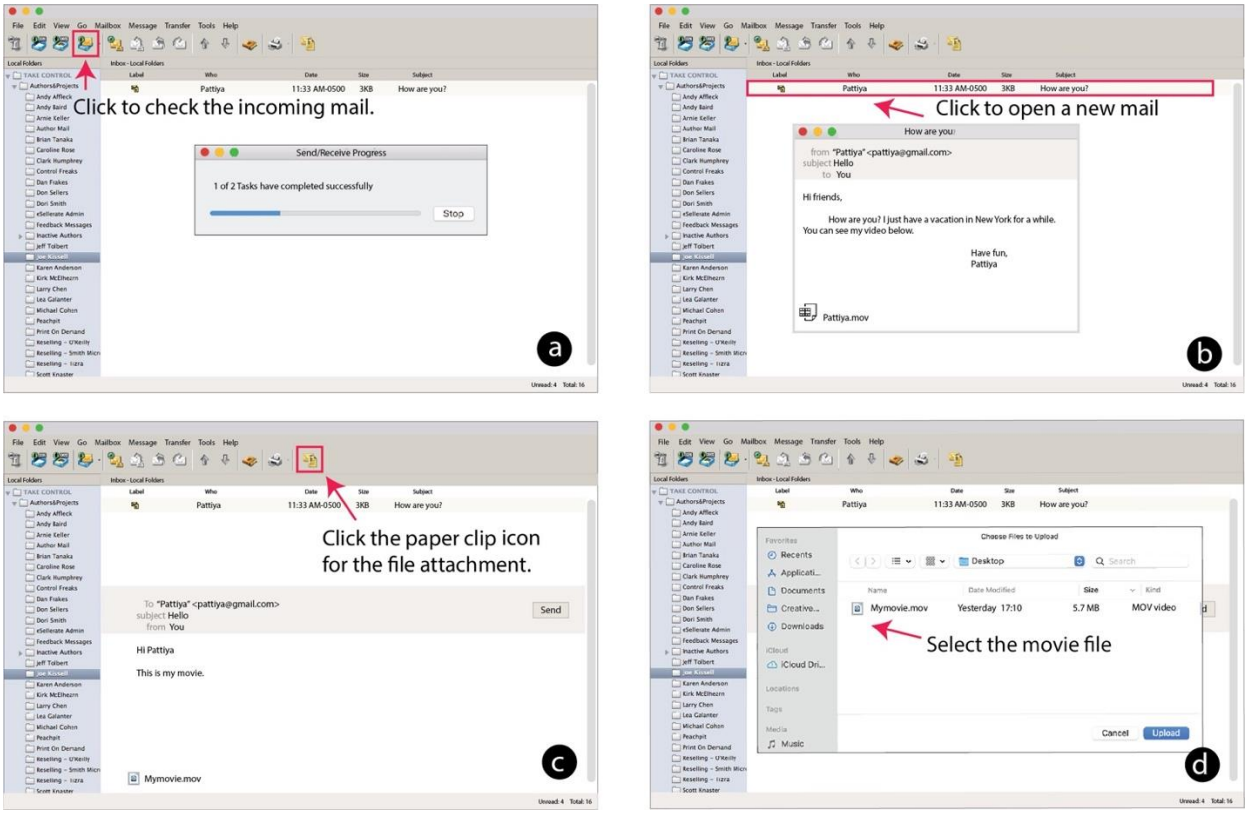

Fig. 3 Office mail program a) receiving the file, b) opening and reading the mail, c) attaching the movie file, and d) selecting the movie file

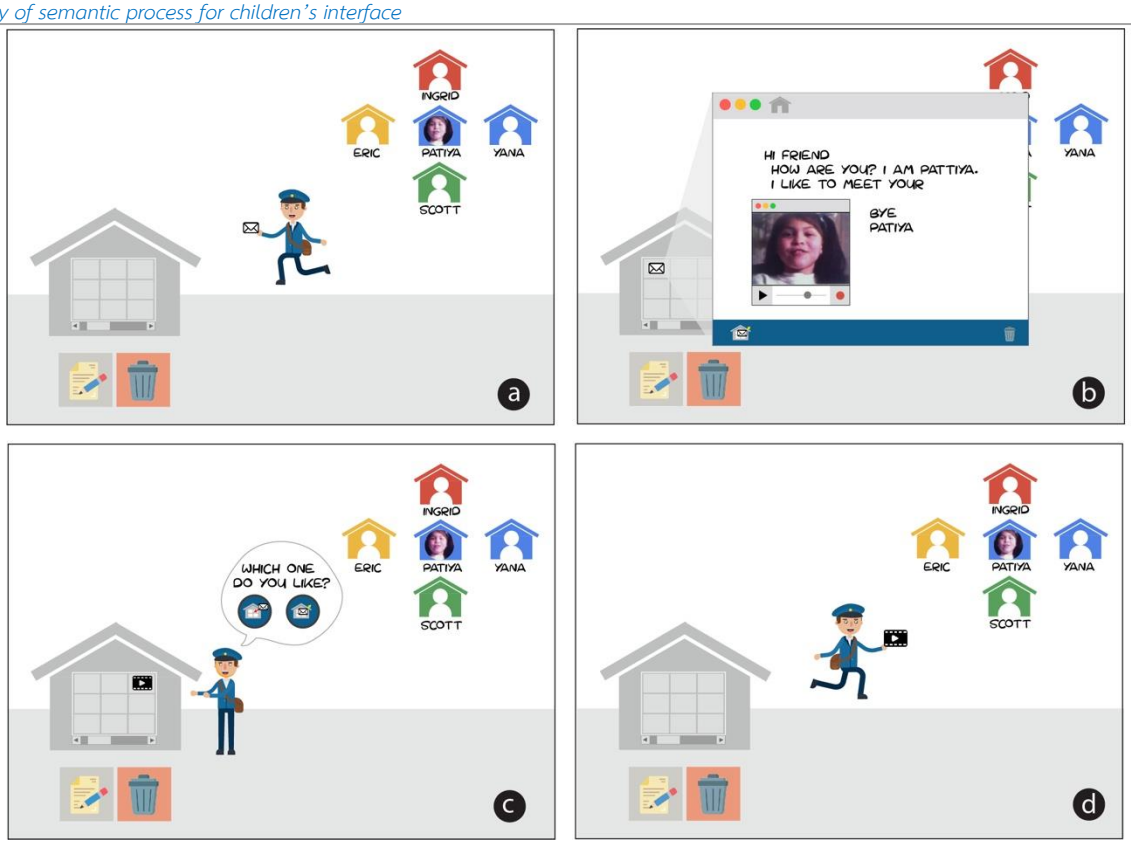

Fig. 4 Mailman program a) Delivering the mail from the sender to the receiver, b) Opening the mail, c) Mailman asking to select either check or send mail, and d) Sending a movie file

Mailman program was designed by using the distance between the village (their friends' houses) and the big house (the subjects' house). The walking distance of mailman replaces the progress bar as in the office mail (Fig. 4a). Subjects can roll over their mouse on the mail icon and the system will pop up the receiving mail with the clip video (Fig. 4b). To make the operation of sending and receiving mail transparency, the mailman is an agent that carried the file or message. He can prompt and guide users by asking the question. Inside the bubble, there is a question that asks subjects to select whether to receive or send the mail (Fig 4c). Subjects can see the inbox messages keeping in the window that has a scroll bar. When subjects click the mail icon, the mailman program with the attached video will be opened. Then the mailman agent walks from the big house to the small houses as a file transaction (Fig 4d). For the sending mail, subjects must select the receiver's destination and drag the file to the mailman for sending.

3. RESULTS

3.1 Task completion time

Fig. 5 shows that there was no significant difference in the task of closing, reopening, and sending mail. On the other hand, there was a significant difference in the task completion for the opening mail conditions in the mailman program (*M=32.06, SD=0.044*) over the office program (*M=7.05, SD=0.329*); $t(59) = 5.9$, $p=0.0001$. The mailman is more effective than the office program

because the subjects saw the animated mailman running from the house in the village to their own houses. On the other hand, subjects spent time finding the mail-in button in the office mail.

There was a significant difference in the task completion for the finding the send mail button in mailman program (*M=59.91, SD=0.601*) over the finding new message button of office program (*M=26.13, SD=0.248*); t(59) = 4.15, p=0.0001. Subjects had difficulty in finding the new mail button in the office mail program. In contrast, the mailman agent asked subjects to select between receiving or sending mails. It is a shortcut process of sending the clip movie file without creating a new message.

There was significant difference in the task completion for attaching a clip file conditions in mailman program (*M=127.15, SD=0.789*) over the office program (*M=15.76, SD=0.388*); t(59)=10.91, p=0.0001. Subjects had difficulty in attaching mail because they cannot understand a clip paper office icon. On the other hand, subjects just dragged and dropped the file from the big house to the mailman as an attachment.

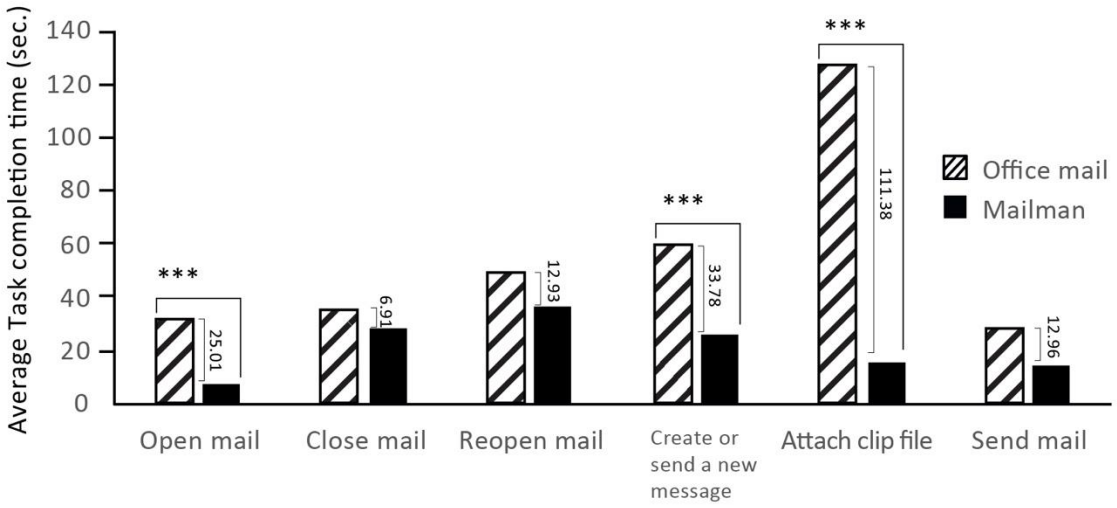

Fig. 5 Paired sample t-test Results for task completion time **p < 0.05, ***p < 0.001.*

3.2 Error

Fig. 6 shows the average number of errors. For the open mail task, there was significant difference in the mailman program (M=0.06, SD=2.946) over the office program (M=1.71, SD=0.252); t(59)=4.27, p=0.0003. Many subjects did not know where the location of new email is in the office mail program. There is less error in open mail since the focus attention is on the mailman agent.

After subjects opened the mail, they needed to close the mail. There was significant difference in the mailman program (M=0.61, SD=4.856) over the office program (M=2.81, SD=0.865); t(59)=3.61, p=0.0003. The icon of closed mail was small and appeared in two places in the office program – the windows of the software and the new message. Many subjects closed the wrong button. They closed the window program instead of the new message.

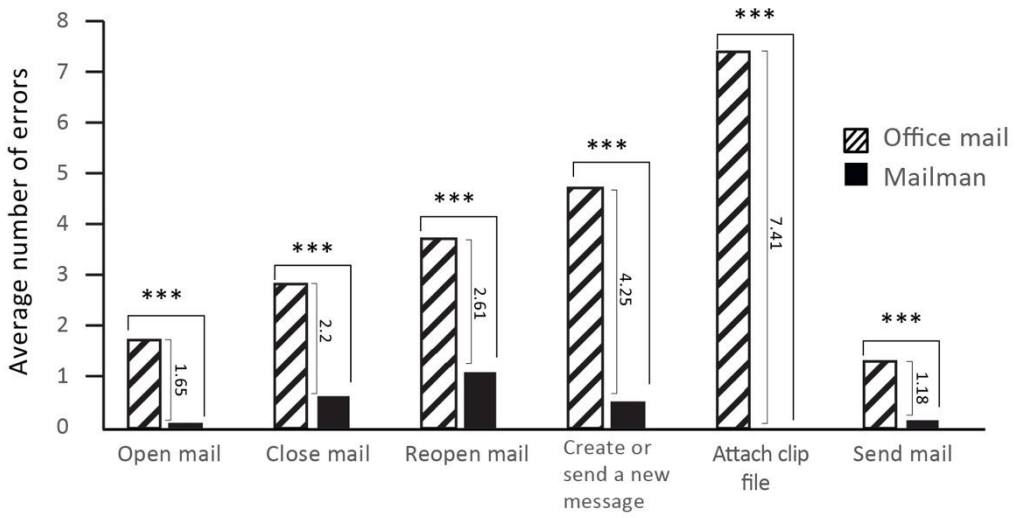

Fig. 6 Paired sample t-test results for average number of errors *$*p < 0.05$, $***p < 0.001$.

When subjects reopened the mail, there was a significant difference in the mailman program (M=1.08, SD=0.363) over the office program (M=3.7, SD=1.499); t(59)=5.26, p=0.0001. Subjects knew where the previous mail that they opened from since they remembered the location of the letter that the mailman sent. On the other hand, subjects did not know where the mail was in the office program.

For finding a new message or the send-mail button, subjects were assigned to send a movie file. Subjects must create a new message first before attaching a file in the office mail program. On the other hand, subjects could select the clip movie file and send to receivers directly without creating a new message. As a result, there was a significant difference in the mailman program (M=0.48, SD=0.365) over the office program (M=4.73, SD=1.157); t(59)=8.64, p=0.0001.

Many subjects did not understand the icon of the new message in the office mail program. The icon is the mail with a star on the corner (Fig. 3). For the mailman program, the agent asked subjects to whether receive or send mail. Some subjects preferred to write mails but many subjects selected to send mails, in most of the case.

Attaching the clip file is an interesting task, since many subjects select the wrong icon as it should be paper clip office icon. There was a significant difference in the mailman program (M=0, SD=4.713) over the office program (M=7.41, SD=0); t(59)=11.79, p=0.0001. Subjects understood the process of dragging the movie file to the mailman. It is an intuitive use without any guidance.

For the sending mail task, there was no error in understanding this action in the mailman program. There was a significant difference in the mailman program (M=0.13, SD=1.316) over the office program (M=1.31, SD=0.133); t(59)=3.42, p=0.0005. The error of mailman program is not much, because it is intuitive for children to select the destination house as a receiver.

4. DISCUSSION

The semantic process was effective with children in grade 2-4. They knew how to make their own strategies by using previous experience with mailmen in the real world. The mailman agent had the responsibility to receive and send mails. The metaphor agent and the icon make the process semantic meaningful. Children learned the actions from the mailman agent. For example, they used the drag and drop method when the mailman said “Give your mail to me please”.

The mailman is one of animated icon that differs from the static icon. The metaphor agent and the icon make process semantic more meaningful. Children understand the underlying meaning of semantic process such as time, space, and task. This is a similar concept like Peircean’s triadic model. The interpretation of an icon metaphor involves three components such as an object which is the abstract task, the icon, which is the pictorial symbol used to stand for an object; and the interpretant, which is an interpretation made by the users[13]. The Mailman agent is an object that represents the abstract task of receiving and sending mail. The process of semantic supports an operational transparency that subjects know the status of the system[11]. For the extension of this experiment, the mailman agent could do other tasks to show how the system did, for example, walking to many houses for receiving the mail.

There is a question when the technology and process change. For example, new generation children might do not understand the icon of a floppy disk or the mailman agent in the future. The floppy disk might be replaced with the thumb drive or SD card. In the same way, the mail might be delivered by drone instead of a mailman in the future. The change of time context could affect the users’ mental model in the period of time. Norman mentioned that knowledge in the head that includes the analogies between the current situation and previous experiences with other situations[14]. Many children’s software may not be applicable when children grow. The mailman program should be developed to follow their growth by changing the graphic user interface. For the further study, the process semantic could be applied for consumer products. On the level of ecology, the process semantics seeks to establish the kind of symbolic resonance that bridges the knowledge in the head and the knowledge in the world. Such aims of process semantics provide a new outlook in design.

5. CONCLUSION

The result responds to the first premise that operation transparency is better than the blind condition. The semantic process shows that the operation transparency makes the subjects understand the process clearly. There is a significant difference in the completion time on three tasks. All error from the mailman program is less than the office mail for all tasks. The blind condition in office mail does not show the process clearly. It does not convey the meaning that makes sense to the subjects. The information on the transparency condition should be relevant and meaningful to the target group. The computer programmer might want the technical

information to solve the problem of the system, while children only want to know what the current activity is. Similar to parcel tracking, the system tells the current activity of shipment. For the mailman program, the system does not need to inform users of the exact time and distance, since children have difficulty understanding the distance and time in the digital world. The mailman's activity is enough to represent the meaning. Moreover, the process semantic supports the navigation concept. The subject knew the current system status where the information came from and when it was delivered.

When using the paper clip office icon that represents the file attachment, the results show the highest completion time and more error in the office mail program. It shows that subjects must have an experience with the icon rather than unfamiliar icon. The result responds to the second premise that subject prefers the familiar icon instead of unfamiliar icon. The title bar button that contains three familiar buttons on the left of window for close, minimize and resize. This standard interface icon seems to be the problematic for children, since the size of button is too small. Children have a problem in precision selection with mouse.

From the observation, many children prefer the looks of cartoon agent and movie file to the traditional e-mail software. Such media like cartoons and video clips are friendly to children. The animation of mailman makes the program lively. They did not exhibit stress or frustration when they played with the mailman program.

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