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研究課題名（和文）Solving the Midas Touch problem in object selection with eye tracking

研究課題名（英文）Solving the Midas Touch problem in object selection with eye tracking

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交付決定額（研究期間全体）：（直接経費）　　4,800,000円

研究成果の概要（和文）：アイトラッキング技術によって、画面上の対象を視線で選択できる。例えば、パスワードを入力する際、「アイタイピング」を行って文字を選択できる。この選択の際、一定時間、視線を留めておく必要がある。この時間（停留時間）が短すぎると、意図しない選択が生じる。一方、長すぎると、アイタイピングに時間がかかる。実験の結果、理想的な停留時間は、35歳以下では約600 ms、55歳以上では約800 msであった。この結果は、文字や数字、ドットパターン、視覚的アイコンなど、幅広い対象に対して得られた。600 msと800 msを標準的な停留時間とすることは、日常生活における視線での情報入力を大いに支援できる。

研究成果の学術的意義や社会的意義
When using our eye gaze to select objects on a screen, the time to focus our eyes on an object (dwell time) can be reduced to just two settings: 600 ms or 800 ms, depending on the user’s age. This greatly simplifies engineering developments of walk-on, touchless screen interfaces that use eye gaze.

研究成果の概要（英文）：By using eye-tracking technology, we can select objects on a screen with our eye gaze. For example, we can perform “eye typing” to select letters to make a password. To select an object on a screen, we need to focus our eyes for a certain amount of time, called a dwell time. When this dwell time is too short, our eyes select objects even if we do not want to, called the Midas Touch problem. However, if the dwell time is too long, eye typing takes too much time. By performing experiments, we found that for persons under 35 years old, the ideal dwell time is about 600 ms. For users over 55 years of age, the ideal dwell time is about 800 ms. Importantly, these two main dwell time settings were obtained with relatively cheap eye-tracking devices, for a wide variety of objects, such as letters and numbers, dot patterns, and visual icons. Simplifying and standardizing dwell times to 600 ms and 800 ms settings will greatly assist the use of eye-gaze-based information input in daily life.

研究分野：perceptual psychology

キーワード：eye gaze　visual object　dwell time　eye tracking　Midas Touch problem　visual password

１．研究開始当初の背景

Many authentication and communication systems in public places (ATMs, ticketing machines) nowadays make use of a touch screen. Since manual input on touch screens is vulnerable to information theft and a potential source of contamination, a new alternative to using a touch screen is information input by means of eye tracking. **By using eye tracking, we can select objects on a screen with our eye gaze**. For example, we can perform “eye typing” to select letters to make a password. This kind of technology is also vital for persons with restricted physical abilities, who solely rely on their eye gaze to communicate via eye typing. To perform eye typing, i.e., to select an object on a screen, we need to focus our eyes for a certain amount of time on the object (e.g., a letter or number). This is called **dwell time**. Eye tracking applications so far have used a wide range of dwell times in between 100 – 1100 ms. However, **the “best” dwell time is not yet been clearly identified**. When the dwell time is too short, our eyes select objects even if we do not want to – **the “Midas Touch problem”**. However, if the dwell time is too long, eye typing takes too much time.

２．研究の目的

The objective was to **obtain the best “dwell time” for individual users**, **depending on user age and the type of objects** that need to be selected with eye gaze. The final aim was to develop and test a calibration program that solves the “Midas Touch problem”.

３．研究の方法

A series of experiments has been performed. The general outline was as follows.

Materials: An eye-tracking interface was created consisting of a display with either alphanumeric characters (i.e., letters and numbers), dots, or visual icons (see **Figure 1**). The objects were placed on a grid of 3 rows by 4 columns. Object dwell times were set in a range from 250 ms to 2000 ms in a preliminary experiment, and later adjusted to a range of 200 to 1200 ms, in steps of 200 ms, for further experiments.

Task: Users were asked to a) input a 4-object sequence and/or a 6-object sequence, like a password, consisting of either alphanumeric characters, visual icons, or a dot pattern on the interface, using eye tracking. The sequence was randomly selected and given to them before each trial. Users were also asked to b) use a rating scale to evaluate how easily they could use each display for information input using their eye gaze, based on their subjective experience regarding the time and number of input corrections they required.

Type of data obtained: From the eye-tracking task (i.e., password input), we obtained the total input time, including object search, of the 4-object or 6-object password, the individual object input time, the password input success rate, and the number of object input mistakes.

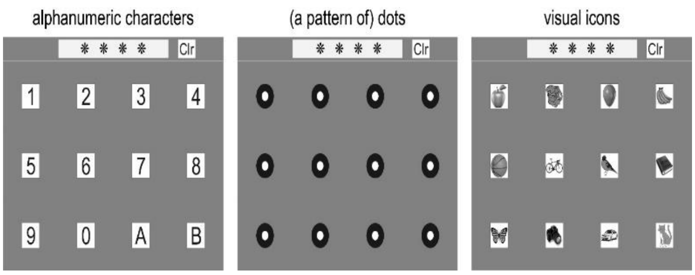

Figure 1. Example of the experiment interface. Users were asked to use their eye gaze to input a 4- or 6-object sequence, i.e., a “password”.

Users (observers): In the first series of experiments, the task was performed by users < 30 years of age (for both a group using glasses and a group without glasses). In a second series of experiments, there were 3 different age groups. Users <35 years of age, users in between 36-55 years of age, and users in between 56-75 years of age performed the object-selection task. **Note:** viewing distances, lighting conditions, eye-tracking equipment, and object grid sizes had been calibrated and determined based on the results of a series of preliminary experiments (e.g., Paulus et al., 2018). The cheapest available eye trackers were used to check performances under lowest possible costs yet with optimal efficiency.

４．研究成果

Overall, the accumulated results of the experiments showed the following:

a) the total time necessary to select the sequence of objects (**object selection time**), regardless of object type, increased when dwell time increased. As expected, longer dwell times resulted in a higher object-selection success rate and fewer object selection corrections. Shorter dwell times (400 ms or less) resulted in the Midas Touch problem, with increased numbers of selection input mistakes. Note that object selection time varied with age (**Figure 2**). Elderly users needed more selection time, regardless of object type (Remijn & Paulus, 2022).

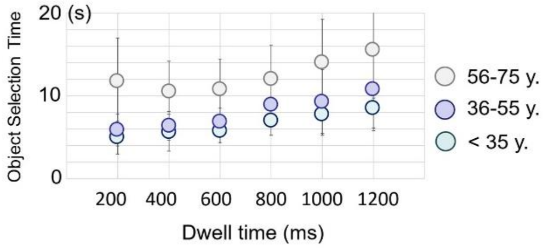

Figure 2. Object selection time of a 4-object sequence for the three different age groups (Remijn & Paulus, 2022).

b) Regardless of object type, eye-gaze-based object selection with dwell times of 200–800 ms was significantly slower for users with glasses than for those without glasses. Yet, total object selection time for 4-object sequences differed by just about 1 s on average, and input success rates between users with and without glasses were not markedly different.

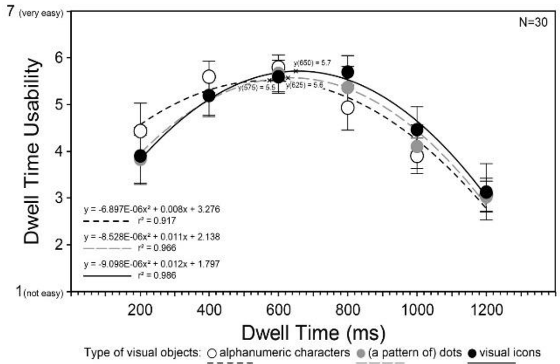

Figure 3. Overall, regardless of object type, users < 35 years preferred a dwell time of 600 ms per object (Paulus & Remijn, 2021).

c) Participant evaluations showed that **a dwell time of 600 ms per object was easiest to use for eye-gaze-based selection for users <30 years of age**. Notably, **the 600-ms dwell time was preferred for all three types of visual objects (Figure 3)**. Subsequent experiments directly comparing eye-gaze-based object input for three different age groups confirmed that for younger persons <35 years old, the ideal dwell time for eye-gaze-based object selection was indeed about 600 ms. **For elderly users in between 56-75 years of age, the ideal dwell time was about 800 ms.** Importantly, these two main dwell time settings of 600 ms and 800 ms were obtained for eye-gaze-based input of all three object types, i.e., letters and numbers, dot patterns, and visual icons.

The present results imply that eye-gazed-based interfaces can be utilized with surprisingly simple dwell time settings of 600 or 800 ms per object. Furthermore, the dwell times were obtained with relatively cheap eye-tracking devices. If walk-on calibration time of such eye trackers were to improve in the near future, **eye-gaze-based information input thus can be a valid alternative instead of touch screen technology in (semi-)public places**, e.g., where ATMs or ticketing machines are available.

Barring individual differences, it is likely that increased experience with eye-gaze-based input will speed up user input ability and the need for longer dwell times than those obtained here. **Future research** thus should focus on **learning effects** in eye-gaze-based interface usage. Second, depending on user purpose, it is conceivable that **personalized dwell time settings for long-time users** are wished for, for example, for persons who use eye typing on a daily basis. More data from different user groups are necessary to investigate the calibration process (and the calibration time) to set a personalized dwell time. We expect that this could be combined with the initial "walk-on" calibration of eye-trackers. The dwell time values obtained here could constitute the initial settings.

References:

Paulus, Y.T., Herlina, Leni, K.Z., Hiramatsu, C., Remijn, G.B. (2018). A preliminary experiment on grid densities for visual password formats. 9th IEEE International Conference on Awareness Science and Technology (iCAST 2018).

Paulus, Y.T., Remijn, G.B. (2021). Usability of various dwell times for eye-gaze-based object selection with eye tracking. *Displays*, 67, 101997.

Remijn, G.B., Paulus, Y.T. (2022). Dwell time preferences for gaze-based object selection of different object types vary with age. *Perception*, 51, 1 (suppl: ECVP 2022 Abstracts)

５．主な発表論文等

〔雑誌論文〕　計3件（うち査読付論文　3件／うち国際共著　3件／うちオープンアクセス　3件）

１．著者名 Paulus, Y.T., Remijn, G.B.	４．巻 67
２．論文標題 Usability of various dwell times for eye-gaze-based object selection with eye tracking	５．発行年 2021年
３．雑誌名 Displays	６．最初と最後の頁 101997
掲載論文のDOI（デジタルオブジェクト識別子） 10.1016/j.displa.2021.101997	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

〔学会発表〕　計3件（うち招待講演　2件／うち国際学会　1件）

１．発表者名 Remijn, G.B.
２．発表標題 fNIRS and eye tracking: “Barrier-free” methods to observe human information processing
３．学会等名 Science and Design Symposium Vol. 4, Kyushu University（招待講演）
４．発表年 2021年

１．発表者名 Remijn, G.B., Paulus, Y.T.
２．発表標題 Dwell time preferences for gaze-based object selection of different object types vary with age.
３．学会等名 European Conference on Vision 2022, Perception, 51, 1 (suppl: ECVP 2022 Abstracts)（国際学会）
４．発表年 2022年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

https://hyoka.ofc.kyushu-u.ac.jp/search/details/K003633/english.html
https://hyoka.ofc.kyushu-u.ac.jp/search/details/K003633/index.html

6．研究組織

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7．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

8．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関