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Information presentation compatibility in a simple digital control panel design: eye-tracking study

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Various designs of typical digital control panels were analyzed experimentally from both the effectiveness and efficiency points of view. Subjects performed information comparison tasks aimed at keeping vehicle velocity at the same level. The experiment involved two versions of speedometers for displaying current and target velocities (clock-face and digital). The stimuli were also differentiated by the target velocity value (20, 50 and 80 km/h) and the correct response type (increase or decrease). Subjects' performance results along with the eye-tracking data were qualitatively and quantitatively analyzed for all 24 experimental conditions.

Keywords: digital panel design; information presentation conformity; visual activity; human–computer interaction; ergonomics

1. Introduction

Control panels have been used for many decades both in the manufacturing sector and in many types of vehicles and machines of everyday use. Thus, it is not surprising that they have been subject to examination by multiple researchers throughout the years. Currently, in the digital era, questions regarding control panel operation quality are still valid. More and more often, they either include electronic components or are even completely replaced by their digital equivalents.

Control panels typically present information that needs to be processed in one way or another. Therefore, one of the first psychological and ergonomic studies dealt with this aspect. As early as 1948, Sleight [1] investigated how different kinds of instrument dial shapes affect legibility. Grether [2] in 1949 focused on speed and accuracy of reading instruments. In this area, one may identify a research trend focused on differences in processing data displayed by clock-face dials or numerical counters. Analog versus digital information presentation was researched in the fields of both perceptual psychology (e.g., Bock et al. [3], Friedman and Laycock [4], Goolkasian and Park [5], Meeuwissen et al. [6]) and ergonomics (e.g., Boles and Wickens [7], Nason and Bennett [8], Nes [9], Rolfe [10], Zeff [11]).

Reaction to information presented on a control panel is usually required in some way. Thus, a series of studies focused on a variety of instruments including buttons, switches, knobs or levers. Early studies in this field concerning, e.g., knobs' and levers' shapes were reported by Bradley [12], Green and Anderson [13] and Jenkins [14]. The accuracy of setting a rotary knob at a desired angular position was examined by Chapanis [15]. Various aspects of push buttons were in turn investigated, e.g., by Moore [16,17]. A number of relevant references regarding classic control panel designs are provided by Muckler [18]. Some recent contributions in this area may be found in the paper by Herring et al. [19], where a physical word selector is analyzed, or in the work of Michalski and Grobelny [20] focused on the examination of virtual button arrangements.

The compatibility between stimuli and human responses was among multiple issues investigated extensively in the context of control panels. Probably one of the first systematic studies dealing with this problem was presented in a seminal work by Fitts and Seeger [21]. They studied square, circular and T-shaped stimuli along with the corresponding response templates. Other investigations in this regard were reported, e.g., by Chapanis and Lindenbaum [22], Fitts and Deininger [23], Michaels [24], Hsu and Peng [25] and Kornblum and Lee [26]. An extensive review of the stimulus–response compatibility studies is provided by Lien and Proctor [27], while a review of and possible explanations for the results about spatial coding for two-dimensional stimulus–response sets are presented by Rubichi et al. [28]. The body of literature dealing with these types of problems is still extending, especially in the field of general psychology. Recently, orthogonal stimulus–response compatibility was subject to investigation by Nishimura and Yokosawa [29]. Le Bars et al. [30] examined, among other things, how subliminal

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primes representing visual action effects influence various kinds of motor actions in relation to the stimulus–response compatibility. In turn, Dagaev et al. [31] in their two experiments investigated the stimulus–response compatibility while performing parallel mental tasks. Giesen et al. [32] focused on the modulating effect of a vicarious feedback on stimulus–response compatibility in a shared color categorization task, whereas Saccone et al. [33] demonstrated a dissociation between affordance and spatial compatibility effects. Some investigators involve oculographic data in this type of research. For instance, Ansorge [34] tried to explain the congruence effect induced by human gaze directions.

Although there is plenty of research on stimulus–response conformity, the body of literature about compatibility between different information display types involving eye-tracking data is quite scarce. The present study aimed at extending the knowledge in this regard by experimentally investigating four combinations of analog and digital velocity presentations while performing a simple comparison and decision-making task. The analysis of visual activity registered by the eye-tracking system provides additional insight into attentional processes accompanying similar situations.

2. Method

2.1. *Subjects*

Altogether, 39 undergraduates took part in the experiment. There were 17 females and 22 males. The subjects' age varied from 18 to 34, with $M = 20.97$ and $SD = 3.13$.

The eyeball tracking ratio for subjects ranged from 41 to 81% with $Mdn = 76\%$. Two women and four men were not included in the oculographic analyses because their tracking ratios were smaller than 70% which approximately amounted to the value of the lower quartile.

2.2. *Apparatus*

A custom-made application was written in JavaScript version 6 for demonstrating and managing stimuli in full-screen mode in Mozilla Firefox version 45. The software also recorded task execution times and mistakes made by subjects.

The experiment was conducted under the same artificial lighting conditions in a separated room with a one-way mirror. There was a desk, typical office chair, keyboard, optical computer mouse and 21″ monitor. A classic color scheme was applied to the Microsoft Windows 7 operating system and the resolution was set at 1680×1050 pixels. Subjects obtained necessary information with microphones and speakers.

The visual activity of subjects was recorded at a 500 times/s rate by a RED500 (SMI, Germany) stationary eye tracker with 0.4° accuracy. The system included an infrared detector situated under the monitor presenting stimuli. The computer responsible for controlling the whole experiment by the SMI Experiment Center version 3.6 application was located in a different room.

2.3. *Independent variables*

The present study examines control panels digitally presented on a computer screen. The experiment requires a user to perform an information comparison task, make a decision and respond by clicking with a mouse on an appropriate control button. The sequence of mental and motor activities applied in the current study is very similar to the one typical in monitoring tasks such as keeping the desired vehicle velocity at the same level on a chassis dynamometer.

All control panels consisted of three sections always located in the same places of the panel. The first included increase and decrease buttons and was situated at the top of the panel. The middle section displayed information about the car target velocity. The bottom panel component showed the current vehicle speed.

The speedometer type used for presenting information about the vehicle's velocity was the first main independent variable in the current research. Because two versions of speedometers were investigated (analog and digital), there were four different combinations: (a) target and current velocities displayed by analog (clock-face) speedometers (AA); (b) target and current speeds presented by digital speedometers (DD); two mixed variants, i.e., (c) the target velocity on an analog and the current one on a digital speedometer (AD); (d) the target velocity on a digital and the current one on an analog speedometer (DA). The specific designs of speedometers were inspired by historical developments described by Mitchell [35]. The presented stimuli were additionally differentiated by the target velocity value (TVV) and the correct response type (CRT). Three levels were used for the former variable (20, 50 and 80 km/h) and two levels (increase or decrease) were specified for CRT. The three factors resulted in preparing 24 different stimuli: the speedometer type combination (STC) (4) $\times$ TVV (3) $\times$ CRT (2). Examples of applied experimental conditions are shown in Figure 1.

2.4. *Experimental design*

A within-subjects design was employed. Therefore, every subject examined all experimental conditions that were randomly displayed by the supporting software. The panel variants order for other subjects was determined according to the Latin square procedure.

2.5. *Dependent variables*

A series of dependent variables was used to assess the influence of examined factors on the control panel operation quality and the nature of the subjects' visual

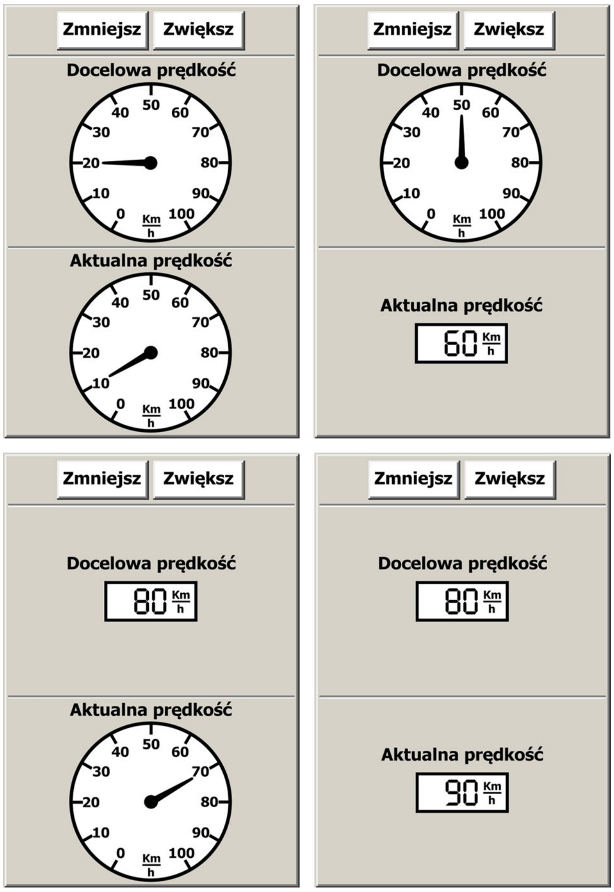

Figure 1. Examples of stimuli presented to subjects by supporting software.
Note: Translations of the Polish texts visible on stimuli are as follows: aktualna prędkość = current velocity; docelowa prędkość = target velocity; zmniejsz = decrease; zwiększ = increase.

activity. Task completion times were employed to assess efficiency while committed errors provided information about graphical panel effectiveness. The visual behavior was investigated by analyzing fixation (longer gazes) and saccade (rapid movement between fixations) characteristics along with pupils' dilations. Particularly, the following parameters were examined: (a) the number of eye fixations and saccades detected within a specific area of interest (AOI) during an interval of interest; (b) the fixation duration specifying how long an individual fixation lasted; (c) the fixation to saccade ratio calculated by dividing the number of fixations by the number of saccades within a specific AOI during an interval of interest; (d) the saccade amplitude (length) understood as a distance between the two fixations delimiting the given saccade; (e) the scan path length computed by summing up saccade amplitudes within a specific AOI during an interval of interest. These eye-tracking features were computed by SMI BeGaze version 3.6. The high-speed event detection method with default parameters was applied. Generally, the

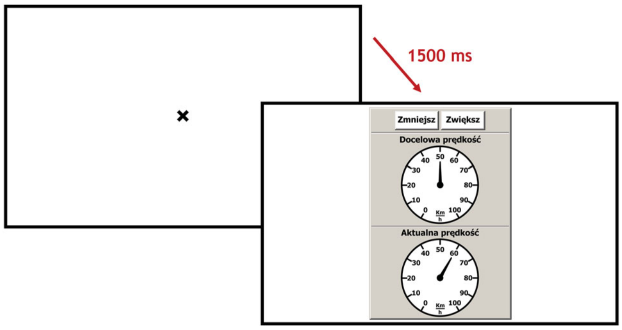

Figure 2. Example of the experimental task sequence.
Note: Translations of the Polish texts visible on stimuli are as follows: aktualna prędkość = current velocity; docelowa prędkość = target velocity; zmniejsz = decrease; zwiększ = increase.

technique first determines saccades and then identifies fixations based on these (e.g., BeGaze Manual [36], Smeets and Hooge [37]).

2.6. *Examination procedure*

First, subjects were informed about the general goal of the study. Next, the overall procedure was explained and an example of the experimental task was demonstrated. The examination started by answering digitally presented questions about the subject's age, gender, visual acuity and potential vision disorders. After performing three training tasks, a quick two-point calibration took place. Each stimulus was preceded by a white slide with a black cross (×) in the middle, presented for 1500 ms. Subjects were asked to fixate on that cross between consecutive stimuli. They were also encouraged to execute trials as quickly as possible. Subjects were not eye-tracked during test trials and filling in the questionnaire. An example of a single experimental task is presented in Figure 2.

2.7. *Statistical analyses*

The SMI BeGaze version 3.6 application was used for making initial analyses and exporting saccade and fixation data. Further calculations including statistical verifications were performed in Statistica version 12. Formal comparisons are generally performed by a classic full factorial analysis of variance (ANOVA), except for the number of committed errors where a non-parametric χ^2 test was used. For post-hoc analyses, Fisher's least significant difference (LSD) test was applied. $\alpha = 0.05$ was considered significant.

3. Results

The obtained data are demonstrated in Sections 3.1 and 3.2. Section 3.1 deals with task completion times and errors made, whereas the oculographic data are presented in Section 3.2.

3.1. *Task completion times and committed errors*

The average task completion times across all subjects and control panel variants amounted to 2506 (*SD* 1078) ms. The best mean result was recorded for the DA combination with 50 km/h TVV and the decrease expected response (2166 ms ± 187 *SEM*). The longest mean times were obtained for the AD variant with 80 km/h and the decrease correct response (2955 ms ± 187 *SEM*).

A four-way ANOVA (gender × STC × TVV × CRT) showed a significant ($\alpha = 0.05$) effect of the STC on mean task completion times ($F_{\text{STC}}(3, 744) = 2.8$, $p = 0.039$, $\eta^2 = 0.011$). The average values for this factor are demonstrated in Figure 3. Further, post-hoc comparisons revealed no meaningful ($\alpha > 0.1$) differences between AA vs. AD and DA vs. DD.

All other main factors together with all two-way, three-way and four-way interactions were not significant. Additional Fisher's LSD analysis of the TVV effect revealed meaningfully smaller ($\alpha = 0.05$) task completion times for 50 km/h (2409 ms ± 67 *SEM*) than for 80 km/h (2603 ms ± 67 *SEM*). The outcome is illustrated in Figure 4.

Overall, subjects made 44 errors, i.e., 5.5% of all attempts. Significantly ($\chi^2 = 6.1$, $p = 0.013$) more incorrect responses were observed for females (7.8%) than for males (3.7%). The χ^2 statistics showed no discrepancies in the number of mistakes for the STC ($\chi^2 = 1.7$, $p = 0.650$), TVV ($\chi^2 = 2.4$, $p = 0.298$) and CRT ($\chi^2 = 0.1$, $p = 0.759$).

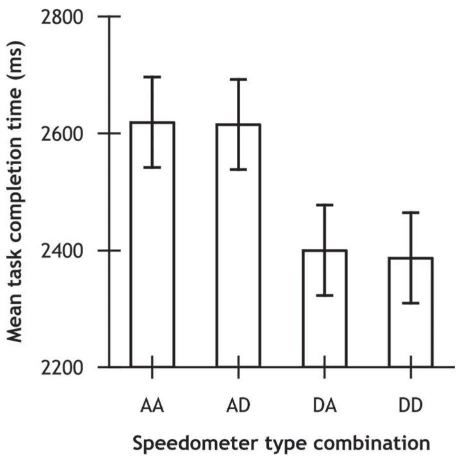

Figure 3. Speedometer type combination effect on mean task completion times: $F_{\text{STC}}(3, 744) = 2.8$, $p = 0.039$, $\eta^2 = 0.011$. Note: AA = target and current velocities displayed by analog (clock-face) speedometers; AD = target velocity displayed on an analog and current velocity on a digital speedometer; DA = target velocity on a digital and current velocity on an analog speedometer; DD = target and current speeds presented by digital speedometers. Error bars denote *SEM*.

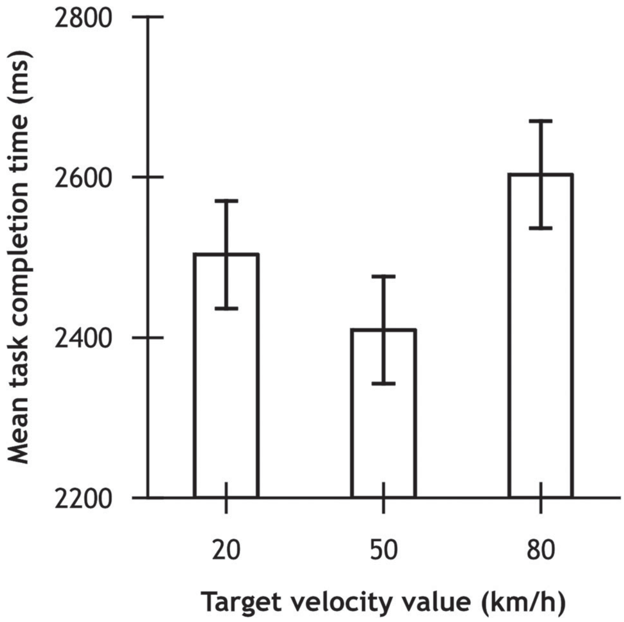

Figure 4. Target velocity value effect on mean task completion times: $F_{\text{TVV}}(2, 744) = 2.1$, $p = 0.123$. Note: Error bars denote *SEM*.

3.2. *Oculographic results*

3.2.1. *Fixation spatial distribution*

The first four consecutive fixations superimposed on 12 experimental conditions are demonstrated in Figure 5. The data generally show changes in subjects' attention while performing experimental tasks.

Several observations may be made while analyzing these data. First, irrespective of the experimental condition, subjects were more prone to focus their attention on the target speed section, especially during the first and second fixations. The situation changes later, because the third and fourth fixations are more or less equally distributed between the target and current speedometers. Interestingly, one may notice that subjects rarely fixated on the control button area.

The subjects' visual behavior regarding the analog speedometer is also worth noting. It appears that the foveal vision was initially directed to the approximate center of the clock-face, and only in further fixations moved to areas indicated by the speedometer's hand. Because digital versions of speedometers were markedly more compact, the attentional processing did not require changes in the visual focus.

3.2.2. *Basic visual activity measures*

Statistical characteristics describing the subjects' average visual behavior for all examined experimental conditions are presented in Table 1.

A standard four-way factorial ANOVA (gender × STC × TVV × CRT) showed the statistically significant effect of STC on the mean number of fixations

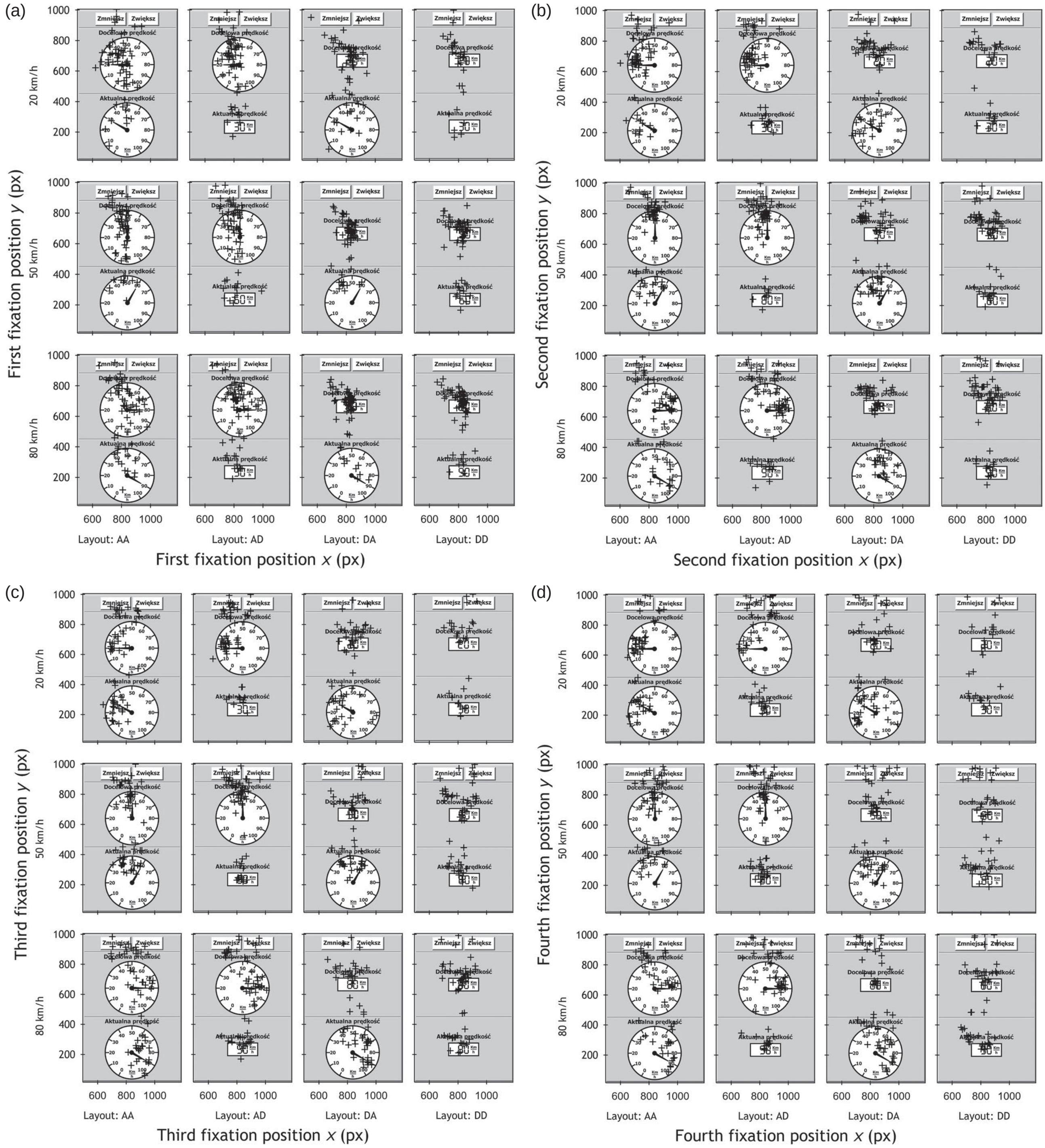

Figure 5. Consecutive first four fixations superimposed on 12 experimental conditions: (a) first fixation position; (b) second fixation position; (c) third fixation position; (d) fourth fixation position.
Note: AA = target and current velocities displayed by analog (clock-face) speedometers; AD = target velocity displayed on an analog and current velocity on a digital speedometer; DA = target velocity on a digital and current velocity on an analog speedometer; DD = target and current speeds presented by digital speedometers.

($F_{\mathrm{STC}}(3, 744) = 4.7$, $p = 0.003$, $\eta^2 = 0.019$). The smallest number of fixations was observed for options with digital target velocity speedometers (7.54_{DD} and $7.53_{\mathrm{DA}} \pm 0.33$ *SEM*) as opposed to the two variants with clock-face target velocity speedometers (8.77_{AA} and $8.76_{\mathrm{AD}} \pm 0.33$ *SEM*). Post-hoc comparisons demonstrated statistically meaningful ($\alpha = 0.05$) differences between these two groups of experimental conditions.

Fixation durations were formally examined by a four-way main effect ANOVA (gender × STC ×

Table 1. Basic visual activity statistics for experimental conditions averaged across subjects.

No.	Experimental condition	Measure of processing: Fixation count	Fixation duration (ms)	Fixation to saccade ratio	Measure of search: Saccade count	Saccade amplitude (°)	Scan path length (pixels)
1.	AA_20_Dec	8.2 (0.59)	160 (9.3)	0.55	15 (1.6)	5.8 (0.37)	1532 (109)
2.	AA_20_Inc	8.5 (0.77)	127 (8.2)	0.59	14 (1.2)	5.9 (0.33)	1750 (152)
3.	AA_50_Dec	8.3 (0.80)	143 (9.7)	0.62	13 (0.9)	5.6 (0.43)	1543 (149)
4.	AA_50_Inc	8.2 (0.75)	151 (13.9)	0.61	14 (0.9)	5.6 (0.38)	1571 (157)
5.	AA_80_Dec	9.3 (0.88)	127 (7.5)	0.54	17 (1.9)	6.5 (0.51)	1969 (165)
6.	AA_80_Inc	10.0 (1.01)	147 (10.1)	0.62	16 (1.2)	5.3 (0.30)	1953 (202)
7.	AD_20_Dec	9.4 (0.96)	141 (8.0)	0.59	16 (1.4)	5.7 (0.25)	1795 (187)
8.	AD_20_Inc	7.7 (0.72)	131 (7.1)	0.57	14 (1.5)	6.3 (0.50)	1555 (134)
9.	AD_50_Dec	8.6 (0.71)	141 (6.1)	0.59	15 (1.2)	6.5 (0.50)	1752 (165)
10.	AD_50_Inc	8.3 (0.92)	148 (10.8)	0.55	15 (1.9)	6.0 (0.42)	1650 (186)
11.	AD_80_Dec	10.2 (1.13)	144 (7.6)	0.63	16 (1.3)	5.9 (0.34)	2088 (264)
12.	AD_80_Inc	8.3 (0.74)	143 (6.2)	0.59	14 (0.9)	6.2 (0.46)	1680 (159)
13.	DA_20_Dec	8.0 (0.69)	152 (10.5)	0.57	14 (1.1)	5.7 (0.36)	1514 (136)
14.	DA_20_Inc	7.4 (0.99)	139 (8.3)	0.52	14 (1.5)	7.2 (0.64)	1692 (171)
15.	DA_50_Dec	6.7 (0.48)	145 (9.0)	0.54	13 (1.5)	6.1 (0.35)	1319 (114)
16.	DA_50_Inc	7.9 (0.74)	161 (9.7)	0.67	12 (0.8)	5.8 (0.43)	1429 (124)
17.	DA_80_Dec	7.2 (0.70)	139 (9.2)	0.54	13 (0.8)	6.2 (0.51)	1573 (133)
18.	DA_80_Inc	8.1 (0.80)	150 (6.8)	0.60	13 (1.3)	6.1 (0.35)	1527 (143)
19.	DD_20_Dec	8.4 (0.66)	152 (9.6)	0.62	13 (1.2)	6.4 (0.41)	1651 (156)
20.	DD_20_Inc	7.2 (0.59)	158 (8.2)	0.60	12 (0.8)	5.9 (0.42)	1351 (108)
21.	DD_50_Dec	8.0 (0.70)	155 (6.2)	0.61	13 (0.9)	6.2 (0.32)	1695 (162)
22.	DD_50_Inc	7.1 (0.66)	162 (8.6)	0.56	13 (0.9)	6.4 (0.38)	1547 (133)
23.	DD_80_Dec	6.4 (0.62)	157 (8.2)	0.56	11 (0.9)	6.4 (0.46)	1409 (156)
24.	DD_80_Inc	8.2 (0.95)	147 (10.8)	0.54	15 (1.7)	5.9 (0.40)	1677 (206)

Note: 20, 50, 80 = target velocity (km/h); A = analog; D = digital; Dec = decrease, Inc = increase. Values in parentheses denote *SEM*s.

TVV × CRT) which indicated the significant influence of gender and STC factors ($F_{gender}(1, 6324) = 11.2$, $p < 0.001$, $\eta^2 = 0.018$; $F_{STC}(3, 6324) = 6.1$, $p < 0.001$, $\eta^2 = 0.029$). Women had on average decidedly longer fixations than men (156 ± 1.9 vs. 148 ± 1.6 *SEM*). The longest mean fixation durations were registered for conditions where both speedometers were digital ($160_{DD} \pm 1.6$ *SEM*). As Fisher's LSD analysis showed, these fixations were significantly longer ($\alpha = 0.05$) than for all of the remaining STC levels. Discrepancies between other pairs were irrelevant ($\alpha = 0.1$). An additional one-way ANOVA revealed that the panel components, i.e., control buttons, target velocity and current velocity areas, meaningfully differentiated fixation durations ($F_{components}(2, 6329) = 36.4$, $p < 0.001$, $\eta^2 = 0.011$). Average fixation durations were decidedly the longest for control buttons (171 ± 2.7 *SEM*), whereas the shortest values were recorded for the target velocity panel section (144 ± 1.8 *SEM*). For the current velocity component, the fixation durations amounted to 155 ± 2.2 *SEM*. Post-hoc comparisons showed significant differences between all pairs of panel components ($\alpha = 0.05$). These results are presented in Figure 6.

A full factorial ANOVA applied for checking the influence of gender × STC × TVV × CRT on the fixation to saccade ratio revealed a significant impact of the gender effect ($F_{gender}(1, 744) = 14.9, p < 0.001, \eta^2 = 0.020$). The examined ratio was markedly higher for females than males (0.68 ± 0.015 *SEM* vs. 0.61 ± 0.013 *SEM*).

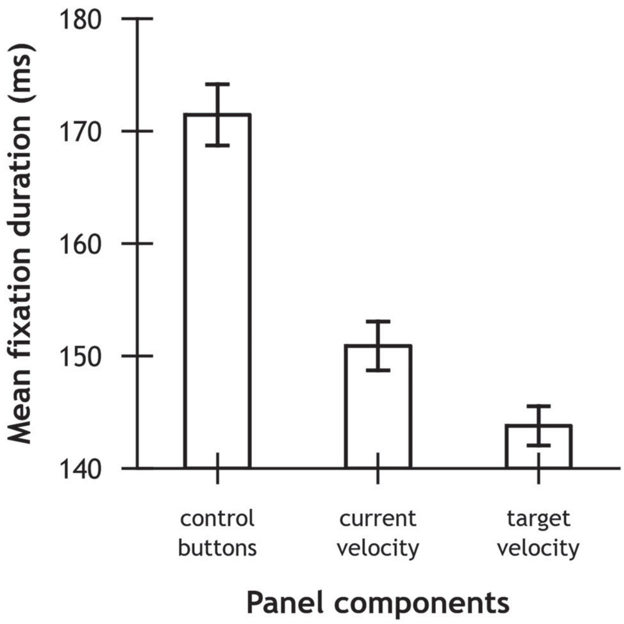

Figure 6. Control panel component effect on mean fixation durations: $F_{components}(2, 6329) = 36.4, p < 0.001, \eta^2 = 0.011$. Note: Error bars denote *SEM*.

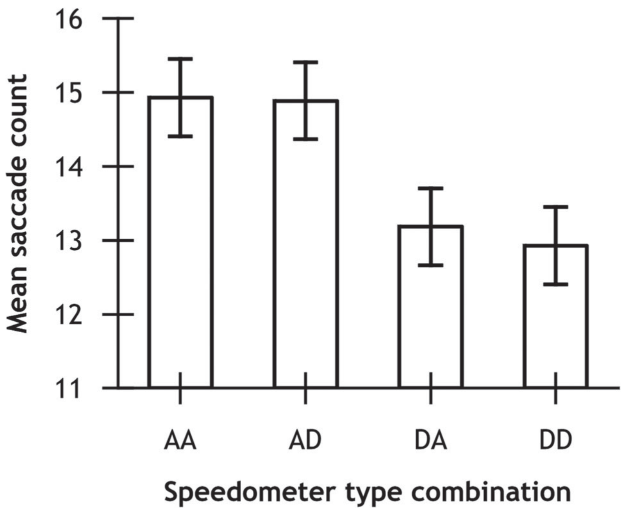

Figure 7. Speedometer type combination effect on mean saccade counts: $F_{STC}(3, 744) = 4.2$, $p = 0.006$, $\eta^2 = 0.017$. Note: AA = target and current velocities displayed by analog (clock-face) speedometers; AD = target velocity displayed on an analog and current velocity on a digital speedometer; DA = target velocity on a digital and current velocity on an analog speedometer; DD = target and current speeds presented by digital speedometers. Error bars denote *SEM*.

A four-way full factorial ANOVA was employed to test the impact of gender, STC, TVV and CRT on the number of determined saccades. The analysis indicated that only STC significantly differentiated the mean saccade count: $F_{STC}(3, 744) = 4.2$, $p = 0.006$, $\eta^2 = 0.017$. The data for this effect are demonstrated in Figure 7.

Mean saccade counts for DD (12.9 ± 0.52 *SEM*) and DA (13.2 ± 0.52 *SEM*) were almost identical. A similar situation was registered for the AA (14.93 ± 0.52 *SEM*) and AD (14.89 ± 0.52 *SEM*) control panel versions. Pairwise tests proved meaningful discrepancies between the pairs DD vs. AA and AD as well as DA vs. AA and AD ($\alpha = 0.05$).

A similar analysis was performed for the saccade amplitudes. However, the four-way full factorial ANOVA (gender × STC × TVV × CRT) showed that the main effects and all of their interactions are insignificant ($\alpha = 0.1$).

Another factorial ANOVA involving the same factors (gender × STC × TVV × CRT) showed significant discrepancies in mean scan path lengths for the STC effect ($F_{STC}(3, 744) = 3.3$, $p = 0.019$, $\eta^2 = 0.013$). The average values for this dependent variable are illustrated in Figure 8.

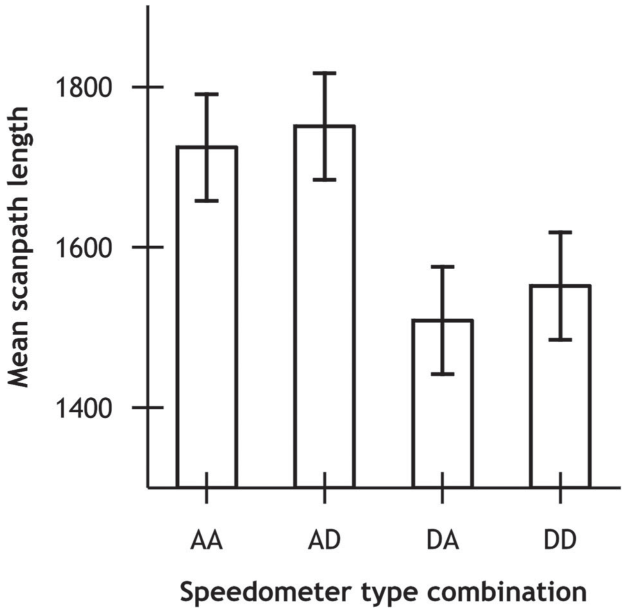

Figure 8. Speedometer type combination effect on mean scan path lengths: $F_{STC}(3, 744) = 3.3$, $p = 0.019$, $\eta^2 = 0.013$. Note: AA = target and current velocities displayed by analog (clock-face) speedometers; AD = target velocity displayed on an analog and current velocity on a digital speedometer; DA = target velocity on a digital and current velocity on an analog speedometer; DD = target and current speeds presented by digital speedometers. Error bars denote *SEM*.

4. Discussion and conclusion

This study experiment was mainly focused on the influence of STCs (clock-face vs. numerical) used for presenting target and current velocities on the speed of performing comparison and decision-making tasks. Additionally, to cover a wider range of possible real-life situations, another two factors were included in the experimental design, i.e., the target velocity (20, 50, 80 km/h) and the expected response type (increase, decrease).

The classical analysis of the control panel operation efficiency was generally consistent, with some previous studies on digital and analog clocks exhibiting a larger processing load for information displayed by clock-face dials versus their numerical equivalents (e.g., Friedman and Laycock [4], Goolkasian and Park [5], Boles and Wickens [7], Zeff [11]). However, the finding was clear-cut solely for AA vs. DD combinations. For AD and DA experimental conditions, the results were actually quite surprising. Use of an analog speedometer for demonstrating current velocity does not seem to negatively influence the processing time, whereas the same clock-face speedometer applied for presenting the target velocity increases significantly the task completion times. These outcomes suggest that in comparison tasks similar to those used in the current study, the way of displaying the target value is crucial to the control panel operation efficiency.

The proportion of incorrect subjects' reactions was higher than in other studies (e.g., Michalski and Grobelny [20], Blatter et al. [38]). This may suggest that current study tasks were more difficult. In the research by Michalski [39] where a comparable task was employed, the overall relative number of errors was very similar to the values obtained in the present experiment. Furthermore, the significantly larger percentage of errors made by females than males was unexpected because in many previous investigations the results were opposite (e.g., Michalski and Grobelny [20], Blatter et al. [38]): females were slower but more effective. Such a result could have been caused by the nature of the task type used in the current experiment that involved more mental manipulations. If this was the case, it seems that women are more prone to errors than males while performing more demanding tasks.

The analysis of oculographic parameters for the examined effects allowed for providing a number of additional observations. The qualitative graphical analysis of the first four fixations presented in Section 3.2.1 may constitute a basis for speculating about the visual activity models of shifting overt and covert attention (see, e.g., Zelinsky et al. [40] or Findlay and Gilchrist [41]). It seems that subjects started executing tasks by focusing on clearly separated panel components. Further changes in fixation locations generally resembled the spotlight model (e.g., Posner et al. [42]), which assumes local, foveal processing first and then jumping to another salient area and repeating the local analysis. When subjects come across clock-face speedometers, however, their visual behavior pattern apparently changes. It seems in this case that attention is first directed approximately toward the center of the clock-face, which may suggest a general processing of the whole speedometer. Only then is the focus moved to specific velocity values, which are visible in the next fixation locations. Such a visual activity is, in turn, typical for the zoom lens model (e.g., Eriksen and James [43]). Thus, it appears that subjects are dynamically changing their attentional strategies depending on the information display times.

Formal analyses of the obtained visuospatial characteristics for all independent factors concerned two general groups of measures described by Goldberg and Kotval [44]. Measures of processing included the number of fixations, fixation durations and fixation to saccade ratios. Saccade counts, amplitudes and scan path lengths were employed to analyze the search activity. None of the visual activity-dependent variables were significantly influenced by the TVV or CRT. The main examined factor, i.e., STC, had a meaningful impact on almost all measures, except for the fixation to saccade ratios and saccade amplitudes. The gender effect was important for the fixation durations and fixation to saccade ratios.

It is believed that longer fixation durations are associated with the more difficult visual task (see, e.g., Goldberg and Kotval [44], Buswell [45], Just and Carpenter [46]). In light of this, women apparently had greater problems with correctly executing experimental tasks, which can be concluded from higher mean fixation durations and a markedly larger number of committed errors than men. On the contrary, these differences did not affect the speed of performing tasks. Comparable results in this respect were probably caused by the females' visual strategy involving a smaller number of saccades accompanying longer fixation durations. This was reflected in decidedly higher values of the fixation to saccade ratios.

The additional analysis of the particular control panels sections suggests that subjects needed to devote more attention to making the velocities' comparison than to search, identify and process the velocity value displayed by speedometers. Moreover, information about the target velocity was less attentionally demanding than the current velocity, irrespective of the speedometer type.

Analyzing the number of fixations and saccades, one can notice that the results follow a similar pattern for the STC effect. Mean values are larger for the AA and AD variants than for the DA and DD options. This indicates that subjects were forced to spend more time on searching for the desired information before making the decision. Naturally, the outcomes regarding the scan path lengths exhibited comparable results because they depend directly on the number of fixations and saccades. Such visual behavior probably underlies the overall task completion time results that revealed almost identical relations for the SCT factor. It also seems that deeper processing for the DD arrangement, indicated by the longest fixation durations, did not negatively affect the speed of decision-making.

While interpreting the presented results, one should take into account that eye trackers register solely the foveal vision, which is assumed to represent the so-called overt attention (see, e.g., Findlay and Gilchrist [41]). Therefore, neither covert attention nor peripheral vision processing was directly examined here.

Another issue that could possibly limit the presented outcomes concerns values of eye-tracking ratios. This parameter gives the reader a notion of how much of the oculographic data were captured and identified by the tracking system and its algorithms. Unfortunately, this piece of information is quite rarely presented by investigators even in prestigious journals (see, e.g., Merkley and Ansari [47], Toker et al. [48], Ganor-Stern and Weiss [49], Guo et al. [50], Nicholls et al. [51]). Naturally, any researcher will welcome as large values of tracking ratios as possible. In the current study, the minimal threshold was set at 70%, which is less than in other papers. Quite often the cutoff tracking ratio value is set at about 80% (e.g., Vansteenkiste et al. [52], Kruger et al. [53], Viaene et al. [54]), and in some papers higher at 85% (e.g., Rau and Evenstone [55], Vansteenkiste et al. [56]) or particularly high at 90% (e.g., Vansteenkiste et al. [57]). On the other extreme, one can find studies where very small levels of tracking ratios are accepted. For instance, in the research by LoBue et al. [58] oculographic data were deemed unreliable if the eye-tracking ratio was $<15\%$. Lately, the problem of lacking consensus as regards the minimum tracking ratio for reliable results has also been analyzed and discussed by Vansteenkiste [59]. The author examined various inclusion criteria values and concluded that a threshold of 50% is a good compromise between the number of subjects included and missing data. This reasoning was further applied by Zeuwts et al. [60].

Taking into account the aforementioned, it appears that, generally, there exists no clear, fixed and minimal level of the tracking ratio below which the research results are worthless. Moreover, it seems that setting the tracking ratio threshold is usually at the discretion of the researcher. A similar view toward oculomotor errors is presented in a methodological paper by Yen and Yang [61], where they notice that inclusion criteria vary among laboratories and can be adjusted to task demands and sizes of the AOIs.

Given that AOIs in the present experiment were quite large, the requirements with respect to the precision may not be very robust (unlike, e.g., in eye-tracking studies on reading the text). This possibly did not greatly influence the obtained results; more important was the quite large sample size and number of trials performed by each subject. Generally, in this study the preference was shifted toward having more subjects with a higher degree of data loss rather than a smaller sample with fewer missing data.

It is also possible that the two-point calibration could have influenced the tracking ratio values. However, on the contrary, the very fast (<3 s) and automatic calibration applied in this study probably positively affected the ability of the subject to focus more on the main experimental task. Longer calibration procedures might increase the mental load and, thus, negatively influence the reliability of the captured data. These considerations indicate the necessity of conducting methodological experiments focused on examining this problem, ideally across various tasks and oculographic systems.

Another reason for decreasing the tracking ratio levels could be attributed to the way the sequence of stimuli was presented. Each task stimulus was preceded by the black cross displayed on a blank image. After qualitative examination of the recorded data, a considerable loss of eye-tracking data appears to take place during display of that cross. Subjects probably relaxed to some degree between consecutive stimuli and moved their heads or adjusted their sitting posture more often at that time.

Potential future experiments that would extend the current study findings may examine other ways of presenting information, different from button types of responses, and may involve various types of experimental tasks. These data, gathered in an artificial experimental setup, should also be confronted with results obtained in more ecological situations. Possibly a promising research direction may be concerned with the application of the hidden Markov process to analyze the oculographic data. Moreover, the outcomes presented by Goslin et al. [62] indicate that it would be very interesting to supplement the eye-tracking analysis with electroencephalographic data.

In summary, notwithstanding the presented limitations, the present experiment provides new findings concerned with the design quality of the classical, simplified panels operated in a computer environment. Secondly, the obtained results are thoroughly examined by a series of visual activity measures providing information on search and processing characteristics. Finally, the presented data allowed for conducting the analysis of possible visual strategies applied by subjects while performing experimental tasks. Thus, the presented outcomes give additional insight into the human visual processes and provide valuable practical recommendations that may be taken advantage of while creating ergonomic control panels.

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