A Comparison of Date Selection Elements on Mobile Touch Devices in eCommerce Sites

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Keywords: Date Input, Mobile Device, GOMS, Forms, Usability.

Abstract: There are several works exploring the different ways in which a user can input a date, as it is a very common operation on many websites, but the number of papers that cover this topic on mobile devices is very limited. In this paper several alternatives are considered, studied using Goals, Operators, Methods, and Selection Rules (GOMS), and tested in an online experiment with hundreds of users using these kinds of devices, to see how each one of them performs. The results show that the drop-down menu outperforms the others, which were more novel to the users, in completion time, user satisfaction and the number of errors committed.

1 INTRODUCTION

Nearly two-thirds (64.14%) of all Web traffic is calculated to come from mobile phones ("Mobile vs. Desktop Traffic Market Share [May 2022] | Similarweb," n.d.). They allow users to conduct daily tasks: order a purchase, make an appointment, plan a travel, etc. In e-Commerce sites users are frequently required to introduce their birthdate during the registration process. A very well-known example is the insurance companies, which ask users to enter their birth, vehicle registration, vehicle manufacturing date, accident date, etc. (for example, *mutua.es*). If the user faces obstacles while filling in the form, they may decide to opt for another, more user-friendly application, thus and rival company. It leads to the loss of users as well as the profit (Wroblewski, 2008). As the form consists of a variety of data input elements and all of them contribute to the whole performance of the form, it is worth in-depth analyzing every single one of them.

In fact, a number of research has already been done analyzing the usability of form elements: some of them provide guidelines for the interaction of the elements (Linderman, Fried, & 37signals (Firm), 2004; Martin, 2013, 2014; Seckler, Heinz, Bargas-Avila, Opwis, & Tuch, 2014); others study elements' performance for specific tasks (Healey, 2007; Jensen, Hansen, Eika, & Sandnes, 2020). A few studies have been executed in order to compare several date entries (Javier A. Bargas-Avila, Brenzikofer, Tuch, Roth, & Opwis, 2011; Brown, Jay, & Harper, 2010). However, a minority of them investigate the topic in the mobile context (Türkcan & Onay Durdu, 2018).

This research aims to compare three different date input methods on mobile applications that were not found to be compared before. These methods include spinners, drop-down menus and radio-buttons. The study seeks to provide guidelines for date entries' usage discussing their completion time, user satisfaction and errors' probability.

2 RELATED WORK

In previous studies, many aspects of Web forms usability have been explored. This section introduces results found about radio-buttons, drop-down menus,

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Romikaitytė, A., Stanci, S., De Andrés, J., Fernández-Lanvin, D. and González-Rodríguez, M.
A Comparison of Date Selection Elements on Mobile Touch Devices in eCommerce Sites.
DOI: 10.5220/0011577800003323
In *Proceedings of the 6th International Conference on Computer-Human Interaction Research and Applications (CHIRA 2022)*, pages 217-224
ISBN: 978-989-758-609-5; ISSN: 2184-3244

overall form structure and previous studies focusing on date entries.

Regarding web form improvement, Bargas-Avila at al. study (J.A. Bargas-Avila et al., 2010) summarizes 20 guidelines for usable web form design. The list is divided into five sections: form content, form layout, input types, error handling and form submission. Several suggestions include: place the label above the input field ("Label Placement in Forms :: UXmatters," n.d.); ask one question per row; use radio buttons or drop-down menus for entries that can easily be mistyped (Linderman et al., 2004); for up to four options, use radio buttons (Healey, 2007); order options in an intuitive sequence (Beaumont, 2002); for date entries use a drop-down menu when it is crucial to avoid format errors (Christian, Dillman, & Smyth, 2007). Seckler et al.'s empirical study (Seckler et al., 2014) aims to challenge the research described and applies holistic approach in order to evaluate guidelines' effect on efficiency, effectiveness and user satisfaction. The results revealed that improved web forms resulted in faster completion times, fewer submission trials, and fewer eye movements.

Jensen et al.'s research (Jensen et al., 2020) compared different country entry elements, such as drop-down menus, radio-buttons and text fields with autocomplete. What concerns task completion time, the radio-button interface was found to be the slowest, while text fields were proved to be significantly faster. Even though, no significant difference between the drop-down menu and text-field could be found.

Desktop date entries were analyzed by Bargas-Avila et al. (Javier A. Bargas-Avila et al., 2011). They compared six date input methods: (1) three separate text fields; (2) drop-down menu; (3) text field with the label on the left; (4) text field with the permanent label inside the box; (5) text field with a temporary label inside the box; (6) calendar view. Wrong format and wrong date errors were counted; completion time was measured, and user satisfaction questioned. The fastest completion time was noticed when using versions 3 and 5. Drop-down menu and calendar view showed no formatting errors, but they also had longer input times. Also, more incorrect dates were captured for the calendar view.

Methods for specifying dates in mobile contexts were investigated by Turkcan et al (Türkcan & Onay Durdu, 2018). The study was conducted in order to evaluate text box, divided text box, date picker and calendar view for date entry. As in the previous study, this research tested task completion time, number of errors, and satisfaction, too. In terms of completion times, even though the text box was found to be the fastest, no significant difference between the text box and the divided-text box was being found. Calendar view proved to be significantly slower. Also, participants made no mistakes when interacting with text boxes, whilst calendar view was found to be the most error-prone. Finally, the greatest satisfaction rate was shown by divided-text box followed by text box.

3 DATE SELECTION IN THE WEB

An analysis of the 10 most visited websites in retail (*amazon.com*, *ebay.com*, *rakuten.com*, etc.), social media (*facebook.com*, *twitter.com*, *instagram.com*, etc.) and information technology (*google.com*, *office.com*, *zoom.com*, etc.) sectors was performed ("Most Visited Websites - Top Websites Ranking for May 2022 | Similarweb," n.d.). Results showed that a drop-down menu for date entry was the most popular (retail – 83%, social media – 100%, IT – 100%). Spanish insurance companies with the heaviest website traffic (*mutua.es*, *generali.es*, etc.) are using more diverse date entry elements, such as radio-buttons, text-fields, calendar views ("Most Visited Websites - Top Websites Ranking for May 2022 | Similarweb," n.d.). Some of those input methods have already been analyzed by previous studies (Türkcan & Onay Durdu, 2018), whilst radio-button analysis for date entry was not noticed, thus made in this paper.

4 METHOD

This study uses similar methodologies to the ones used by Bargas-Avila et al. (Javier A. Bargas-Avila et al., 2011) and Turkcan et al. (Türkcan & Onay Durdu, 2018).

4.1 Experimental Design

As a first filter, different date entry methods were evaluated using Goals, Operators, Methods, and Selection Rules (GOMS) method. GOMS allows estimation of the time required to complete different tasks on the GUI (Card, Moran, & Newell, 1983), while the Keystroke-Level (KLM) extension minimizes the effort needed to accomplish the calculations (Setthawong & Setthawong, 2019). The theoretical concept is widely known and used in

Human-Computer Interaction (HCI) research (John, Kieras, & Kieras, 1996), mainly due the GOMS models' ability to make exceptionally accurate predictions (Gray, John, & Atwood, 1993).

The calendars that were examined: (1) mathematical; (2) mathematical-aligned; (3) spinner; (4) date picker; (5) date picker with arrows; (6) slider; (7) radio-buttons. The designs are illustrated in Fig. 1-7.

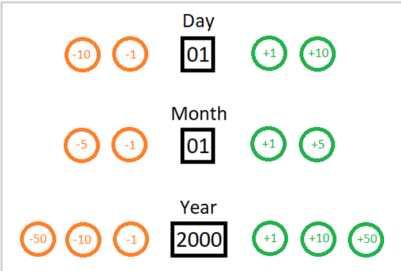

Figure 1: Calendar No. 1 – Mathematical.

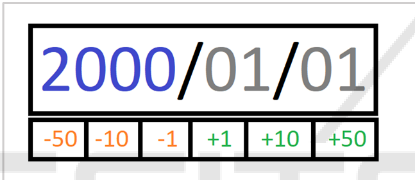

Figure 2: Calendar No. 2 – Mathematical-aligned.

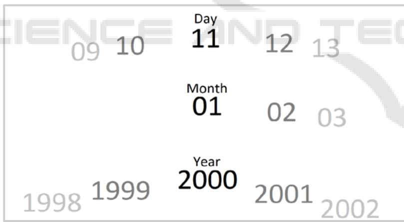

Figure 3: Calendar No. 3 – Spinner.

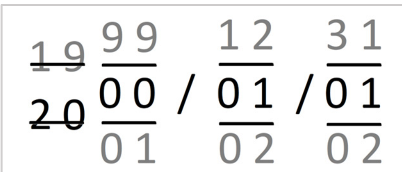

Figure 4: Calendar No. 4 – Date picker.

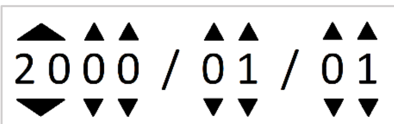

Figure 5: Calendar No. 5 – Date picker with arrows.

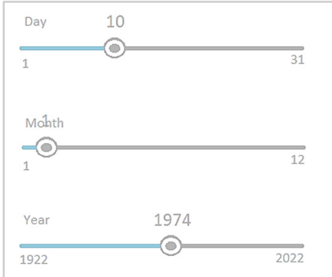

Figure 6: Calendar No. 6 – Slider.

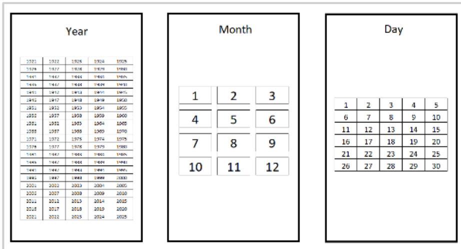

Figure 7: Calendar No. 7 – Radio-button.

As the study focuses on mobile applications' usability, adapted GOMS operators were being used (see Table 1). Adaptations were made by Settgawong et al. (Setthawong & Setthawong, 2019) so that element completion time could be accurately calculated for touchscreen interactions.

Table 1: Updated GOMS operators for interactions with a touchscreen.

Code	Description	Time(s)
E	Prepare fingers	0.5
T	Touch screen with finger	0.2
TT	Touch screen twice with finger	0.4
D	Move finger over surface	0.5
M	Move finger to a direct part of screen	0.7
F	Move finger over surface rapidly	0.4
S	Pinch, squeeze, spread, or splay gesture	0.7
P	Touch screen with finger for a long time	1.1
R	Touch screen with 2 fingers and rotate	0.8
L	Release fingers	0.1

Evaluated results revealed that Radio-buttons (M = 6.75 s) and Spinners (M = 8.48 s) are the most promising in terms of date entry completion times (see Table 2). Therefore, these two as well as the drop-down menu (the most popular in the industry) date entries are being investigated further.

Table 2: Average completion times estimated using GOMS.

Calendar	M (s)
Mathematical	12.53
Mathematical-aligned	12.53
Spinner	8.48
Date picker	11.03
Date picker with arrows	13.47
Slider	10.95
Radio-buttons	6.75

4.2 Procedure

For carrying out the experiment, an application was developed in which the users had to input the same 3 different dates using the calendars mentioned previously (drop-down menu, radio-buttons and spinners). The technologies used for the development were HTML, CSS and JavaScript. The IDEs used were Visual Studio Code and IntelliJ; in order to host the website Firebase was used, and it can be accessed by visiting https://researchprototype.web.app/. The Firestore service provided by Firebase was used for storing the data.

At first, a page with a small explanation of the experiment was shown, then the user was asked about the age and gender, for classification purposes. Afterwards, a page with videos regarding how to use each calendar was presented, in order to make the users more familiar with them and gain some expertise. Before starting the experiment the user was asked not to navigate back through the pages, as it would interfere with the validity of the data.

The experiment consisted in introducing the following dates: 5th of March of 2022, 16th of May of 1998 and 20th of June of 1964. These dates were hand-picked having in mind the objective of not repeating numbers, and also varying the closeness to the current date (one near, one far and one in between them).

The drop-down menu was implemented with a combo box for each field, and the other two calendars were implemented following the design shown previously, that is, for radio buttons (7) and for spinner (3). Technical settings, set for the spinner, where: *Accuracy = 0.001, MinStepInterval = 5, MaxStepInterval = 500, MaxSpeedAtSteps = 30, NoActionDistance = 0.01, OneStepDistance = 0.02.*

For storing the times, the time span between the selection of the first element of the calendar and the completion of the last one was calculated (the operation of pressing the button for proceeding to the next date was not taken into account), which would be the time it elapses from the beginning to the end of the task.

After the user finishes with all the inputs, a questionnaire was shown, with the aim of measuring user satisfaction. It was composed by two questions that were also used in the study of Bargas et al. (Javier A. Bargas-Avila et al., 2011), and it followed a 5-point Likert scale (scale: 1 = Strongly disagree; 5 = Strongly agree): (1) Filling in the date was comfortable; (2) I could fill in the date quickly and efficiently. When the user completed this questionnaire, the data (which comprises the user age and gender, times, dates and answers to the questionnaire) was sent to the database and there also existed the possibility of sharing the prototype through several social media pages, to provide the experiment with as much reach as possible.

5 RESULTS

In order to provide more accurate results, the data was processed removing entries that did not fulfil the necessary requirements for being considered as valid. The data was required to have all the questions in the questionnaire answered, all the dates completed (but not necessarily correct, as the mistakes were later counted for further analysis), and be done on a mobile device, which was verified using the User Agent from the browser of each participant. Entries that did not fulfil all these requirements were deleted.

Data records were considered to be outliers if the date entry completion time differed from the mean value by three standard deviations (Javier A. Bargas-Avila et al., 2011). Outliers were erased from the data sample.

After data cleaning, the date entries' completion times were checked for normality. Shapiro-Wilk test was being executed. As normality was not noticed ($p < .05$), calendars' completion times were log-transformed. Comparisons of the calendars were done by analyzing the mean values of figures for three dates entered by the recipients. For all statistical methods, .05 alpha value was used.

5.1 Recipients

After deleting invalid data or outliers, 277 data records in total were gathered from the participants for further analysis. 183 of them were male and were 94 female, with ages ranging from 14 to 57 years old ($M = 23.25$, $SD = 0.26$). Recipients were invited to participate in the experiment via Social Media platforms or by e-mailing current universities' students.

5.2 Errors: The Wrong Dates Entered

In order to test for significant differences between the errors of the three calendar versions, a linear regression model was used. Results showed no significant differences between the data entry elements, as $p > .05$. Even though, the drop-down menu showed the best results, with M = 1.28 %, SD = 0.24 %, while the radio-buttons performance proved to be the worst (M = 3.16 %, SD = 2.06 %) (see Table 3).

Table 3: Average and standard deviation of errors made.

Calendar	M (%)	SD (%)
Drop-down	1.28	0.25
Radio-buttons	3.16	2.06
Spinner	2.49	0.63

5.3 Completion Times

Data on date entries' completion times did not follow a normal distribution ($p < .05$), thus it was log-transformed. A Multiple Linear Regression (MLR) model was built. Equation:

$$\text{CompletionTime} \sim \text{CalendarTypeBinaryValue} + \text{userAge} + \text{userGender} \quad (1)$$

Three models were tested, comparing two different calendar versions each time. The results indicate significant differences between all calendars' completion times (see Table 5). The best performance was shown by Drop-down menu (M = 6.31 s, SD = 1.76 s), followed by Radio-buttons (M = 8.83 s, SD = 2.88 s). Spinner proved to be the slowest date entry element (M = 13.25 s, SD = 3.81 s), noting that the test was being performed on Spinner with the settings described in the Procedure section (see Table 4). Compared to the completion time results estimated using GOMS, experimental analysis proved to have higher time needs for entering the dates. Although, as in GOMS estimation, Radio-buttons calendar proved to show faster performance than Spinner.

Table 4: Statistics for calendars' completion times.

Calendar	M (s)	SD (s)
Drop-down menu	6.31	1.76
Radio-buttons	8.83	2.88
Spinner	13.25	3.81

5.4 User Satisfaction Rating

The first statement users had to evaluate was about date entry elements' comfortability. As shown in Table 6, significant differences were noticed between every calendar pair. Table 7 indicates mean and standard deviation values for user satisfaction. Drop-down menu demonstrated highest comfortability ratings (M = 4.25, SD = 0.98), whilst Spinner did not prove to be a preferred option (M = 2.34, SD = 1.54).

Accordingly, the drop-down menu's results showcase that according to the participants, the calendar is significantly faster and more efficient than the other versions (M = 4.24, SD = 0.91). Spinner is significantly slower and the least efficient (M = 2.36, SD = 1.55). Radio-buttons remain having a neutral evaluation (M = 3.59, SD = 1.48).

Table 5: Statistics for user satisfaction.

	Comfortability		Speed/ Efficiency	
Calendar type	**M**	**SD**	**M**	**SD**
Drop-down menu	4.25	0.98	4.24	0.91
Radio-buttons	3.67	1.38	3.59	1.48
Spinner	2.34	1.54	2.36	1.55

6 DISCUSSION

6.1 Discussion of the Findings

First, an overview of the results of each metric can be made to provide a perspective of the performance of each calendar.

Regarding completion time, the best option was the drop-down menu and the worst, by a considerable margin, was the spinner, which took more than double the time to complete compared to drop-down menu (the mean of drop-down menu was 6.31 seconds, whilst spinner had one of 13.25 seconds), while radio-buttons was almost 2 seconds slower to the drop-down menu.

User satisfaction was another important measure in the analysis, and the ranking in the methods follows the same order as with completion time, the drop-down menu was the preferred option, and the spinner the least preferred one, with radio-buttons being in the middle of them, closer to the drop-down menu than to the spinner (this order is maintained in both comfortability and efficiency, as evaluated by the users).

As for the errors made, it is worth noting that, despite not being significant differences between the three calendars in this regard (as shown in section 7.B), the most error-prone method was radio-buttons, and the least one was the drop-down menu.

The conclusions at which we can arrive using these results is that the drop-down menu is the fastest and most effective option. But this result may be conditioned by several factors, such as the other two calendars being more novel to the user, and also their implementations, which can vary more than the one of the drop-down menu, and the optimal implementation for the best user experience remains to be researched. Many users had operated with drop-down menus before and were already familiar with it, but for others they had to gain some more expertise, which could be done using the explanations provided in the webpage (see section 4.B). One benefit that all of the methods share is that no formatting errors can be made, as it is implicit in the design of the calendar.

6.2 Limitations

The results suggest that spinner is an option that should be avoided, due to it having very poor results, but it has to be taken into account that there are many variables that affect its usage, such as its sensitivity or speed. The configuration used for this experiment has proven not to be very effective, but using a more user-friendly one could give results closer to the ones predicted by GOMS (see section 4.A), by taking advantage of the possibility of making a swiping movement in mobile devices more effectively. The experiment consisted in filling several dates, with no other field to be completed, but this is not a very realistic scenario, as usually there are other components around, so the results could change if the calendar was integrated in a more conventional environment, such as a registration form in a website. The role of using the same dates for each calendar has to be considered as well, this could have had an effect on the expectations of the user over the course of the experiment. As mentioned in the previous section, drop-down menu is a very popular option, and users were more familiar with it than with the other two alternatives, in order to deal with this, more dates could be used, so that the user can achieve the same level of training for each option.

6.3 Feedback

Several users provided some feedback after doing the experiment, with the goal of describing how their experience was and what they struggled with the most. Many users felt that the sensitivity in the spinner was too high, which suggests that for future research it should be lowered so that users can be faster and more accurate. Another user noted that the drop-down menu was more aesthetic compared to the radio-buttons, as it required much less space in the webpage. One common suggestion was to change the order of the years in the radio-buttons method, and start from the current year instead of the lowest one, as many users had to scan the page for more time and to scroll down in order to find the requested year.

6.4 Future Work

As for future related research, several things could be further tested in order to clarify even more which type of calendar is more suitable for mobile devices. Many of the calendars presented were not included in the experiment, as the GOMS estimation was used as a criterion for deciding which ones to include, but as this research has shown, the numbers are not exactly the ones predicted (see section 4.A), so it remains to be seen how they would perform in another experiment. Another line to be extended would be testing different configurations of the spinner in order to find the most efficient one for the users, and see how it would perform.

Table 6: MLR models' statistics for completion times.

I compared calendar	II compared calendar	Intercept coefficient	Calendar coefficient	T value	F statistic	P value
Drop-down menu	Radio-buttons	9.08	-0.32	-12.22	50.01 > F(3, 550)	< .001
Drop-down menu	Spinner	9.42	-0.74	-33.04	365.06 > F(3, 550)	< .001
Spinner	Radio-buttons	9.44	-0.42	-16.41	89.94 > F(3, 550)	< .001

Table 7: MLR models' statistics for user satisfaction.

		Compared calendars		
		Drop down menu and Radio-buttons	Drop-down menu and spinner	Spinner and Radio-buttons
Comfortability	**Intercept coefficient**	3.67	2.43	3.84
	Calendar coefficient	0.57	1.9	-1.33
	T value	6.21	19.86	-12.88
	F statistic	13.55 > F(3, 550)	131.54 > F(3, 550)	55.52 > F(3, 550)
	P value	< .001	< .001	< .001
Speed / Efficiency	**Intercept coefficient**	3.56	2.32	3.69
	Calendar coefficient	0.65	1.88	-1.23
	T value	7.02	19.85	-11.67
	F statistic	16.68 > F(3, 550)	131.77 > F(3, 550)	45.47 > F(3, 550)
	P value	< .001	< .001	< .001

ACKNOWLEDGEMENTS

This work was funded by the Department of Science, Innovation and Universities (Spain) under the National Program for Research, Development and Innovation (Project RTI2018-099235-B-I00).

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