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# Skeuomorphic, Flat or Material Design: Requirements for Designing Mobile Planning Applications for Students with Autism Spectrum Disorder

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## Abstract

This study explores the user interface design requirements for developing a mobile planning application for students with autism spectrum disorder (ASD). We developed a mobile agenda application to support students in planning their activities. To test students' preference for a particular style, we designed three versions of the app, based on three different design styles (flat design, material design, and skeuomorphic design). Results show that the app was perceived as useful, likeable and user-friendly. Although, no significant difference was found between three designs, the material design was largely preferred over other two designs.

## Author Keywords

Autism; Material; Mobile; Skeuomorphic; Flat design

## ACM Classification Keywords

H.5.2 [User interfaces]: prototyping, evaluation

## Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that results in impaired communication and social interaction along with

repetitive behaviours. According to the American Psychiatric Association [1], the worldwide prevalence of ASD has approached one percent of the population. Although, when describing ASD, social and language difficulties are often seen as core deficits, several other symptoms may also cause serious problems in daily life. For example, deficits in 'executive functioning' may result in problems with planning, problem solving and switching tasks [2]. These problems may cause significant difficulties for students with ASD since they hinder the necessary skills to succeed in higher education. Such students are often perceived as "*inconsistent, manipulative, oppositional, distractible, dependent, and unfocused when trying to participate in classroom activities*" [3]. Nevertheless, students with ASD often possess various unique qualities and can prove to be a valuable asset to the society. To make use of these qualities, a systematic support is needed.

Because of the known advantages of technological tools for ASD intervention, there has been a recent growth in both research based systems and commercially available technologies for assisting people with ASD in developing necessary skills required to live an independent life [4]. However, most of these apps have been developed for children and relatively less attention has been paid to other large groups of participants i.e. teenagers and adults, who also need digital aids in managing their life. It is important to facilitate these user groups and support their lives with appropriate tools.

How well a particular technology or solution is adopted depends, among other things, on its usability and likeability. Improving the Graphical User Interface (GUI) design results in higher usability and acceptance

[5]. Over the last years, trends in user interface (UI) design moved from more realistic looking designs to more flat designs. Two opposing styles that represent this transition are skeuomorphic and flat design. Skeuomorphism is characterized by an interface design that is mapped on its real-world counterpart [6]. Skeuomorphism in UI design has received quite some attention and criticism on its usefulness and purpose in the design of smartphone applications. While skeuomorphic design is meant to adequately link human and machine through its rich and illustrative approach [5], the excessive use of textural elements could cause a loss of functionality. Flat design, on the other hand, is also known as 2-D interface design and discards all shadows, highlights, gradients and textures. Stripping away superfluous design elements makes content easier to digest, but could mislead users in which elements are interactive and which are static [7]. Finally, more recently Google introduced a new design style 'material design'. Unlike flat design, which discards highlights and shadows, Material Design "makes more liberal use of grid-based layouts, responsive animations and transitions, padding, and depth effects such as lighting and shadows" [8].

All three designs have their own specific strengths and weaknesses and might therefore support students with ASD in different ways. For instance, skeuomorphic design can become cluttered and distracting, which could make the product less usable. According to the *Theory of Weak Central Coherence*, too many details could distract users from the main purpose and therefore cause problems for people with ASD [9]. Using realistic representations has proven to be successful in enhancing the understandability of app style icons for elderly users, which is also a group with

special needs [5]. Because people with ASD have trouble understanding ambiguous symbols, using skeuomorphic design might also influence their understandability of an interface. On the other hand, if distraction and inconsistencies cause stress, then a flat design might perform better since that design style is more calm and clean [10]. However, there is no clear evidence on which design style is the most suitable for students (teenagers and adults) with ASD. In this study, we explore (1) the needs of students with ASD (2) the potential of mobile planning apps to support students with ASD, and (3) the design preference of students with ASD (flat design, material design, and skeuomorphic design).

### **User research**

Ten males and one female took part in the user research. Seven were diagnosed with PDD-NOS, three with Asperger Syndrome and one with classical autism. The mean age was 23.45 years ( $SD = 6.19$ ). The autism-spectrum quotient (AQ-score) was used to measure the extent to which a person possesses autistic traits. The mean AQ-score was 25.36 ( $SD = 11.48$ ). A total of three group sessions for eliciting requirements were held. The sessions lasted between 90 and 150 minutes depending on the number of participants. The sessions were recorded using a video camera. The goal of this exercise was to identify general problems in the daily lives of participants and problems related to planning. First, participants were asked to individually write down as many problems as they could for five minutes - each problem on a separate sticky note. While the researchers collected the sticky notes and roughly clustered them on the wall, the participants were asked to follow the same procedure but then for problems they encounter related

to planning. Finally, participants were asked to finish the clustering of sticky notes and to explain their problems. The sticky-notes were used as topics in a semi-structured interview.

### *Results*

As the main focus of this paper is on comparing three different designs and the planning app is used as a base for the comparison (as far as this paper is concerned), we only very briefly discuss the planning related problems faced by the participants. Participants mentioned they have problems with planning and organizing their daily lives, but try to cope with these problems by the means of different tools. Only two participants make use of a paper agenda, while the rest makes use of mobile agenda applications on their smartphone. One participant created his own agenda in Microsoft Excel because his smartphone app did not meet his requirements. The majority of participants also mentioned they are not pleased with their agenda applications. We found that participants face trouble with *sticking to their planning*. This also jeopardizes future appointments. For example one participant mentioned that he forgets the time and goes to sleep too late, this results in being systematically late for work. Participant no. 8 mentioned that he likes to precisely plan his day: "*A tight schedule can help as motivator but it is not always easy*".

Problems with *prioritizing activities* occur because often the importance of one appointment over another is estimated differently. As participant no. 3 explained: "*School and work require a lot of planning and I experience those as more important, that is why I find it hard to plan for other things, resulting in a pretty chaotic private life*".



Figure 1: Material design - All (top), week (bottom). Also the use of bars to show calendar which participants did not like

In order to assign the right priority to an activity it is important for the participants that their agenda tool supports them in an intuitive manner. While using existing apps, participants also have trouble with *keeping overview* because they focus more on specific elements rather than generic ones in an interface, and this sometimes results in losing track of the interface. As participant no. 2 put it: *"When a lot of details are present I don't know where to start, I cannot see the wood for the trees"*. We learned that participant notice very basic things in the interface and small things, like an abbreviation, can disturb them. For example participant no. 5 said, *"Using one letter for the indication of days of the week is unclear, for example both Tuesday and Thursday start with a 't'"*.

In summary, our user research clearly showed that participants find it hard to plan their daily activities and they are not pleased with the digital aids they use. They are not only unhappy about the functionality but also about the way these applications are designed.

### Design and Development

Based on the results, we designed an agenda app for an iPhone. The app was fully functional with 12 menu items and 70 screens. The key features of the app were: (1) Add appointment (short and detailed), (2) Add reminders (time and untimed), (3) Colored agenda (color of your own choice), (4) To do list, (5) Search the agenda, (6) check off functionality (when done), (7) Invite persons, and (8) View agenda (different views i.e. day, week, month, year). Before the final testing, the app was evaluated by interaction designers (N = 5) and laymen (N = 4). The app was further optimized based on the feedback from these pre-tests.

Subsequently, three versions of the app were created representing three design styles: material design, skeuomorphic design and flat design.

*Material design:* The style makes use of shadows in a minimalistic way to create layers between objects only when this is required, such as with buttons and menus. This creates clear affordances within the interface without completely losing the clean look of a flat design (Figure 1). Material design treats all parts as if they are real world materials in a sense as if they possess physiological properties (Google, 2015).

*Flat design:* For the flat design style all components were stripped of their shadows, which eliminated all depth (layers) from the interface (Figure 2). The individual components, which were separated by lines in the material design, were replaced by colored blocks to signify distinction. This difference clearly shows between Figure 1 and 2 within the header menu, appointment items and footer menu. To contribute to the minimalistic look of flat design, the colored bars referring to different agendas were replaced by clean colored dots. This was done throughout the whole app.

*Skeuomorph design:* The skeuomorph design (Figure 3) was created based on the flat design and supplemented with real world style elements. All buttons were designed with a sense of depth similar to real buttons to clearly indicate they can be clicked. The background was filled with a texture to simulate a paper agenda. The colored dots were replaced by 'hand drawn' dots, the checkmarks were replaced by 'hand drawn' check marks, and the selection indicators were replaced by red 'hand drawn' circles (figure 3 – bottom).

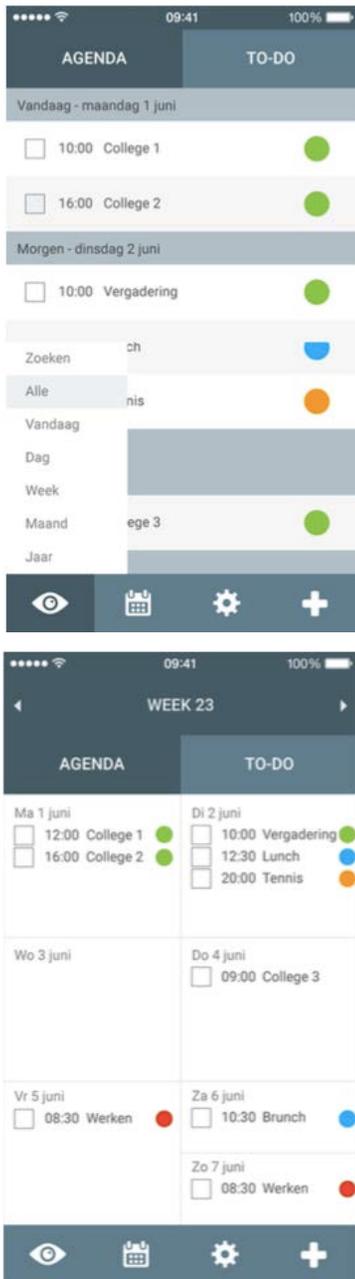


Figure 2: Flat design - All (top), week (bottom). Also the use of circle to show calendar which participants preferred

## Evaluation

In order to compare the three designs of the agenda application and test the overall functionality, we invited end-users to test the three designs. We used the Technology Acceptance Model (TAM) to measure the intention of using the app [11]. All questions were translated to Dutch. The result was a questionnaire consisting of thirteen questions, which measure the *usability*, the *perceived usefulness*, and the *overall evaluation*. Next to the questionnaire, which was filled out by participants for each design, the principle of attractiveness [12] was used to measure the likeability of the designs in the post-test interview. The principle of attractiveness claims that when a technology is more visually attractive, it is likely to be more persuasive and more likely to be used [13].

A total of thirteen persons with ASD participated in the evaluation. Eleven males and two females with a mean age of 23.31 years ( $SD = 5.69$ ) and a mean AQ-score of 28.00 ( $SD = 9.64$ ) were all functioning on a normal to high level. Each session started with explaining the procedure followed by 5 minutes of free exploration with one of three planning apps. Subsequently, six tasks were performed in that same app ( $\pm 5$  min) and a questionnaire was filled out ( $\pm 5$  min). Performing six tasks and filling out the questionnaire was repeated for the two other apps. After each questionnaire the participant was briefly interviewed on the app they just had tested ( $\pm 1$  min). After the third questionnaire participants were interviewed extensively. To avoid order effect, the apps were presented in a different order to different participants. A total of eighteen unique tasks were designed to test the three designs. These were divided in the categories: add, remove, adjust, navigate, etc. so all functionalities of the

application would be covered. To exemplify, the user can *add*, *adjust* or *remove* appointments, to do's and agendas and can *navigate* to a specific date or task.

## Results

In this paper, we mainly report the comparison between three designs. However, participants evaluated the app positively. Nine out of thirteen would like to use the app when it becomes available in the App Store. This outcome is due to special features like the plan reminder, to do list with explicit check offs and agenda invites. Participants who indicated they would not like to use the app attributed this to the fact that they would not use any smartphone agenda, as participant no. 3 puts it: *"Yes I would use the app, but still have an aversion to scheduling things in agendas because they always change"*. Seven participants thought that the app would be useful for a large number of people with ASD. As participant no. 9 summarized: *"I think you are heading in the right way"*. Finally, participants mentioned that the app would also be beneficial to other people, both with and without ASD due to the unique functionalities and clear interface.

## COMPARING DESIGN STYLES

A Friedman's ANOVA was conducted for analyzing the usability, the perceived usefulness and the overall evaluation. Material design, flat design and skeuomorphic design were compared on these three constructs. No significant difference was found between the three apps on usability ( $\chi^2(2) = 2.88, p = .237$ ) and overall evaluation ( $\chi^2(2) = 3.26, p = .196$ ). For perceived usefulness a significant difference was found, ( $\chi^2(2) = 6.95, p < .05$ ) where the material design was

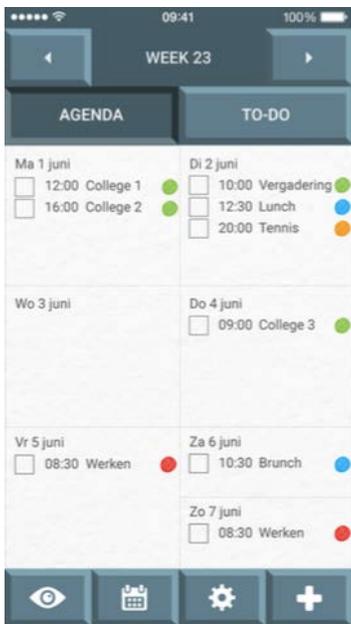


Figure 3: Skeuomorphic design -all (top), week (bottom)

preferred over the other two. Participants were asked to rank the three designs from the most to the least preferable. The majority of the participants preferred the material design whereas the flat design was chosen by half of the participants as the second most preferable. The skeuomorphic design was chosen by more than half as the least preferable. Even though this task resulted in a clear ranking, preferences did vary among participants.

#### BACKGROUND, HEADER AND FOOTER OF THE APP

For the background, a paper-like texture was used in the skeuomorphic design and plain white color in the other two. Only three participants liked the paper-like texture, as participant no. 8 said: *"I think the texture is calm and nice, that is important"*. On the contrary, the majority of the participants did not appreciate it. For example, participant no. 6 said: *"The background is only distracting me, when you see it, it starts to annoy you"*. In line with [14], no unanimous preference was derived from the evaluation. However, most preferred a clean white background on a real world texture.

In the case of header and footer menus, the buttons from the material and skeuomorphic design were most preferred. Participants found these buttons in the footer menu clear and more usable because they indicate where to click by their cast shadows, however the looks of the flat design were preferred because they are designed in a clean fashion without distracting elements. Participant no. 6 explains: *"I think the delimitation of the buttons [skeuomorphism] is very nice, but further the design is too old-fashioned"*. Clear affordances are liked, as participant no. 12 reacted to the skeuomorphic design: *"I find these buttons more useful because you can see more clear where to click*

*on"*. Table 1 shows a simple summary of these findings. To improve the buttons in the flat design footer menu, it was suggested to add thin lines between them. These comments on buttons also hold for the header menu and other buttons used in the designs. In addition to that, participants reported on the header menu that the 'tabs' clearly indicate which screen is currently being showed (appointments/to do's). Nevertheless, most participants preferred the header from the material design.

Rank	View	M	SD	Median	Mode
1	Material design	1.75	0.89	1.50	1
2	Flat design	1.75	0.71	2.00	2
3	Skeuomorphic	2.50	0.76	3.00	3

Table 1: Mean rankings of designs (1 for highest)

#### ELEMENTS FROM EACH DESIGN

Participants were asked to pick their favourite elements from all three designs to form one perfect app. This resulted in most cases in a combination of the material design header menu with the agenda content of the flat design and the buttons from the material or skeuomorphic design. The header was preferred because it highlights this more clearly than the header in the flat design which screen is currently being viewed. For the flat design, the highlighted area was found to be ambiguous in some cases. The agenda items from the flat design were preferred most because the grey bars clearly make distinction between days and because the colored dots are designed in a clean fashion. The colored bars used in the material design and the background from the skeuomorphic design (paper texture) were too distracting.

Figure 4: Evaluation of the footer menus on affordances and appearances

Design	Affordances	Appearances
	+	+
	-	+
	+	-

The skeuomorphic and material design footer menus were preferred over the footer menu from the flat design because they both have clear buttons. Which of the two was preferred depended on which style participants personally liked the best.

A clear preference was found for different elements within the app. For participants the buttons needed clear affordances, which are present in skeuomorphic designs. Further, elements within the app should not distract the user, which is done quite neatly in flat design. Style elements like textures and hand drawn circles are distracting and are only preferred by two participants who liked to decorate the interface to make it look less 'boring'. The combination of all preferred design elements in the material design resulted in the creation of a design that with minor adjustments can be optimized to completely fulfill the needs of the user.

### Discussion and Conclusion

In this paper, we investigated the GUI design requirements for developing a mobile planning application for students with ASD. We interviewed users to identify the problems they face while managing their daily life. Based on the results, we developed a mobile

planning application. To identify users' preference towards a particular design (flat, skeuomorphic, material), we designed three different versions of the same app.

The results showed that participants had a positive attitude towards the app. The initial main purpose of the application appears to be feasible: participants expect that the app would support them in organizing their daily lives and would enhance their planning skills. The high ratings on the *perceived usefulness* scales and the fact that nine out of the thirteen participants would use the app, indicate that the app is perceived to be useful. Additionally, the results from the interview also indicated that participants perceived the app as easy to use, useful and clear. No significant differences were found between the three design styles on *usability*, and *overall evaluation*. *In the case of perceived usefulness, material design was preferred*. This is inline with the results of the interviews, where participants showed clear preference for certain elements taken from each design. Nevertheless, most participants preferred the material design over the other two designs.

The results of this study should be interpreted with caution due to the small sample sizes. Moreover, participants found it difficult to take part in the research because of unknown situations and new social interactions. We thought that unlike children, adults would be more comfortable in visiting a new place for focus groups. Unfortunately it was not the case. Participant found it is hard to mingle with other students with ASD. Therefore it is important to conduct research in a place where participants feel familiar and comfortable and reserve more time for building a rapport in the beginning of the group discussion. For this study, we designed one standard application and

three different designs. This gave us a complete control over the manipulation without affecting the core functionality. However, the skeuomorphic design might be significantly different on usability and likeability when the certain design elements like textures and shadows are exaggerated. In our next study, we would like to create different versions of the skeuomorphic design with different levels of emphasis.

As planning is one of the key issues for students with ASD, an agenda application with the right functionality and design has a potential to have a positive effect on the lives of students with ASD. Based on these results, we would redesign the interface of the app by borrowing design elements from all three designs while using the material design as a core design style.

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