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The Impact of Combining Gestalt Theories with Interface Design Guidelines in Designing User Interfaces

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ABSTRACT

Software systems are one of the most important technologies that are present in every task that humans and computers perform. Humans perform their tasks by using a computer interface. Graphical user interfaces are the most common interface that developers rely on to create easy-to-use, easy-to-learn and easy-to-understand software systems so that end users can improve their performance. However, many times, developers tend to create software using their own preferences based on their skills and abilities but do not consult theories that would produce better outcomes. We conducted a study to identity whether software that is developed by using Gestalt theories combined with interface development guidelines produces better outcomes compared to software developed using developers' current skills. Results show that for the present research, participants perceived the system that was developed using such approach had superior quality compared to another that does not. However, results should be taken cautiously.

Keywords

Graphical user interface, Gestalt Theory, Quality, Information systems

INTRODUCTION

Software is one of the most used technologies. Everyday different applications are created for many purposes such as management, information processing and information sharing, among others. Many software applications are intended for the general population, so that end users are unlikely to fully exploit all software capabilities. End users interact with software through interfaces. Wu (2000) believes that a good interface should be: a) easy for novices to learn, b) efficient for experts to use, and c) provide the means for users to make the transition from the easy-to-learn but inefficient methods of novices to the more difficult-to-learn and efficient methods of experts. Lane et al. (2005) argue that graphical user interfaces (GUIs) meet these criteria fairly well. However, this is only true when GUIs are well-constructed by taking into account end users' needs.

Frequently, software developers create applications based solely on their own preferences rather than by having in mind information regarding end user. In addition, Aberg and Chang (2005) state that "different industries require specialized functions from one another; thereby it is difficult to apply any specific set of interface design guidelines" (p. 23). Therefore, it is not an easy task to develop GUIs that meets all people's expectations.

We believe it is important that developers should be capable of designing improved GUIs that would be more likely to be accepted by end users. Traditional systems design methodologies do not provide "grounded" guidelines for building GUIs. That is, developers should rely upon past theories and research, such as those based in Gestalt Theory (Chang et al., 2002) on the subject to create superior information systems (IS). This study intends to provide some insights into how existing research can be used for the purpose of enhancing software system interfaces. The research question is as follows: *Is there is a significant difference between a system's GUI developed using a traditional approach compared to a system's GUI developed using design guidelines grounded in Gestalt Theory?*

MOTIVATION

Software engineers should deliver high-quality software to users, which complies with all requirements, and, ideally should be easy-to-use, easy-to-learn, and easy-to-understand (Pressman 2007). Software development is an increasingly complex task (Bowen and Reeves 2008) that requires the effort of a set of experts. Frequently, users report that IS' interfaces are not easy-to-use. For example, Ko et al. (2006) report that 26% of users are not satisfied with ISs' GUIs. Ahonen and Juntilla (2003) report that usually there is not enough budget or time allocated for the development of GUIs, which could lead to developers being unable to put enough effort into the project.

Since software is an intangible product, its quality depends on the perspective of each user. Pressman (2007) argues that users put a high software quality value on the interface, which is the mechanism that allows interaction between people and the IS. Interaction means the coordination of information exchange between the user and the IS (Bosch and Juristo 2003). It is important to remember that the most visible component of any system is the interface. An ill-designed interface prevents users from maximizing performance as well as being unable to use all of an IS's features. Hence, user interface (UI) design is a critical step for IS developers.

For interface design, the balance and general organization of the graphical elements can have an important impact on end users' perception of an IS (Buitrón de la Torre 2004; Liu and Osvalder 2004). In the field of psychology, Gestalt is a formal theory for visual perception of objects (Gordon 2004), which explains how humans perceive graphical elements that are "captured" through human senses. Past research (Chang et al. 2002; Chang and Nesbitt 2005) argues that this theory is formed by a series of principles or laws that can be used to suggest how visual elements can be represented so that effective results can be achieved. They identify eleven principles that can be used as the basis of an interface design, which has a structure that is easy-to-understand and learn. This effect would contribute to the development of high quality UI.

LITERATURE REVIEW

Software quality (SQ) includes both process and product quality. Process quality is completely transparent for end users. However, they demand that any software complies with product quality standards. Thus, measuring product quality becomes an absolute necessity.

Graphical User Interfaces

"GUIs as means of human-computer interaction has greatly contributed to the usability of systems" (Costagliola et al. 2000, p. 581). Recently, much effort has been devoted to create more effective graphical applications so that they better address end users' needs (Costagliola et al. 2000). Interface design is part of the human-computer interaction field (Galitz 2007), and is one of the factors that has the biggest impact for organizations (Machiraju 1996). In addition, Interface design focuses on three main areas (Pressman 2007):

1. Software components
2. Software, other products and external entities
3. End users.

In this area, we can distinguish between hardware and software interfaces. For the present research only the latter are studied.Even with the existence of powerful and useful tools, the development of GUIs is an expensive and difficult task (Costagliola et al. 2000). For example, previous literature (Costagliola et al. 2000; Te'eni et al. 2007) reports that EUIs require most of the implementation time and represent about 48% of the application's code (Costagliola et al. 2000). Interface design is the process of specifying how end users will use IS functionality as well as the information produced (Sommerville 2006). Input and output tasks together satisfy end users' requirements. Galitz (2007) argues that a well designed interface is the one that goes unnoticed and allows people to focus on the information and the task that is being performed and not get distracted by the input/output mechanisms. In addition, Galitz believes that UIs were revolutionized by the use of graphic elements because displaying information in this format enhances end users' abilities for interpretation due to the reduction of the required mental load and data recoding.

A well designed UI requires taking into account several very important aspects. Pressman (2007) believes that knowing end users' expectations is one of them because issues such as gender, age and physical conditions, among others, affect such expectations. For example, users that have visual problems prefer large graphics and text (Sharp, Rogers et al. 2007). In addition, another important factor is end user experience and based on that Galitz (2007) classifies them as expert, intermediate and novice; experts prefer UIs that can lead to a high performance and allow complex tasks; on the other hand, novices prefer UIs that guide them through tasks, and have minimal options and more help (Pressman 2007). The challenge is to design UIs that satisfy expert end users' needs without introducing too much complexity for the less experienced (Galitz 2007). However, knowing end users' needs is not an easy task, especially when they are not willing to cooperate with developers. Moreover, it is important to do more regarding EUI design because in many cases is unsatisfactory and organizations pay a high price for unsatisfactory quality (Te'eni et al. 2007). Thus, it is important to research new areas that could help developers create IS that could be well accepted and used.

An Overview of Gestalt Theory

Chang et al. (2002) explain that Gestalt Theory (GT) is a family of psychological theories that have influenced several research areas, including visual design issues. In addition, they argue that GT can be used as one of the foundations for instructional screen design. GT is usually expressed as laws, and it intends to explain how people perceive and recognize patterns (Chang and Nesbitt 2005). This theory proposes that perception is loaded with memories. Originally, was only studied in psychology, but the concepts have influenced many research and study areas (Chang and Nesbitt 2005). Some examples that applied GT are diagram design (Lemon, Allen et al. 2007), language patterns (Flieder 2007) and aesthetics (Lim, Stolterman et al. 2007). The key GT laws taken from past research (Chang et al. 2002; Chang and Nesbitt 2005) are: Balance/Symmetry, Continuation, Closure, Figure-Ground, Focal Point, Isomorphic Correspondence, Proximity, Similarity, Simplicity, and Unity/Harmony.

Development of the Graphical User Interface Studied Attributes

An interface is the first product or service that a user touches to interact with an IS (Blair-Early and Zender 2008). It is in charge of connecting humans with computing resources such as: operating systems, applications, and data. However, individual preferences have an impact on how each person prefers to interact with an IS. “In many cases, the way we access and use, and even the degree to which we rely on technology, may be vastly different from generation to generation” (Blair-Early and Zender 2008, p. 85). GUIs help people to increase productivity (Orubeondo and Mitchell 2000). The design of GUIs should include human factors principles (Staggers and Kobus 2000) so that end users' acceptance might be enhanced. Based on the above, our research studied a series of important aspects for GUI design, which are described below, and which are related to guidelines specified by Blair-Early and Zender (2008), Chang et al. (2002), Chang and Nesbitt (2005) and Te'eni et al. (2007).

1. *Obvious Starting Point*. It is important that end users must know how to start interaction with the content. Pre-attentive features are proven to “pop-out” and include: size, value, hue, orientation, shape, enclosure, blurriness, and movement, of which movement is the most basic pre-attentive feature. Pre-attentive features should be applied because they immediately stand out from their peers. A starting point is needed because every new interface requires a learning process. A *Focal Point* is important that a visual presentation has a focal point, which is called the centre of interest or point of emphasis. This focal point intends to catch the viewer's attention and persuades the viewer to follow the visual message further. Cognitively, people learn through finding patterns among details. Thus, the user must know where to begin the learning process.
2. *Clear Reverse*. The user must know how to reverse any action, including how to end the session. Therefore, the reversal should become obvious “on demand” and should be omnipresent and clear but subtle. The *Balance/Symmetry* is a psychological sense of balance that is usually achieved when visual ‘weight' is placed evenly on both sides of an axis; also, *Simplicity* is a graphical message must be uncluttered, but if the graphics are complex and ambiguous the simplification process may lead to unintended conclusions.
3. *Consistency.* An end user must be able to quickly identify a logical, rational pattern of relationships between user actions and effects in an interface's content. Design patterns should have an acceptable level of consistency within the world the interface develops. Users' representation is just how they usually simplify the real world. Consistent patterns and rationally connected to actions and content, users with average cognitive abilities will recognize the patterns and their corresponding meanings. Also, *Figure-Ground allows* people to distinguish the foreground from the background in a visual field. Two different foreground colors make the viewer perceive different things that are presented in the same illustration; in addition, *Unity/Harmony* is the congruity among the elements in a particular design; they look like they belong together. If the related objects do not appear within the same form, the viewer will consider such objects to be unrelated to the main visual design, which could lead to confusion.
4. *Observe Conventions*. It is important to identify and respect a user's familiar interface language of words, phrases, images and conventions because of Isomorphic *Correspondence,* which is the fact that each image has a different meaning to different persons since we interpret their meanings based on our personal experiences. In addition, existing conventions can be built upon, extended, or even played with as appropriate for user and content parameters.
5. *Feedback*. End users should receive feedback as they perform tasks. The feedback should be as immediate as possible to the action performed in time and space. Immediate feedback is necessary so that users are informed that their actions are having an effect. *Simplicity* explains that a graphical message must be uncluttered, but if the graphics are complex and ambiguous the simplification process may lead to unintended conclusions.
6. *Landmarks*. Information should be available to users that suggest their location in the conceptual space of the interface. Some of these should be available at any time. In addition, landmarks build upon end users' ability to build a mental model of their experience. *Closure* is the natural tendency that human minds have to close gaps and complete unfinished forms, especially on those with which they are familiar. When information is missing, people focus on what is presented, and they fill in the blanks with a familiar line.
7. *Proximity*. “A user should not have to traverse great physical, conceptual, or time spaces to perform similar actions or access related content” (Blair-Early and Zender 2008, p. 101). In addition, there are at least three types of proximity: a) space, associating content and interface in a consistent or logical evolution of X Y Z space; b) time, making content available when the user wants it; and c) concept, grouping related items together. *Proximity* means that items that are placed near each other appear to be a group. People will mentally organize closer elements into a coherent object, because they assume that closely spaced elements are related and those that are further apart are unrelated.
8. *Interface is content/aesthetics*: A user utilizes an interface to get access to content. In addition, the interface is part of the content, not just a means to access content and it is important that the design should be aesthetic. Thus, it is important to design the interface so that interaction is as direct with content as possible and avoids interfaces where

the content interferes with the user. Designers should make the interface part of the content as much as possible, and not just an unrelated control. The interface must serve the content, not the other way around. It is important visual objects must appear complete; they must be *Balanced/Symmetric* to create a sense of balance usually achieved when visual 'weight' is placed evenly. In addition, content should differentiate from the ground where it is presented (*Figure-Ground*).

9. *Help.* Errors are part of human activity, therefore it is important to design a support source of last resort -- available, but subtle. However, help must be only for the current action, not as a help menu so that users have to search for what they need. *Simplicity* means that messages must be uncluttered as well as to draw a viewer's attention (*Similarity*).

The Proximity feature was divided into 3 variables based on its corresponding categories (space, time, and content). Thus, we studied a total of 11 features (see Table 1).

Gestalt Laws / GUIs guidelines	Balance/ symmetry	Continuation	Closure	Figure-ground	Focal point	Isomorphic correspondence	Proximity	Similarity	Simplicity	Unity/harmony
Obvious Starting Point					X					
Clear reverse	X								X	
Consistency				X						X
Observe conventions						X				
Feedback									X	
Landmarks			X							
Proximity in space							X			
Proximity in time							X			
Proximity in concept							X			
Interface is content/aesthetics	X			X						
Help								X	X	

Table 1. Studied Attributes

METHODOLOGY

In order to test the effects of guidelines and GT on the effectiveness of the design of end user interfaces two versions of the same system that performs race identification based on facial recognition were developed. System requirements were delivered to the developer team by the researchers. The first version was developed using a traditional approach using current developers' skills and technical knowledge. The development approach was incremental prototyping. Each prototype was tested in order to address any performance and technical errors. The final prototype was tested by a panel of three experts, which made final suggestions to the developing team. The final system was completed once such suggestions were addressed.

Before developing the second version, developers were taught the principles of GT (Chang et al. 2002; Chang and Nesbitt 2005) and GUI guidelines (Blair-Early and Zender 2008). After that, developers modified only the GUIs without changing anything in the algorithms used for racial identification and facial recognition. Again, the final version was tested by the same panel of three experts. In this case, no suggestions were made.

The following describes how each GUI's development guidelines were addressed in constructing the system used to test the research question.

1. *Design an Obvious Starting Point***.** The second version included a pop-up box that provides basic instructions so that users can see what the main goal of the system is. In addition, it provides a description about how to start working with the system.
2. *Clear Reverse*. Navigation buttons were added to the second version so that users could identify how to go back to the previous action. In addition, the Close window button was eliminated.
3. *Consistent Logic*. Instructions and labels were redesigned so that descriptions and buttons match the action to be performed and make them consistent throughout the system.

4. *Observe Conventions*. Some icons were changed to have a more commonsense description.
5. *Feedback*. Messages regarding performed actions as well as dialogues were added and rewritten.
6. *Landmarks*. Information regarding position of the current action performed was added so that users could understand how deep they are in the actions.
7. *Proximity*. GUIs were revised regarding proximity for each point as follows:
   a. Consistency for position, size and shape for all interfaces was redesigned.
   b. Performance was enhanced so that time expended between actions was reduced.
   c. Contents that are related were put as close together as possible.
8. *Interface is content*. Distracters were eliminated or changed such as animations and colors so that content was emphasized.
9. *Help*. Help was redesigned so that users do not have to search for a particular issue; instead, it was designed as context-related.

Pilot Study

Data was collected through a questionnaire which was created based on previous literature. In order to validate the measurement instrument, a pilot study was conducted in a 30-minute session. A total of 35 students from a bachelor's degree program were invited to participate and 28 did. The instrument consists of 11 questions related to the studied variables and two questions regarding demographics (age and gender) because the system that was developed for this study fits this demography. Moreover, since all of the subjects were enrolled in the same semester of a Computer Systems bachelor degree, it is assumed that they are equally technologically-savvy. Questions related to IS features have a Likert scale that ranges from 1) Excellent to 7) Extremely Low. Each question was analyzed using dispersion analysis to determine if answers behaved in a normal-like fashion. Results show that all of them were normal.

Data Collection

A two-group design was used in the present study: control GUI (NonGUIG) and Gestalt GUI (GUIG). All participants were students of a public university in central Mexico that were in the 9th semester of a bachelor's degree majoring in Computer Systems. However, the school requested that students should not be assigned randomly to groups because they already had formed their own groups. We randomly selected two out of three enrolled groups and then the system version was assigned randomly to those groups. Demographics for each group are shown in Table 1. Age mean in both groups is very similar as is gender representation, and is consistent with 7% of the Mexican population (INEGI 2011).

Group	N	Age Mean	Gender	
			Male	Female
NonGUIG	59	20.9	31	28
GUIG	56	21.5	30	26

Table 1. Demographic Data

Each group received a half-hour training session regarding how to use the system. After that, participants used the system for up to one and a half hours. They were free to drop out of the study at any time but no one did and everyone stayed the full time. They were required to explore at least twenty faces that are in the database. After the session finished, participants were asked to answer the questionnaire regarding the studied GUIs' attributes.

RESULTS

End user perception of the 11 attributes was measured using a discrete Likert scale from 1 (best) to 7 (worst). A Mann-Whitney *U* test was conducted to evaluate the hypothesis that GUIs developed using design guidelines would score lower, on average, than GUIs developed using a traditional approach. This test was used because answers represented qualitative differences depending on the evaluators' perception (ordinal level) rather than an exact value of each variable (interval level). The results of the tests are as expected and significant, for example, Starting Point (z =-4.536, p<.001) (see Table 2). Therefore, GUI acceptance by end users is significantly dependent on the development approach used.

Test Statistics[a]

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Starting Point	925.000	2521.000	-4.536	.000
Clear Reverse	396.000	1992.000	-7.318	.000
Consistent Logic	906.000	2502.000	-4.520	.000
Observe Conventions	540.000	2136.000	-6.501	.000
Feedback	420.500	2016.500	-7.175	.000
Landmarks	437.500	2033.500	-7.101	.000
Proximity in Space	655.500	2251.500	-5.810	.000
Proximity in Time	482.500	2078.500	-6.910	.000
Proximity in Concept	827.500	2423.500	-4.875	.000
Interface is Content	721.500	2317.500	-5.569	.000
Help	548.000	2144.000	-6.480	.000

a. Grouping Variable: Group

Table 2. Results from Mann-Whitney Test

Green and Salkind (2008) suggest that differences in mean ranks between the two groups can serve as an effect size index. For example, Clear Reverse has the biggest index (-43.72) and the Gestalt Group had an average rank of 35.57, while the Control Group had an average rank of 79.29, also, the means difference is 2.32 (see Table 3). We argue that this was the most important feature in designing GUIs. On the other hand, Design and Obvious Starting Point has the lowest index (-25.30) and means difference (0.71); the Gestalt Group had an average rank of 45.02, while Control Group (NonGUIG) had an average rank of 70.32. We argue that this is the least important feature for designing GUIs.

Ranks

	Group	Mean Rank	Sum of Ranks	Effect Size Index	Mean	Std. Deviation	Means Difference
Starting Point	NonGUIG	70.32	4149.00	-25.30	2.25	0.958	0.71
	GUIG	45.02	2521.00		1.54	0.503	
Clear Reverse	NonGUIG	79.29	4678.00	-43.72	3.68	1.925	2.32
	GUIG	35.57	1992.00		1.36	0.483	
Consistent Logic	NonGUIG	70.64	4168.00	-25.96	2.47	1.466	0.97
	GUIG	44.68	2502.00		1.50	0.572	
Observe Conventions	NonGUIG	76.85	4534.00	-38.71	3.53	1.906	2.10
	GUIG	38.14	2136.00		1.43	0.535	
Feedback	NonGUIG	78.87	4653.50	-42.86	3.31	1.417	1.83
	GUIG	36.01	2016.50		1.48	0.632	
Landmarks	NonGUIG	78.58	4636.50	-42.27	3.63	1.66	2.00
	GUIG	36.31	2033.50		1.63	0.489	
Proximity Space	NonGUIG	74.89	4418.50	-34.68	3.31	1.664	1.61
	GUIG	40.21	2251.50		1.70	0.57	
Proximity Time	NonGUIG	77.82	4591.50	-40.70	2.92	1.164	1.37
	GUIG	37.12	2078.50		1.55	0.63	
Proximity Concept	NonGUIG	71.97	4246.50	-28.69	3.14	2.013	1.59
	GUIG	43.28	2423.50		1.55	0.537	
Interface is Content	NonGUIG	73.77	4352.50	-32.39	3.29	1.702	1.54
	GUIG	41.38	2317.50		1.75	0.548	
Help	NonGUIG	76.71	4526.00	-38.42	3.36	1.627	1.74
	GUIG	38.29	2144.00		1.62	0.62	

Table 3. Ranks for the 11 attributes

DISCUSSION

Based on the results of the analysis and observations of how the subjects used the software, we discuss the apparent reasons for the differences. Attributes are discussed order by its effect size index.

1. *Clear Reverse* (-43.72). This difference was likely caused because the first version was not clear on how to navigate through the system. Adding a clear way for cancelling an action, and going back and forward was extremely helpful for the users.
2. *Feedback* (-42.86). Participants require feedback about the tasks they are performed so that they can be certain that every task has been done accordingly. Adding this ability likely caused the mean difference in this guideline.
3. *Landmarks* (-42.27). Another source of confusion in the first version was that users were not really sure how deep they were performing actions in the system and were unaware how many clicks had to be done in order to go to a desired point in the system. Adding a clear landmark helped users better understand the system's structure and navigation.
4. *Proximity in time* (-40.70). Users typically want to perform their tasks on time. The second version requires less time for performing actions.
5. *Observe Convention* (-38.71). Users were confused in using the first version of the system. The second version addressed eliminated the confusion. We believe that since end users are familiar with particular aspects of standard GUIs, developers should not try to "re-invent the wheel". Rather, developers should focus on what end users are familiar with and just add to existing paradigms to complete new actions in the system.
6. *Help* (-38.42). The first version has help that can be searched. However, the second version has an improved help because it is context-related to the current task. Therefore, users did not need to search; they just needed to activate the help.

7. *Proximity in space* (-38.42). The second version of the system has a better object distribution in each GUI so that at first glance, the users can see everything they need for each action. It is important for developers to manage screen space as well as understand end users' memory limitations.
8. *Interface is content* (-32.39). The second version of the system allows end users to concentrate solely on the task rather than having additional distracters in the GUI. Therefore, they can focus on what is being done, not on the "fanzines" of the GUI.
9. *Proximity in concept* (-28.69). The second version grouped tasks that belong together in a better fashion so that they were easier to understand. This is an important issue because memory load can be reduced helping end users to understand, learn and perform tasks in the system.
10. *Consistent Logic* (-25.96). The second version included redesigned instructions and labels and buttons that match the actions performed. This consistency was of value to those who used this version.
11. *Design an Obvious Starting Point* (-25.30). The users did not seem to be concerned about having a starting point because this is the first GUI that they see once the system is running. Therefore, they know where the system starts.

Figure 1 shows a plot of the mean differences for the eleven studied attributes so that differences can be perceived easily.

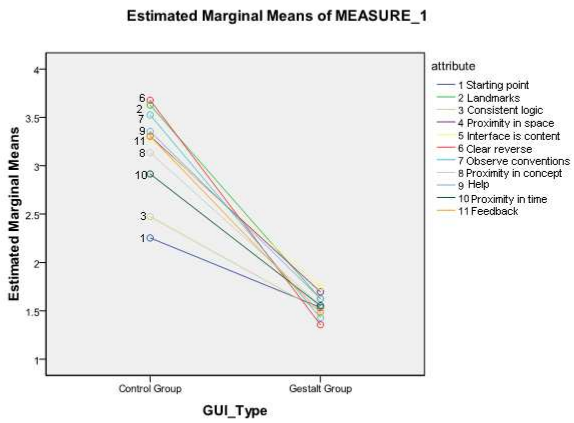

Figure 1. Plot for Means Differences

CONCLUSIONS

Our results are a very good indication that by applying past research into new software developments developers are able to provide improved IS to end users. In the present study, we used Gestalt Theory (Chang et al. 2002; Chang and Nesbitt 2005) and guidelines from past research (Blair-Early and Zender 2008) as means for improving a software system. We found that by combining this two into a single approach improves outcomes, in this case, GUIs quality perception by end users. Results show that participants that used the software version constructed using both approaches are perceived as higher quality compared to those that used the software developed using a traditional approach. Thus, we believe that this approach not only provides a relevant outcome but also follows a more rigorous developing approach.

Based on our early results we believe that developers and users can benefit by using a development life cycle based on past research. This approach enhanced outcomes in the present research. Therefore, we highly encourage developers and researchers to further explore our approach.

Limitations and Future rResearch

Results are encouraging. However, the present study has some limitations that might have an effect on outcomes. The study was conducted only with young adults. Results might be different if it is replicated with end users that are in different age groups. We call for a study with more diverse participants. Participants were not assigned randomly to groups; this could also have an effect on outcomes. It is recommended to conduct an additional study assigning participants randomly.

We cannot identify the threshold for an effect of practical importance. However, the "starting point" effect size may indicate a limit. We call for a research that identifies such a threshold.

In addition, both systems were developed by the same team of developers, who, unconsciously, would have improved the second version of the system. However, while some of the benefits of the second version would have been due to general improvement caused by a second iteration, the specific changes related to guidelines would not have been inferred from just revisiting the prototype. It is important to conduct a new study with two groups of developers teaching only one the GUI development guidelines and Gestalt theory principles as well. Then, both groups would be presented with the same requirements for the system and the same resources.

There might be additional issues that have an effect on outcomes that went unnoticed by researchers.

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