Applying Cognitive Semiotics to User Interface Design

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Abstract

Cognitive semiotics is the field of studying the creation and interpretation of symbols and their meanings by applying the theories of cognitive science. The findings and frameworks created by this field could be very useful for designing and evaluating user interfaces. Multiple cognitive semiotics frameworks can easily be incorporated into the process of designing an interface. These theories could be particularly useful when selecting the icons to assign to specific functions. Existing experimental evidence already demonstrates improvements to existing evaluation techniques. However, further research is still necessary.

Keywords: Semiotics, Cognitive Semiotics, Cognitive Science, User Interfaces, HCI

Introduction

Cognitive Semiotics applies the theories of cognitive science to semiotics, the study of creating and interpreting symbols. According to the theory of semiotics, words, letters, numbers, images, and sounds act as “tokens”, which are used to represent different thoughts, ideas, and concepts (Abbott, 2002). The token is also called the “signifier” and its associated concept is also called the “signified” (Herman, 2022).

Signifiers can be divided into different categories based on their relationship to what they signify. Signs are capable of acting as a substitute for what they are meant to signify within the viewer’s mind (Abbott, 2002). Language offers a clear example of signs, with each word acting as a sign representing a different concept (Abbot, 2002). Symbols, rather than acting as a substitute for what it signifies, are instead substituted by their signified concepts once they have been conveyed. Colors are often used as symbols, such as the color red symbolizing danger or a warning. Abbott (2002) describes icons as being closely related to signs but requiring more specific connections to what they represent (pp. xiv-xv). To facilitate these more specific connections to their meanings, icons typically need to be less abstract than signs (Abbott, 2002).

Cognitive semiotics focuses on how the theories of semiotics interact with psychological theories. In particular, the role of perception, memory, and judgment in the use of symbols (Mouratidou, 2020). Applying cognitive semiotics to the evaluation and design of user interfaces should lead to an increase in usability and an increase in user satisfaction.

Creating Symbols

Symbols develop their meanings socially through repeated communication (Fay et al. 2018). New symbols do not always have an immediately apparent meaning and therefore may be misunderstood. As the meaning of a symbol shared within a group, it is more frequently understood, creating a “shared symbol” (Fay et al. 2018).

Two experiments conducted by Fay et al. were designed to observe the symbol creation process. These experiments involved participants being given a prompt and instructed to give a visual depiction. If another participant could correctly guess the prompt from only looking at the visual depiction, it would be considered a successful communication.

The first experiment modified the levels of interaction between participants, finding that participants that were allowed to directly interact with each other were more likely to understand the symbols they created than the other participants (Fay et al. 2018). In addition, the visual depictions for the same prompt would become simpler for each repeated trial, with the simplest visuals also being provided by participants allowed to directly interact (Fay et al. 2018).

The second experiment was designed to observe the importance of “imitation”, or reusing a symbol, and “feedback”, indications of whether the symbol is understood (Fay et al. 2018). Participants were divided into groups that allowed either only imitation, only feedback, both imitation and feedback, or neither. While successful communication was found to be more reliant on imitation than feedback, the simplification of symbols over repeated use was more reliant on feedback than imitation (Fay et al. 2018).

These experiments demonstrate that symbols gain meaning from repetition and communication. As a new symbol is repeatedly used to convey the same meaning, it becomes more likely to be understood. These experiments also demonstrate that symbols can become simplified while retaining the same meaning.

Meaning in Memory and Decision Making

An experiment conducted by Mouratidou explored the significance of the meaningfulness of a decision with its memorability. Mouratidou (2020) begins by describing two different processes of decision making, “operative intentionality” and “categorial intuition”. Operative intentionality describes the faster decision making processes based more on intuition (Mouratidou, 2020). Categorial intuition describes slower, but intentional decision making processes derived from closer, more attentive perception than operative intentionality (Mouratidou, 2020).

Mouratidou’s experiment involved offering participants a choice between two images, either two faces or two abstract inkblots (Mouratidou, 2020). This choice could be either a simple question of preference or a choice with more significance, such as receiving a tattoo of one of the inkblots (Mouratidou, 2020). After providing their answers and completing a distraction task, Participants were then presented with their answers again and prompted to explain their answers. Some of the images were not the original choices made by the participants, in order to determine whether they remembered all of their decisions (Mouratidou, 2020).

While the significance of the decisions did not influence the likelihood of a participant to detect an incorrect image, subjects were far more likely to detect incorrect

faces than incorrect inkblots (Mouratidou, 2020). Mouratidou also noticed different levels of memory in the responses to incorrect images. In addition to multiple levels of detecting incorrect images, Mouratidou (2020) also noticed varying levels of failing to detect images, ranging from uncertainty to total acceptance (p. 16). When participants gave more detailed descriptions of their choices, Mouratidou (2020) classified their choice as categorial intuition (p. 21). Participants who used categorial intuition rather than operative intentionality when making their choices were more likely to detect incorrect images as well (Mouratidou, 2020).

Mouratidou also noticed that presentation of the choices could also affect whether an error was detected by participants. If the researcher providing the answers appeared willing to admit a mistake was made, participants became more likely to declare images were different from what they originally chose (Mouratidou, 2020). This suggests there are more factors that need to be controlled if this experiment is repeated.

Applications for User Interfaces

User interfaces are often reliant on symbols, with each function of an interface being given a designated symbol. Using icons and symbols in place of words can not only allow users to rely on recognition rather than recall as well as reducing the amount of information within an interface that needs to be translated (Yan, 2011). Designers need to ensure that their interfaces are understood by their users to ensure they can properly utilize them. As such, an understanding of cognitive semiotics would allow for more intuitive interfaces, allowing users to more efficiently learn how to use different functions based only on their assigned symbols.

In fact, designers may have already started considering semiotic theory without recognising it as an independent discipline (Scolari, 2009). With a better understanding of semiotic theory, designers could not only develop new design practices, but better understand existing practices as well.

Graphical User Interfaces

Graphical User Interfaces (GUI) would clearly benefit from the incorporation of cognitive semiotics into interface design due to their visual nature. According to Yan (2020), a GUI requires a combination of four elements, a window, icons, a menu, and a pointer (p. 2). The use of symbols is already common within graphic user interfaces. However, different programs will often use different symbols for the same function, requiring users to relearn the symbols for each function (Yan, 2020).

Using Existing Symbols and Creating New Symbols

The experiments conducted by Fay et al. (2018) demonstrate that symbols can be simplified without losing their meaning. This allows for designers to use simplified

versions of symbols that they expect their users to be familiar with and still have those symbols recognized and correctly interpreted. In fact, Yan (2020) recommends using simple familiar symbols to ensure that users can quickly determine their function. However, if a designer believes a function requires a completely new symbol, they will need to provide some way to explain what their symbol means, and users will require time and repeated use of the symbols before it becomes familiar enough for instant recognition.

Error Detection and Explanation

The connection between meaningfulness, affect, and memory made by Mouratidou could have applications in error detection. When designing a new user interface, designers need to anticipate the decision making processes of their users. Designers cannot expect users to always act according to categorial intuition. Therefore, they cannot expect users to fully explain their thought processes when encountering an error. However, in the instance of repeated errors, encouraging users to carefully examine their decision making process can allow for the source of an error to be found and corrected. Not every error is caused by the users, flaws in the design can lead to errors as well. As Mouraitou's (2020) experiment demonstrates, users may be more willing to assert flaws in design if designers are willing to admit that mistakes can be made during the design process. Error reporting should be clearly visible to users to demonstrate this willingness.

Design Frameworks Based on Semiotics

Scolari (2009) proposes four levels of interface design and analysis, plastic, figurative, communicative, and meta communicative (p. 9). The plastic layer focuses on This layer of analysis focuses on the general layout of the interface rather than the content. As such, it analyzes the simple colors and shapes of the interface (Scolari, 2009). In addition to the shapes created in graphic design, the shapes created by the content itself, such as the format of text is also analyzed within this layer (Scolari, 2009). Certain design principles can help design this layer to guide the user through the interface, specifically by assisting the user in determining the importance of different areas. Generally, information either at the top of the page, with the largest silhouette, or a different color from its surroundings, will be considered more important than other information.

The figurative layer is similar to the plastic layer as it is also focused on the visual elements of the interface. However, rather than focusing on the overall layout of the interface, the figurative layer focuses on the individual elements (Scolari, 2009). For example, while the plastic layer focuses on how the colors of an interface contrast with each other, the figurative layer focuses on the symbolism of the chosen colors.

The Communicative layer analyzes the content of the interface itself. This is the layer where the purposes of each component of the interface are properly conveyed through the user. The meaning of the icons, rather than just their color, are conveyed to the user. Combined with the order of importance conveyed through the previous layers, the process of navigating an interface may create a form of narrative (scolari, 2009). Every action a user takes should be meaningful, contributing to the completion of their task in some way (scolari, 2009). A poorly designed interface will lead to the user feeling misdirected and that their time is being wasted. This could even extend to users seeing a poorly designed interface as an antagonistic force, actively preventing them from achieving their goals (scolari, 2009). User satisfaction, as well as their willingness to continue using a particular interface, will depend on whether they believe the designers are communicating not only the different functions of the interface, but the likely locations of these functions as well.

The final layer, the meta-communicative layer, is usually only present in interfaces with multiple simultaneous users (scolari, 2009). Users must communicate with each other through the provided interface. All of the previous layers must assist the users with this communication as any time searching for a function could create interruptions.

An alternative framework for designing and analyzing interfaces with semiotics is the “Semiotic Interface Sign Design and Evaluation” or “SIDE” framework (Islam et al., 2020). This framework uses five different “levels” of evaluation: the syntactic level, the pragmatic level, the social level, the environmental level, and the semantic level (Islam et al., 2020, p. 84399).

The syntactic level focuses on the same design components as the plastic and figurative levels of design, such as color, design, and general layout. However, it also explicitly includes evaluating the general level of “interactivity” a user is given by the interface (Islam, 2020). This interactivity includes both the overall control the user is provided by the user interfaces as well as the functionality of individual elements within the interface, such as whether an icon represents an actual function or serves purely decorative purposes (Islam, 2020). The syntactic level also emphasizes the effects of overlapping elements within an interface, which will cause some functions to become initially hidden from view (Islam, 2020).

The other four levels act as a further expansion of the communicative layer outlined by Scolari (2009). Each level is meant to analyze the signs and symbols of the interface based on specific contexts.

The pragmatic level is most concerned with understanding connections between the chosen symbol for a function and the function itself (Islam, 2020). It is concerned with the placement of symbols within the interface as well, particularly the chosen placement of symbols in relation to the other symbols in an interface. There should be

some form of reasoning behind the placement of each symbol that users can understand.

The social layer prioritizes the cultural backgrounds of users in relation to the symbols chosen by the designers (Islam, 2020). An understanding of the culture of their users will allow for designers to anticipate how users will interpret the symbols used in the design. Symbols develop their meanings only if they have been shared with an individual or group (Fay et al. 2018). Therefore, if a designer uses a symbol that has not been shared with the user before, they will have no way to interpret it from any social context. In situations like these, designers may need to include some additional explanations for their symbol choices if no alternatives are available. In addition to signs, symbols, and colors, if any words are used within the interface, they must be in a language the user understands (Islam, 2020).

The environment level attempts to anticipate what the user already knows about the symbols used within an interface (Islam, 2020). Rather than the wider social contexts of the previous level, the environment level is focused on the personal knowledge and skills of the users themselves (Islam, 2020). When designing for specific fields, there will likely be common symbols for common functions which designers can expect their users to already understand. Using a different symbol than what the user may expect from previous experience may also cause unnecessary frustration (Yan, 2020). This level relies on the users' memory of these symbols (Islam, 2020). Therefore, if a user is a beginner in a specific field, they may not recognize as many relevant symbols as an expert.

The semantic layer is the final layer of the SIDE framework. It is simply concerned with whether users are able to correctly determine the designers intentions behind each symbol chosen within an interface (Islam, 2020). If a user is unable to correctly determine why the designers chose a specific symbol, they may also be unable to determine its function (Islam, 2020). To prevent misinterpretation, designers should attempt to communicate their intentions for each symbol using the previous levels as guides.

Evaluation

The SIDE framework can be combined with existing heuristic evaluation techniques to improve their effectiveness at analyzing user interfaces. A pair of experiments conducted by Islam et al. attempted to use both a heuristic evaluation, and an evaluation based on the SIDE framework to analyze two different types of user interfaces, websites and mobile applications. Participants were sampled from usability courses and provided with both a heuristic evaluation and a SIDE based evaluation created by Islam et al. (2020). The first experiment prompted the participants to use both evaluations to analyze a government website and the second experiment prompted the participants to do the same for a fitness mobile app (Islam et al. 2020).

After each experiment, participants would provide feedback on the usability of the SIDE based evaluation itself.

Through these experiments, the researchers noticed that both the Heuristic evaluation and the SIDE based evaluation discovered flaws in the design that the other evaluation would not detect (Islam et al. 2020). Based on these results, Islam et al. (2020) believe that while their evaluation is effective, it still should not be used on its own. However, Participants also reported that they felt that the SIDE base evaluation allowed them to consider possible sources of the issues they discovered (Islam et al. 2020), implying that the evaluation may have additional utility.

An Example of Applying Cognitive Semiotics

On a webpage or web application, a user will most likely read the visible contents in the order of what they think is most important to what they think is least important. Therefore, the plastic and figurative layers of the application should properly convey this order of importance. For web applications, the largest uninterrupted space within the user interface should be the user's work area, with all menus surrounding the edges of this work area. The most important functions should have the most contrast from the rest of the interface, to allow the user to easily locate them without needing to search each function by their name or icon. Even a user's first look at an interface should allow them to quickly find these functions before they begin working. Colors themselves can also have symbolic meanings. Thus, while the colors of important functions should contrast with the rest of an interface, an appropriate color should be selected as well.

With a clear understanding of the importance of different components of the interface, The user can now begin to determine the exact purpose of different components. The user will likely use the order implied by the previous layers when navigating an unfamiliar interface. Designers must ensure that the information on these layers do not conflict with each other. When a user is looking for one of the interface's main functions, they will likely look in the areas they believe to be most important, such as areas with large icons or high contrast. The plastic and figurative layers will control how users navigate the communicative layer. Designers can use this control to anticipate where users will search when attempting to find specific functions. More accurate predictions will allow for more efficient use of the interfaces, and thus higher satisfaction for the users.

Applying the SIDE framework can provide more specific design recommendations. Users should be provided with some method to quickly understand which elements of the interface are and are not interactable.Visual indications between these types of elements should be sufficient to convey intractability. Overlapping elements layout can also cause some elements to be hidden by others. If overlapping elements are necessary to a layout, hidden elements must be chosen carefully, as functions in unexpected places will negatively affect user satisfaction.

The pragmatic level clarifies the purpose of design within the figurative layer. The different functions arrangement should create its own internal logic that users can quickly learn and apply when navigating the interface. Understanding the reasoning behind the layout will allow users to quickly find functions while learning an interface. Thus, once the user understands the layout, they can begin working with the interface before memorizing the individual locations of every function they need.

The social, and environment layers provide further guidelines for the communicative layer. Designers can anticipate how users will interpret different symbols based on the contexts provided by both their cultural backgrounds and their prior knowledge of a specific field (as long as the interface will be used specifically in that field). Certain common functions may already have associated symbols that designers can use in their own interfaces. However, an entirely novel function may need its own symbol created by the designers themselves. In this case, there will need to be other methods of sharing the meaning of a symbol with users.

Assisting the user in understanding design choices allows for the maximum level of usability and efficiency. By using symbols the user already understands, they can also quickly determine why those symbols were chosen, and therefore what their function in the interface will be.

Conclusion

Through the incorporation of cognitive semiotics into user interface design and evaluation, designers will be able to not only discover new issues with existing interfaces, but better understand their causes as well. By understanding the possible reasons why users struggle to understand novel symbols created by designers, and potentially create new but still easy to learn symbols that resemble existing symbols from users' cultural or professional backgrounds. Users may not remember every decision they made that resulted in an error, regardless of what the consequences of error may be. Users may also only disclose a flaw with the system itself if they believe designers are willing to admit to a mistake (Mouratidou, 2020). An understanding of cognitive science can allow for testing techniques that account for missing memories from users and encourage reporting more system flaws. The field of cognitive semiotics already includes multiple different design frameworks that can easily be adapted into evaluation formats. Additional experiments should be conducted for semiotic evaluations, especially when paired with other methods.

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