UX Heuristics for Cross-Channel Interactive Scenarios

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Abstract. This research presents a set of UX heuristics for cross-channel interaction scenarios. The proposal has its foundation on usability principles evolution derived from gradual technology innovations, new interaction possibilities, as well as, changes in users' needs and affordances during the last decades. The beginning of the third wave of computing brings a pervasive scenario of ubiquitous ecology systems and cross-channel interactions, where user experiences permeate distinct touch points with a system to create a narrative of experience. A journey in a dinamic ecosystem of interaction.

Keywords: User experience · UX heuristics · Cross-channel interaction

1 Introduction: Technology, Interaction and Experience Evolutions

The technology evolution and its crescent integration into our day-to-day lives reverberate in new ways people interact with devices and their surroundings. Faster information, a huge quantity of data in real time, connection possibilities and integration between different channels bring an innovation rhythm faster than people, society, and sometimes laws, can absorb and adapt. As the physical and digital realms have been merging over the years, our references, mental models and expectations have been changing accordingly, transforming human-computer interactions in human-information interactions. And as a reflex from these changes, usability principles evolve and adapt to new circumstances. The future scenario of technology [1] presents interaction possibilities in the next five to ten years where ubiquitous technology will be everywhere in daily objects, environments and wearable devices, integrated by a dynamic ecology system. Therefore, User Experience studies have to go beyond usability tests on isolated devices and understand the whole user experience process as one journey trespassing many devices.

John C. Thomas, PhD, from the IBM J.T. Watson Research Center sees the process of user experience as narratives [2], and he structures it as several short stories with connections and touch points (points in which users interact with the system). Rosenfeld suggests mapping devices used in each story "scene" in order to understand the usage of systems within the whole user's narrative [3]. The idea of narrative as a journey [2] can be used to translate either the Jared Spool's Disney Experience example [4] or the designers' process in managing their studios [2] into experience stories.

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An usability evaluation could concentrate on the experience of users interacting with a single system, but the whole experience trespasses the system and include moments that are precedent and subsequent to the direct interaction with the system. From the UX Design perspective, products and services have to go beyond the good usability of systems and focus on users' whole journey [2].

2 The Journey of Experience

The user experience as a narrative journey involves actions in the physical world using many different digital devices linked together by a dynamic ecology, with connections that brings together one whole story. For instance, when a person intends to travel for vacation, the experience starts much before the act of buying the flight tickets through a website or an attendant and the experience related to the trip goes much further than the flight itself. Each part of the narrative can involve different digital artifacts accessing the same system in diverse contexts, influenced by the physical part of the experience.

The UX designer has to understand the whole journey in order to plan possible touch points and create a service or product experience integrated by different channels: a pervasive cross-channel experience.

Although usability measurements and tests focus primarily in interactions with isolated devices, a number of user research techniques and usability tests can surface information about users that help understand their mental model, interaction needs and cultural-interaction references in order to better comprehend their journey of experience and map contexts that could take users to interact with specific systems.

Cross-channel scenarios take the user experience to new amplitudes, and therefore, it is necessary to adapt usability principles to a journey experience context. Technology advancements have been gradually influencing and transforming usability heuristics [5] from the late 80 s. These changes are responses to attend new interaction possibilities, new user expectations and new correlations in dynamic systems ecology. Adaptations from Nielsen and Molich's heuristics are clearly observed in heuristic proposals from Apted *et al.* [6] in 2009, Inostrozza [7] in 2012 and Neto and Campos [8] in 2014, as a response to new possibilities of interaction, new display sizes and new users' necessities.

3 Evolution of Heuristics

In 1990, Nielsen and Molich [5] developed a set of usability principles to be considered when planning a system with a visual interaction interface. The ten principles were well known as the ten usability heuristics and became a base for the usability evaluation technique, well known as heuristic evaluation, in which three to five usability experts could be guided to evaluate a system's usability and point out problems within a range of 5 different severities (0- not a problem, 1- cosmetic problem, 2- minor problem, 3- major problem, 4- catastrophe). The heuristics are consecution to users' needs in a time where the world was moving to the second wave of computing (one computer to one user):

1. Visibility of system status – the system should always keep users informed about what is going on, through appropriate feedback within reasonable time;
2. Match between system and the real world – the system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order;
3. User control and freedom – users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo;
4. Consistency and standards – users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions;
5. Error prevention – even better than good error messages is a careful design, which prevents a problem from occurring in the first place.
6. Recognition rather than recall – minimize the user's memory load by making objects, actions, and options visible;
7. Flexibility and efficiency of use – accelerators - unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions;
8. Aesthetic and minimalist design – dialogues should not contain irrelevant information nor rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility;
9. Help users recognize, diagnose, and recover from errors – error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution;
10. Help and documentation – even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

These ten heuristics had its foundation on Norman's six principles [9] from 1988:

1. Visibility – the more visible functions are, the more likely users will be able to know what to do next;
2. Feedback – feedback is about sending back information about what action has been done and what has been accomplished, allowing the person to continue with the activity;
3. Constraints – the design concept of constraining refers to determining ways of restricting the kind of user interaction that can take place at a given moment;
4. Mapping – this refers to the relationship between controls and their effects in the world;
5. Consistency – this refers to designing interfaces to have similar operations and use similar elements for achieving similar tasks;
6. Affordance – is a term used to refer to an attribute of an object that allows people to know how to use it.

During the same period of Nielsen and Molich, other authors developed similar principles regarding interaction with interfaces. Bastien and Scapin [10] developed eight ergonomic criteria in 1993 for systems' interface evaluation:

1. Orientation – refers to means used to guide, inform and take users to their objectives while interacting with a computer;
2. Workload – refers to elements of the interface to help diminish the perception and memory load while interacting with a computer;
3. Explicit control – the user must always have control of actions;
4. Adaptability – the system should be able to respond accordingly to different contexts, needs and users' preferences;
5. Error management – refers to all means to prevent or reduce errors, as well as correct them, if necessary;
6. Consistency/coherence – refers to how the design interface should be aware of identical contexts;
7. Code importance – adequacy of information or object with respective icons, names, graphic representations etc.;
8. Compatibility – refers to the degree of similarity between applications or ambiences.

And Ben Schneiderman [11], in 1987, based on his research regarding human-computer interaction exposed eight golden rules for user interface:

1. Objective consistency – similar situations requires consistency of actions, terminologies, prompts, menus, screens and help;
2. Shortcuts for frequent users – with use frequency, users prefer diminish number of interactions to increase the flow of interaction;
3. Offer informative feedback – for each action, should be a feedback;
4. Plan windows that encourage completion – sequence of actions must be organized in groups from start to finish;
5. Offer simple objective error recovery – plan a system that prevents users to make critical errors. If a mistake is made, the system should detect it and offer simple action to solve and recover from it;
6. Reverse actions easily – it relieves users' anxiety when knowing an action can be undone;
7. Sustain control – operators must feel they are in control of systems and that it responds to their actions;
8. Short-term memory load reduction – the human limitation of processing information in short-term memory require that displays be simple.

When new necessities derived from new possibilities of interaction, new digital devices, in a new wave in computing (3rd wave of computing - many computers to one user), researchers adapted the 10 usability heuristics of Nielsen and Molich to new contexts and new possibilities.

Apted *et al.* [6], analyzing tabletop's possibilities of interactions, focused on the difference of display size, its proposal of collaborative interaction (with at least two or more users at the same time) and concern with reorganization of elements.

The researchers present heuristics that takes human reach, physical ergonomics and the possibility of many users at the same time into consideration:

1. Design independently of table size – design for different tabletop sizes and allow flexible resizing of all interface elements;
2. Support reorientation – allow all interface elements to be easily rotated to support users working at any position around the table, and consider users moving around the table while using it;
3. Minimize human reach – consider that users may not be able to physically reach all interface elements;
4. Use large selection points – design independently of tabletop input hardware, but support large input cursors (e.g. human fingers) where possible;
5. Manage interface clutter – support quick removal or hiding of objects on the tabletop, while ensuring management of clutter by one user does not have unwanted side-effects on other users of the table;
6. Use table space efficiently – avoid modal behavior that limits the utilization of table space. Allow arbitrary groupings of interface elements for personal and group spaces;
7. Support private and group interaction – support interaction by a single user or multiple users. Interface elements should be usable by a single user, or used as a shared resource by multiple users, possibly with different goals.

Inostroza [7] in 2012 presents twelve heuristics for smartphone interaction. Based on Nielsen's ten heuristics, Inostroza expresses the heuristic seven (flexibility of use) as "customizations and shortcuts", specify a new eighth heuristic regarding efficiency and performance of use, and add a twelfth heuristic regarding the smaller display size of smartphones and the context of interaction with fingers: physical and ergonomic interaction.

1. Visibility of system status;
2. Match between system and the real world;
3. User control and freedom;
4. Consistency and standards;
5. Error prevention;
6. Minimize the user's memory load;
7. Customization and shortcuts – the device should provide basic and advanced configuration options, allow definition and customization of (or to provide) shortcuts to frequent actions;
8. Efficiency of use and performance – the device should be able to load and display the required information in a reasonable time and minimize the required steps to perform a task;
9. Aesthetic and minimalist design – the device should avoid displaying unwanted information in a defined context of use;
10. Help users recognize, diagnose and recover from errors;
11. Help and documentation;
12. Physical interaction and ergonomics – the device should provide physical buttons or similar for main functionalities, located in recognizable positions by the user, which should fit the natural posture of the user's hands.

When Neto and Campos [8], two years after Inostroza, present their 12 heuristic principles for multi-modal interactive ambiences (a combination of inputs and outputs of several sensory modalities – hearing, smell, taste, touch, sight – as part of a more natural computer communication), it is perceptive the strong relation with the ten heuristics from Nielsen and Molich, added by important points on physical ergonomics and vocal commands, resulting in principles concerned with graphical interface, physical and vocal interaction (organized content, direct manipulation, human range). With exception of the second principle, the first seven heuristics are strongly related to Nielsen and Molich's heuristics, but expanded to vocal possibilities. The eighth to twelfth heuristics are mostly related to physical interaction and clearly related to Apted *et al*.' proposal [6]. The compatibility heuristic regards the compatibility between the different inputs from several sensors with the central system. Based on Sandrine et al. theories [6] regarding vocal interactions and linguistic limitations in a multi-modal environment, as well as the tendency of people using short commands, the authors add criteria to vocal interaction in their research and set of heuristics: (1) generic vocabulary, (2) simple and direct vocal commands and (3) vocal interaction should be and alternative input, applied to all set of heuristics:

1. Visibility and feedback;
2. Compatibility;
3. Control and freedom;
4. Consistency;
5. Error prevention;
6. Minimum actions;
7. Flexibility of use;
8. Organized content;
9. Error management;
10. Direct manipulation;
11. Changes of orientation;
12. Human range.

A different approach comes from Resmini e Rosatti [12] when they present five principles in their book *Pervasive Architecture Information*. Their main focus is related to information organization, instead of graphical interfaces or physical interaction. Their principles, independent of display sizes nor type of device, are concerned with how users access information in an interactive ecology.

Their manifest, based on new factors that surge with the advancements of ubiquitous technology, presents a set of good practices in information architecture and pervasive experience:

1. Place making – refers to the capacity of user build a sense of self- localization. The principle suggests that the architecture reduces the possibility of users disorientation. The heuristic interconnects conceptually with notions of space, place and context. The space is related to physical elements, objectives, impersonal and stable, while place structure itself in layers, and incorporate psychological characteristics, subjective, experimental, dynamics and existential;

2. Consistency – refers to a model of pervasive information to attend objectives, contexts and users, keeping the same logic in different medias, environments and shift of necessities with time. It is directly related to categorization, classification and taxonomy processes. The heuristic dialogue with labeling and representation systems – metadata, thesaurus and controlled vocabulary;
3. Resilience – refers to capacity of the pervasive information model adapt to specific users, their needs and search strategies and gradually change to fulfill the evolution of users' needs and expectations in different contexts, places and times;
4. Reduction – refers to the capacity of a huge quantity of information management being organized for easy and simple access by users, in order to minimize stress and frustration in a crescent set of information. The heuristic is directly related to the form of how choices and options are presented;
5. Correlation – refers to the relevant connections between pieces of information, services and products to help users reach objectives or stimulate latent needs. Correlation connects integrated environments, users and objects, producing a continuous experience (a journey) and exploratory discoveries in all parts of the ecology.

The authors consider Place-making, Consistency and Resilience as foundation heuristics. Reduction and Correlation are considered related to bringing purpose and complexity to a project.

4 Conclusion: UX Heuristics for Cross-Channel Scenarios

Analyzing the different heuristic proposals by Nielsen and Molich (and Scheiderman, Bastien and Scapin and Norman similarities), Apted *et al.* and Inostroza, it is perceived that all have their focus primarily on graphical interfaces. The difference among each proposal relies on the influence that different display sizes can have on users' interactions. Neto and Campos expose heuristics for multi modal ambiences with focus on both graphic interfaces (based mostly on Nielsen and Molich's ten heuristics), vocal commands and environment interaction (similar to Apted *et al.* proposal) that encompasses gestural touch and vocal commands.

Resmini and Rosatti go apart from graphic interfaces and can be applied easily in any device proposed by the other researchers, for its direct relation to information, independent of display. But in order to reach the full journey of experience, it is important to go beyond information organization and propose principles more suited to a UX point of view, since technology and interaction advance fast into more integrated cross-channel experiences in interactive ecologies. Table 1 presents a comparison between all the proposed heuristics throughout the years:

Cross-channel contexts take the user experience to new amplitudes and it is imperative to adapt usability principles to a narrative experience scenario (Fig. 1), as the technological evolution and our interaction with devices and environment have been gradually changing and is expected [1] to evolve to an even more integrated cross-channel experience. A more adequate set of principles to narrative experiences is needed.

Table 1. Comparison of heuristics with different focus and necessities.

Nielsen e Molich (1990)	Apted *et al.* (2009)	Inostroza (2012)	Neto and Campos (2014)	Resmini and Rosatti (2014)
Desktop	Tabletop	Smartphone	Ambiente	Independent of technological device
Usability of graphic interfaces	Usability of graphic interfaces	Usability of graphic interfaces	Usability of graphic interfaces and physical-vocal interactions	Information architecture
Visibility of system status	Design independently of table size	Visibility of system status	Visibility and feedback	Place-making
Match between system and the real world	Support reorientation	Match between system and the real world	Compatibility	Consistency
User control and freedom	Minimize human reach	User control and freedom	Control and freedom	Resilience
Consistency and standards	Use large selection points	Consistency and standards	Consistency	Reduction
Error prevention	Manage interface clutter	Error prevention	Error prevention	Correlation
Recognition rather than recall	Use table space efficiently	Minimize the user's memory load	Minimum actions	
Flexibility and efficiency of use	Support private and group interaction	Customization and shortcuts	Flexibility of use	
Aesthetic and minimalist design		Efficiency of use and performance	Organized content	
Help users recognize, diagnose and recover from errors		Aesthetic and minimalist design	Error management	
Help and documentation		Help users recognize, diagnose and recover from errors	Direct manipulation	
		Help and documentation	Changes of orientation	
		Physical interaction and ergonomics	Human range	

In order to explore and propose UX cross-channel heuristics, the five principles of Resmini and Rosatti are the perfect start, due to its pervasive cross-channel characteristics and link to the idea of dynamic interaction ecology. However, their descriptions have to expand, considering user experience concepts and its relation to visual

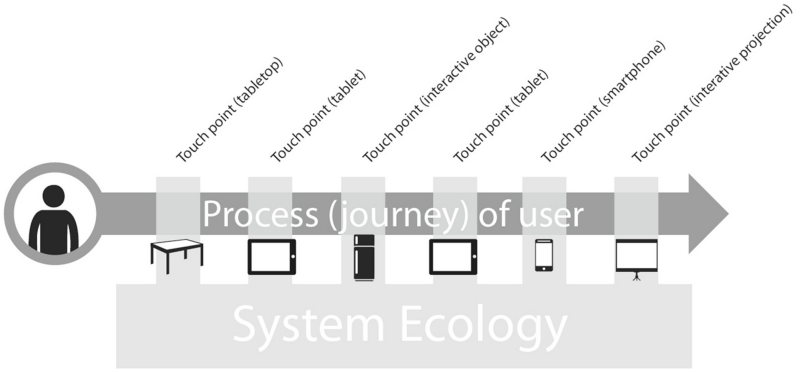

Fig. 1. Construction of an UX narrative through pervasive cross-channel sequence of interactions. Touch points with each apparatus can have diverse temporality and contexts – figure from Renzi's Thesis [2]: *User Experience: the journey of designers in their studio's management processes using a fantasized system based on a ecosystem of cross-channel interaction*

cognitive recognition, physical and verbal interactions and interaction context in a future scenario where everything that can be touch screen, will be touch screen [1]. Furthermore, some of the usability principles that have been evolving with new interaction concepts also have to expand its characteristics in order to contribute to a set of 9 UX heuristics:

1. Place-making – refers to the self localization of users in the system and within the experience journey. Visual interaction, hierarchical layout and structure, as well as physical environment should facilitate the user's understanding of where he is. Since users most likely will use different devices and the ambience itself [1] to fulfill objectives, it is important that physical environments also be part of the user experience strategies to create an integrated journey;
2. Consistency – the system has to present visual, typographic, information, actions and interaction consistency. If a user utilizes different devices to execute partial actions of the whole experience, each touch point access has to present the same rules and responses to actions, independent of the artifact that is being used;
3. Resilience – flexibility of the interaction flow and touch points in order to adequate to different users, different journey strategies and different contexts of use. The interactive ambiance and the system structure should be prepared to search, interaction and journey diverse strategies by different users, sometimes with distinct roles in the same journey;
4. Reduction – even if the back-end of the system is complex in its structure, the options and the contents have to be presented to the users in objective way and with simple usage, providing reduced interactive actions and minimum cognitive workload in their journey. From the users' point of view, the path of possible actions has to be obvious to their necessities;

5. Correlation – the system has to go beyond the semantic correlation exposed by Lévy [13] and Resmini and Rosatti [12], to help users find information and content naturally. The principle expands to a correlation of data between distinct points of interaction and apparatuses, as well as correlation of actions from different users within the same experience journey;
6. Equivalency to cultural conventions – it is important to understand users' references regarding technology, processes, functionality comprehension and interactions, to use as a base in the development of a new system. To create structures and interactions that users are not familiar with can surface doubts and misunderstanding about the system;
7. Visual intuitive content – users must recognize functionalities, hierarchy, pathways and information with minimal memory load, by making objects, actions and options easy to recognize and understand;
8. Natural, intuitive and direct interactions – any touch point of interaction with the system should be as intuitive as possible, by direct gestural manipulation or objective simple vocal commands;
9. Contextual ergonomics – physical environments, contexts of use within the journey of experience and human physical limitations should be considered while projecting touch points of interaction with the system.

The concept of journey points to an approximation between UX Design, Pervasive Information Architecture and Service Design, with focus on the physical-digital integrated experience in one whole narrative. It is expected that the nine heuristics proposal can help further investigate these relations. New experiments are needed to compare its effectiveness in different contexts.

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