Improving the Discoverability of Interactions in Interactive Systems

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ABSTRACT

In an ever increasingly complex technological landscape, interaction methods need to support users in their own discovery. This is exacerbated by a general aversion to instruction manuals and a trend towards invisible controls. Consequently, a lack of support for awareness or recognition of interaction possibilities leads to inefficient usage or complete disregard of the system. However, despite standard work imploring that users should be able to *"figure out what actions are possible and where and how to perform them"*, this problem is rarely considered in the introduction of new interaction methods. My doctoral research is focused on improving the discovery of interaction possibilities. To do so I am combining a theoretical approach, focused on identifying, defining and framing relevant considerations with a practical approach to validate those theoretical considerations and identify and formulate actionable improvement methods for researchers and designers. In the process I hope to highlight the importance of discoverability to the research community and advocate for its increased consideration.

KEYWORDS

discoverability, learnability, conceptual framework

1 INTRO - CONTEXT AND MOTIVATION

New technology is being introduced with ever increasing speed. This is accompanied by HCI research proposing novel interaction techniques to utilise these expanding technical capabilities. Consequently, proposed interfaces and interaction methods have expanded beyond established WIMP or touch interactions. However, this abundance of possibilities is rarely fully utilised, as users are unaware of all the available functionalities and overburdened with discovering features and interaction methods through accidents, social examples and articles about "hidden tricks"[24, 25] or "things you didn't know" [4, 29, 34] rather than spontaneous interaction. This is exacerbated by propositions and implementations of novel

interactions lacking visual signifiers i.e. elements that convey information about possible interaction with the system [26]. Examples of this can be found in commercial products (iPhone 3D touch [11]) as well as research [30]. Additionally, existing systems receive constant software updates that not only update background functionality but, at times, also the user interface.

If users don't even realise they are presented with an interaction possibility, or if they don't understand how to utilise it, they will not benefit from its introduction. Consequently, the lack of *discoverability* of these novel interaction possibilities impedes successful usage or adoption of the technology altogether. Despite the clear problems caused by a lack of discoverability, introductions of new interactivity, both commercially and in research, rarely feature considerations of how new users are expected to become aware of and comprehend the new possibility.

I hypothesise that this absence of consideration is not only due to a lack of awareness or acknowledgement of discoverability's importance but also due to:

- unclear and overlapping terminology used to describe the problem
- lack of knowledge on how discovery can be facilitated and supported
- lack of knowledge of how discovery occurs (circumstance consideration)
- lack of established methodology to test whether something is discoverable

My doctoral research is focused on filling these gaps in order to improve the discovery of interactions by providing a clear understanding of the problem and offering recommendations allowing its increased and systematic consideration.

2 BACKGROUND AND RELATED WORK

Given the objective of investigating and improving the discovery of interactions, my focus is on *initial interactions* which I use to describe the specific circumstance of an interaction occurring for the very first time, either intentional or by chance. This includes the first encounter with, and discovery of, an overall system as well as its individual features and input methods. I explicitly consider these separate entities as such since their recognition and usage may be supported through differing means.

In HCI these beginning phases of interaction have been primarily examined in the context of *learning* how to interact with the system. Consequently, learnability is the most commonly used term to describe the users' first understanding and subsequent improvement when using an interactive system.

Grossman et al.'s survey of learnability research [12] found that, while there was an agreement among researchers that learnability

is an important aspect of usability, there was a lack of consensus in the definition, evaluation and improvement of learnability in user interfaces. They grouped definitions into two main categories: *initial learnability* (new users gaining proficiency with a system) and *extended learnability* (long-term learning and mastering of a system). As they consider initial learnability as the ability to *perform* something well in a single interaction, the inception of interactions is a precondition inducing initial learnability. The separation of learnability into *initial* and *extended* illustrates the broad use of the term in both time frame and scope.

Often mentioned in conjunction or synonymously with learnability is discoverability [8, 15, 21]. The term 'discoverability' in the context of usability and human-computer interaction was popularised by Norman [26], who describes it through the following question:

> *"Is it possible to even figure out what actions are possible and where and how to perform them?"*
> [26, p.3]

As such it describes a less purpose driven aspect of initial interaction than learnability.

Other offered definitions vary widely in scope and specificity. While some offer loose explanations of discoverability such as *"the effort required to locate or "discover" an application amongst others"* [14] or *"the ability for users to find and execute features through a user interface"* [15], others define discoverability specifically for their context like noting how *"the "invisible" nature of VUIs can challenge users' ability to discover its capabilities and limitations"* [8] or how gestural interfaces *"are not discoverable in the sense that it is hard to know what gesture to do and we often cannot look it up in the way we would look at a menu to see what options are on it"* [10]. Notably many of the offered explanations of discoverability either allude to or directly reference *learnability* by referring to discoverability as *"a means to achieve learnability"* [8] or describing discoverability as a challenge one is confronted with when trying to *learn* a system [7]. Furthermore, definitions of discoverability as, for example, *"the ability with which a user can find features of the system to increase proficiency over time"* [27] resemble those offered for learnability. This validates the notion that discoverability aids learnability and is a necessary component when aiming to achieve good learnability. However, this close association may be the cause for the lack of separate consideration of the concepts.

3 RESEARCH GOALS AND APPROACH

The objective of my research is to establish a body of work on how to design systems that foster the discoverability of interaction possibilities.

In doing so, I aim to improve the recognition and successful adoption of novel interaction methods upon their introduction as well as lower the entry threshold for advanced interactions with complex technology.

To achieve this, the main objectives of my PhD are to

(1) Clarify the concept of discoverability and highlight how semantically related concepts differ
(2) Provide fundamental knowledge of factors impacting discoverability

(3) Establish and test interface design guidelines that support the discovery of interaction
(4) Design and test user interface components supporting independent discovery of interaction possibilities
(5) Define experimental protocols for the evaluation of discoverability

Through these objectives, I hope to highlight the importance and potential of increased consideration of discoverability when introducing new interaction possibilities, while providing tools and guidelines on how to do so.

To achieve these goals, I first concentrated on the theoretical and conceptual work required to accomplish the first two objectives. This is primarily to clearly define the focus of my work and establish a conceptual basis of related concepts and relevant factors to base my practical work on. Additionally this fit the restrictions of beginning my PhD during the Covid 19 pandemic.

4 RESEARCH PROGRESS AND CONTRIBUTION TO DATE

4.1 Terminology Clarification

Following an extensive literature review concerning the usage and definition of discoverability, I identified three focus areas of discoverability in HCI: System, Interaction and Feature. System discoverability is focused on whether potential users notice the overall system and recognise it as something they can interact with. Interaction discoverability is concerned with whether users can identify and successfully use novel interaction and input methods. Finally, feature discoverability covers the user's ability to discover features or functionality they were previously unaware of while using a system. While this separation between different discoverabilities has been implicit with research specifying a focus on interaction discoverability [3] or feature discoverability [31], these focus areas have not been collated and considered in relation to one another. The clarification of *what* needs to be discovered is essential when examining the connection of different discoveries since they may not always be facilitated through the same measures. My understanding of discoverability is informed by this separation and a combination of comprehensive definitions from Cardello and Srinivasan. Cardello describes discoverability as users encountering *"new content or functionality that they were not aware of previously"* [2]. Srinivasan et al. consider discoverability as entailing *"(1) awareness — making users aware of the operations that can be performed using speech; and (2) understanding — educating users on how requests should be phrased so the system can interpret them correctly"* [32]. Combining these approaches, I consider discoverability as the ability for users to perceive and comprehend a system, function or input method as such when encountering it for the first time despite a lack of previous awareness or knowledge. This may be through intentional effort or serendipitously.

To highlight the differences between learnability and discoverability, figure 1 shows the approximate timeline of an isolated initial interaction. This isolation is for clarification purposes, however initial interactions can happen continuously and concurrently as users encounter new interactivity within a system and during other interactions.
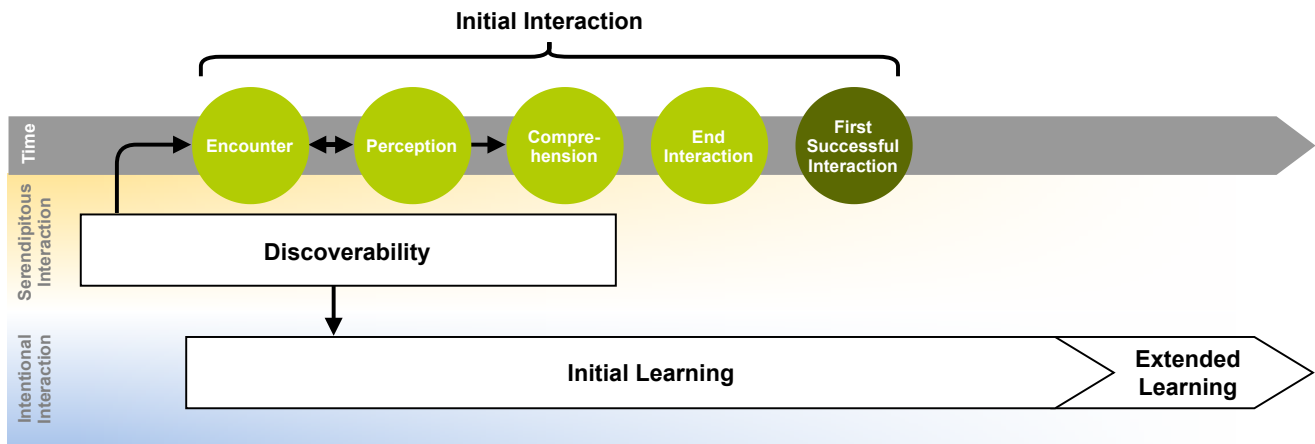
Figure 1: Timeline of progressing initial interaction. Both discoverability and learnability apply during this timeframe and influence the interaction's occurrence and success. While the diagram suggests a strict separation between serendipitous and intentional interaction, these commonly overlap. Although discoverability and learnability are each more applicable to the circumstance they are placed in, they are both applicable to either.

Discoverability, since it covers users that may not have a particular aim to interact and yet unaware of an interaction possibility, precedes learnability and triggers initial interaction. If a potential user encounters functionality but does not notice or comprehend it as such, the initial interaction is unlikely to continue. The initial interaction ends once the user first successfully utilises the interaction possibility they are presented with. Therefore, the mere encounter with an interaction possibility is not yet an initial interaction if the user fails to successfully utilise it.

Learnability exceeds discoverability both in scope and time frame. Even when examining just initial learnability, it extends past discoverability by incorporating the user being able to successfully interact with something. As Berkun notes, *"discoverability does not guarantee success"* [1]. He argues that simply being able to discover something, does not necessarily mean people can, or know how to, use it. Thus, discoverability is not a measure of efficiency or improvement. In contrast learnability is often considered in the context of performance.

While discoverability undoubtedly is a factor contributing to learnability, and both concepts influence one another, these distinctions show that they should be considered independently before any conjoined examinations. Nonetheless, both are a phenomenon occurring during initial interactions and therefore influenced by similar factors.

## 4.2 Conceptual Framework of Impacting Factors

Investigating the factors influencing and facilitating initial interaction is crucial to enable and improve discoverability, which often triggers these interactions.

I examined literature focused on the first stages of interaction and extracted relevant factors. To determine their impact on interaction and relation to one another I then reviewed literature specific to these factors. The main concepts identified can be categorised

into three main *actors*: the system, the user and the environment. Through organising these factors and examining how factors within individual actors interrelate, I constructed a conceptual framework which is considered in depth in an ongoing submission. Figure 2 shows the separation of actors and some examples of factors that are considered within the context of that actor.

4.2.1 System. The factors considered within the system are separated into system *characteristics* and system *qualities*. The characteristics considered are *visibility*, *consistency*, *constraints*, *signifiers*, *feedback and feedforward* as well as *affordances*. The first three influence the success of signifiers and feedback/feedforward, while all of them convey the presence of affordances. System qualities are considered as such as they are inherently qualities *of the system* but describe interactivity and are therefore part of the interaction space. The considered qualities are *communicability* [5, 28], *navigability*, *findability* [2, 22] and *guessability* [35]. The framework collates definitions for these, semantically related, terms and highlights differences before considering how these concepts impact initial interaction.

4.2.2 User. Factors considered as part of the user include various dependencies. *Familiarity* enables both *perceived affordances* and *expectations and assumptions*, while *goals and objectives* enable *motivation*. The relation between *attention* and *awareness* is contentious with some arguing attention is necessary for awareness [6, 19] while others question the necessity of attention for awareness [16, 17] arguing that enhanced attention to specific stimuli can come at the expense of overall awareness. Additionally to identifying these factors, putting them in relation to one another and initial interactions and considering their impact, the framework also highlights how these factors contribute to endogenous triggers of interaction. Endogenous triggers focus on the users by themselves, and without outside influence, discovering unfamiliar functionality or interactivity through a set of different circumstances. Familiarity
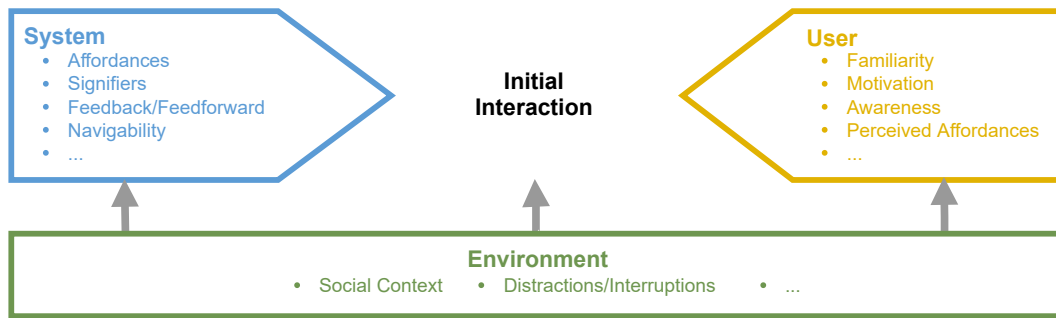
Figure 2: The actors influencing the initial interaction as well as examples of the factors placed within them. Since the interaction happens between the system and the user they impact it while they, as well as the interaction, are influenced by the environment in which they are placed. The listed factors act as examples and do not cover all those considered in the full framework.

can trigger interaction through transfer. Similarly, the presence of motivation influences how interactions are triggered. Motivation can lead to intentional or curiosity driven interaction while in the absence of motivation interactions are only triggered through the user serendipitously or accidentally.

4.2.3 Environment. The environment in this context encapsulates the physical environment in which both, the system and the user, are placed, as well as the social context of this environment. The factors considered here are the *social context*, as well as *examples/instructions*, *distractions/interruptions* and *constraints*. While independently influencing interactions (social learning [13, 18], technology adaptation [9, 33]), the social context can also impact the other factors. Examples and Instructions originate through the social context and can influence user behaviour. This is not only effective in co-located settings but also remote work settings [23] and advertisements such as keynotes [20]. Distractions and Interruptions can stem from people in the space as well as general noise, light or other technology. Constraints can be environmental (semantic and physical constraints e.g. bright light on a screen) as well as imposed through the social context (social and cultural constraints). Finally, the social context can be the trigger of initial interaction through examples, word of mouth or explicit instruction.

5 NEXT STEPS

Having investigated the first 2 research objectives through theoretical and conceptual work, the aim is to now validate the conceptual framework and extracted recommendations (Research Objective 3) in practical application. To do so, I aim to design and test various approaches of creating user interface components that support independent discovery of their interaction possibilities. These approaches will be informed by the considered factors and extracted guidelines. I then plan to consider their success or shortcomings strategically through the framework to identify which factors were leveraged to improve discovery and which oversights might have hindered it. The process of iteratively designing and testing differing improvement approaches will inform the correction and expansion of guidelines provided for improvement of discovery of interactions. While, due to time constraints, objective 5 will not be

addressed through a specific scientific contribution, projects aimed to address the other objectives will include evaluation for which I will iterate on existing study designs. My current work is focused on the first identified approach.

My current ongoing work, the *Touch Affordances* project, is focused on investigating whether real world metaphors can be used to communicate the presence of multiple input possibilities on one soft button.The aim is to bring attention to otherwise signifier-less activity without modifying the properties identifying the element as a button and communicating its purpose.

Plans for following approaches to test, such as leveraging animated transitions to convey otherwise hidden functionality, exist, but are not explicitly formulated in order to remain agile by allowing the inclusion of considerations arising through the current work, research and commercial releases or external feedback.

6 RESEARCH SITUATION

I am pursuing my doctorate under the supervision of Sylvain Malacria and Géry Casiez as a part of LOKI, an Inria project-team in partnership with the Université de Lille within the Joint Research Unit UMR 9189 CNRS-Centrale Lille-Université de Lille. Having started my PhD in October 2020, I am in my second year and projected to complete my studies at the end of the standard three years of a PhD program in France, in September 2023.

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REFERENCES

[1] Scott Berkun. 2012. The myth of discoverability. https://ns.inria.fr/discovery/refs/berkun2007myth.pdf retrieved December 9th, 2021 from https://scottberkun.com/essays/26-the-myth-of-discoverability/.
[2] Jennifer Cardello. 2014 updated 2019. Low findability and discoverability: Four testing methods to identify the causes. https://ns.inria.fr/discovery/refs/cardello2014low.pdf retrieved December 9th, 2021 from https://www.nngroup.com/articles/navigation-ia-tests/.
[3] Victor Cheung. 2014. Improving Interaction Discoverability in Large Public Interactive Displays. In *Proceedings of the Ninth ACM International Conference on*

Interactive Tabletops and Surfaces (Dresden, Germany) *(ITS '14)*. Association for Computing Machinery, New York, NY, USA, 467–472. https://doi.org/10.1145/2669485.2669489

[4] Christian de Looper. 2021. 6 Things You Didn't Know Your iPhone Could Do | Digital Trends. https://ns.inria.fr/discovery/refs/delooper2021ios.pdf retrieved December 9th, 2021 from https://www.digitaltrends.com/mobile/6-things-you-didnt-know-your-iphone-could-do/.

[5] Clarisse Sieckenius De Souza, Bonnie A Nardi, Victor Kaptelinin, and Kirsten A Foot. 2005. *The semiotic engineering of human-computer interaction*. MIT press.

[6] Stanislas Dehaene, Jean-Pierre Changeux, Lionel Naccache, Jérôme Sackur, and Claire Sergent. 2006. Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends in cognitive sciences* 10, 5 (2006), 204–211.

[7] Ekwa Duala-Ekoko and Martin P. Robillard. 2011. Using Structure-Based Recommendations to Facilitate Discoverability in APIs. In *Proceedings of the 25th European Conference on Object-Oriented Programming* (Lancaster, UK) *(ECOOP'11)*. Springer-Verlag, Berlin, Heidelberg, 79–104.

[8] Anushay Furqan, Chelsea Myers, and Jichen Zhu. 2017. Learnability through Adaptive Discovery Tools in Voice User Interfaces. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI EA '17)*. Association for Computing Machinery, New York, NY, USA, 1617–1623. https://doi.org/10.1145/3027063.3053166

[9] Michelle Gantt and Bonnie A. Nardi. 1992. Gardeners and Gurus: Patterns of Cooperation among CAD Users. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Monterey, California, USA) *(CHI '92)*. Association for Computing Machinery, New York, NY, USA, 107–117. https://doi.org/10.1145/142750.142767

[10] Marco Gillies. 2016. What is Movement Interaction in Virtual Reality For?. In *Proceedings of the 3rd International Symposium on Movement and Computing* (Thessaloniki, GA, Greece) *(MOCO '16)*. Association for Computing Machinery, New York, NY, USA, Article 31, 4 pages. https://doi.org/10.1145/2948910.2948951

[11] Vindu Goel. 2017. Apple Piles On the Features and Users Say, 'Enough!'. https://ns.inria.fr/discovery/refs/goel2017features.pdf retrieved December 9th, 2021 from https://www.nytimes.com/2017/06/02/technology/apple-iphone-developer-conference.html.

[12] Tovi Grossman, George Fitzmaurice, and Ramtin Attar. 2009. A Survey of Software Learnability: Metrics, Methodologies and Guidelines. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 649–658. https://doi.org/10.1145/1518701.1518803

[13] Cecilia Heyes. 2012. What's social about social learning? *Journal of Comparative Psychology* 126, 2 (2012), 193.

[14] Simo Hosio, Jorge Goncalves, and Vassilis Kostakos. 2013. Application Discoverability on Multipurpose Public Displays: Popularity Comes at a Price. In *Proceedings of the 2nd ACM International Symposium on Pervasive Displays* (Mountain View, California) *(PerDis '13)*. Association for Computing Machinery, New York, NY, USA, 31–36. https://doi.org/10.1145/2491568.2491576

[15] Philipp Kirschthaler, Martin Porcheron, and Joel E. Fischer. 2020. What Can I Say? Effects of Discoverability in VUIs on Task Performance and User Experience. In *Proceedings of the 2nd Conference on Conversational User Interfaces* (Bilbao, Spain) *(CUI '20)*. Association for Computing Machinery, New York, NY, USA, Article 9, 9 pages. https://doi.org/10.1145/3405755.3406119

[16] Christof Koch and Naotsugu Tsuchiya. 2007. Attention and consciousness: two distinct brain processes. *Trends in Cognitive Sciences* 11, 1 (2007), 16–22. https://doi.org/10.1016/j.tics.2006.10.012

[17] Victor AF Lamme. 2003. Why visual attention and awareness are different. *Trends in cognitive sciences* 7, 1 (2003), 12–18.

[18] Jingya Li, Erik D. van der Spek, Xiaoyu Yu, Jun Hu, and Loe Feijs. 2020. Exploring an Augmented Reality Social Learning Game for Elementary School Students. In *Proceedings of the Interaction Design and Children Conference* (London, United Kingdom) *(IDC '20)*. Association for Computing Machinery, New York, NY, USA, 508–518. https://doi.org/10.1145/3392063.3394422

[19] Arien Mack and Irvin Rock. 1998. *Inattentional blindness*. MIT press.

[20] Sven Mayer, Lars Lischke, Adrian Lanksweirt, Huy Viet Le, and Niels Henze. 2018. How to Communicate New Input Techniques. In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction* (Oslo, Norway) *(NordiCHI '18)*. Association for Computing Machinery, New York, NY, USA, 460–472. https://doi.org/10.1145/3240167.3240176

[21] Martin Mihajlov, Mark Springett, and Effie Lai-Chong Law. 2019. Learning to Drag: The Effects of Social Interactions in Touch Gestures Learnability for Older Adults. In *Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces* (Daejeon, Republic of Korea) *(ISS '19)*. Association for Computing Machinery, New York, NY, USA, 205–215. https://doi.org/10.1145/3343055.3359716

[22] Peter Morville. 2005. *Ambient findability: What we find changes who we become*. O'Reilly Media, Inc.

[23] Emerson Murphy-Hill and Gail C. Murphy. 2011. Peer Interaction Effectively, yet Infrequently, Enables Programmers to Discover New Tools. In *Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work* (Hangzhou, China) *(CSCW '11)*. Association for Computing Machinery, New York, NY, USA, 405–414. https://doi.org/10.1145/1958824.1958888

[24] David Nield. 2021. 10 hidden tricks to try on your Android phone. https://ns.inria.fr/discovery/refs/nield2021android.pdf retrieved December 9th, 2021 from https://www.popsci.com/hidden-android-tricks/.

[25] David Nield. 2021. Hidden iPhone tricks that will change the way you use iOS. https://ns.inria.fr/discovery/refs/nield2021ios.pdf retrieved December 9th, 2021 from https://www.popsci.com/hidden-iphone-tricks/.

[26] Donald A. Norman. 2013. *The design of everyday things: Revised and expanded edition*. Basic books.

[27] Venkatesh Potluri, Priyan Vaithilingam, Suresh Iyengar, Y. Vidya, Manohar Swaminathan, and Gopal Srinivasa. 2018. CodeTalk: Improving Programming Environment Accessibility for Visually Impaired Developers. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–11. https://doi.org/10.1145/3173574.3174192

[28] Raquel O Prates, Simone DJ Barbosa, and Clarisse S de Souza. 2000. A case study for evaluating interface design through communicability. In *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*. 308–316.

[29] Arianna Rebolini. 2014. 16 Things You Didn't Know Your Android Could Do. https://ns.inria.fr/discovery/refs/rebolini2014android.pdf retrieved December 9th, 2021 from https://www.buzzfeed.com/ariannarebolini/things-you-didnt-know-your-android-could-do.

[30] Anne Roudaut, Eric Lecolinet, and Yves Guiard. 2009. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Boston, MA, USA) *(CHI '09)*. Association for Computing Machinery, New York, NY, USA, 927–936. https://doi.org/10.1145/1518701.1518843

[31] Ross Shannon, Aaron Quigley, and Paddy Nixon. 2006. Software considerations for automotive pervasive systems. *Workshop on Software Engineering Challenges for Ubiquitous Computing* (01 2006).

[32] Arjun Srinivasan, Mira Dontcheva, Eytan Adar, and Seth Walker. 2019. Discovering Natural Language Commands in Multimodal Interfaces. In *Proceedings of the 24th International Conference on Intelligent User Interfaces* (Marina del Ray, California) *(IUI '19)*. Association for Computing Machinery, New York, NY, USA, 661–672. https://doi.org/10.1145/3301275.3302292

[33] Sandra A. Vannoy and Prashant Palvia. 2010. The Social Influence Model of Technology Adoption. *Commun. ACM* 53, 6 (June 2010), 149–153. https://doi.org/10.1145/1743546.1743585

[34] Brittany Vincent. 2018. Best Android tricks You Didn't Know About. https://ns.inria.fr/discovery/refs/vincent2018android.pdf retrieved December 9th, 2021 from https://www.komando.com/smartphones-gadgets/10-tricks-you-didnt-know-your-android-phone-could-do/506805/.

[35] Jacob O. Wobbrock, Htet Htet Aung, Brandon Rothrock, and Brad A. Myers. 2005. Maximizing the Guessability of Symbolic Input. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1869–1872. https://doi.org/10.1145/1056808.1057043