

Make Me Think

Guidelines for designing reflective interfaces

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Graduation Thesis

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December 2013

Abstract—An interface that meets optimal usability standards should be operated without *making you think*. We propose a different view on user interface design and argue that an interface that is designed to *make you think* will possibly enable profound reflection. A reflective interface aims to *make you think*. Up to now a reflective approach towards interface design has not been profoundly explored. Nor has a well-researched set of design guidelines been drafted.

After defining a possible framework for reflective interfaces we formulate a set of design guidelines that can serve as a reference for designing reflective interface.

Index Terms — Reflective Interface, Interaction Design, User Interface Design, Reflective Design, User Experience Design

I. INTRODUCTION

In interface design methods are often oriented towards efficient satisfaction of short-term goals. From this perspective the main purpose of an interface is to facilitate a flawless interaction between man and machine [15]. A user interface that is designed according to optimal usability standards can be appropriate in accomplishing practical tasks that require a short-term, quick resolution. When a user wants to conclude an online transaction, such as paying for a purchased item, nothing should delay the accomplishment of this straightforward task.

When a more long-term, profound outcome is sought an interface that is designed from a reflective perspective will possibly be more effective. The main characteristic of reflective interaction is not completion at maximum speed. A reflective interface may be deliberately slow and induces delay. In this manner it creates more time to consider different options and thus enables reflection.

Possible fields of application for reflective interfaces are:

- **Behavioral change:** By reflecting on his behavior a user creates space to change that behavior.
- **Design:** Reflective interfaces can induce profound and creative ideation in a design process.
- **Education:** Reflective interfaces can enhance the quality and effect of a learning process.

Up to now a reflective approach towards interface design has not been profoundly explored. Nor has a well-researched set of design guidelines been drafted that can be used as a practical, applicable reference during the design process of such an interface.

In this study we research the relevance of a reflective view on interface design. First we discuss related work and define the space where our research can be complementary. By exploring the subject from the perspectives of psychology, experience design and art we give substance to the concept of reflective interfaces. From these research findings we define a set of design guidelines for reflective interfaces. This set of guidelines is a proposal that yet has to be verified. We aim to evaluate the applicability of this set in further studies. In supplementary studies we will develop a prototype that serves as a case study to profoundly research the applicability of the guidelines.

II. THE ART OF REFLECTION

Art is one big all-encompassing reflective framework. The significance of art works is ambiguous, art is often deliberately confusing and usually encourages reflection. As a point of departure several works of art will serve as stepping-stones to provide some direction in denoting some key concepts that can be closely associated with reflection.

A. Reflecting through time delay

We are usually superficially aware of the passing of time. To enable reflection on our slowness or speed in the time continuum we need conditions to encourage contemplation. Conceptual artist Dan Graham [12] realized such conditions by creating an installation that enables reflection on time perception, making use of time delay.

In "Present Continuous Pasts" [13] the spectator is caught in a loop of time perception. A spectator enters a space with mirrored walls, a TV monitor and a camera hidden behind a two-way mirror. He sees his present image in the mirror but just when he gets accustomed to this image he sees himself entering the room on the monitor. The mirror reflects present time, the camera records the space, and the monitor plays back the recording after an eight-second delay. Thus presenting, in Graham's words: "*An infinite regress of time continuums within continuums.*"¹ The spectator becomes a participant that completes the artwork while perceiving the past in the present.

¹ Dan Graham, *Present Continuous Past 1974*, Youtube.com (online resource: <http://www.youtube.com/watch?v=aLNfUB7JtA4>, accessed Nov 15, 2013)

Through a time delay a reflective condition is created that allows the spectator to contemplate his presence in the time continuum. This conscious reflective process of the spectator cannot be designed or reproduced, the artwork is only a constructed (designed) condition to evoke this process [12].

B. The spiritual quality of time and technology

Godfather of video art Nam June Paik [11] states that perception of time cannot be defined in objectively verifiable units. Therefore even video can never capture time and reproduce time in an objective verifiable way. According to Paik video imitates nature's time structure but does not objectivates time perception. Paik states: "*Once on videotape, you are not allowed to die.....in a sense. Video art imitates nature, not in its appearance or mass, but in its intimate time-structure.*" [10]



Figure 1. TV-Buddha, Nam June Paik (1974).

Slowness, spirituality and time perception are all played out in his series of TV-Buddha's (Figure 1). These installations present a sitting Buddha-sculpture looking at his own picture on a closed circuit TV screen. Is this Buddha reflecting on his own divine image? Is Paik demeaning a religious symbol of his own cultural heritage? The Buddha is a traditional symbol of reflection and contemplation. A TV is a representation of modern technique. The image on the screen is not a sculpture in a traditional way but in Paik's words a representation of the intimate time structure. But this sculpture is an inanimate, immobile object. It seems unchanged over time.

Does Paik want the spectator to reflect on the spiritual quality of the Buddhist culture or is this an iconoclastic move on his own cultural icons? One thing is clear: an old medium (sculpture) is contemplating a new one (TV). Presenting a serene, timeless symbol of reflection on a time-based medium that encompasses the hectic nature of the present, media-driven, society is hilarious and of a transcendent, spiritual nature. It is like god using an electronic medium to contemplate his own holiness and presenting us with a volatile, glowing image that emphasizes his intimate, metaphysical time structure. Funny and spiritual at the same time.

In Grahams mirror room reflection is triggered through a time delay of 8 seconds. In Paik's TV Buddha "*past and present gaze upon each other in an encounter between traditional oriental deity and modern western media*"² thus creating a more profound time-delay that reflects the possible antithesis between transcendentalism and technology.

Like Graham Paik incorporates the consciousness of the spectator in his art. He plays a complex game with technology and the perception of time that is no compulsory thought construction but a poetic, sensorial, seductive experience. Thus enabling reflection.

Through this brief exploration of some reflective artworks we came to know that art is possibly an effective reflective framework that through its ambiguous and creative nature, that is not restricted by any rules, provides a fertile ground for reflective processes.

III. THE DESIGN OF REFLECTIVE INTERACTIONS

Although the subject of reflective interfaces is not extensively explored, some literature on reflective design and reflective interfaces is published. In part A of this section we describe related studies, identify well-grounded content that can lead to valid design guidelines and define the gaps that we cover in the following sections. In part B we explore usability heuristics from a reflective perspective and rephrase some of them into design guidelines for reflective interfaces. In part C we considering seductive interaction design from a reflective perspective. We describe seductive design principles and derive some guidelines for reflective interfaces from them.

A. Reflective design, slow technology and reflective interfaces

In their paper on reflective design Sengers *et al* [1] define reflection as "*referring to critical reflection or bringing unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice*". According to Sengers this critical reflection is strongly related to individual freedom. Reflective interfaces should encourage contemplation but the act to reflect remains a decision for the user. The user should experience reflection as an active, in the moment, and almost intuitive, visceral process. This delicate process can be easily disturbed when too much pressure is applied or when the user is not truly motivated to start reflecting.

Sengers carried out a case study concerning a mobile digital guide in an art museum. The objective is optimizing the visit by providing more information or customizing this information for a particular visitor style. Sengers states that the first design, providing a comment channel on the handheld tour guides for visitors to add their own voice (reflective comments on the artworks) to the curator's voice, failed. When asked why they did not participate visitors replied: "*I don't feel like what I have to say is of value.*" Simply

² Nam June Paik, *TV-Buddha* 1974, medienkunstnetz.de (online resource: www.mediakunstnetz.de/works/tv-buddha/, accessed Nov 17, 2013)

providing technology is not enough to encourage reflective behavior. The visitors felt inhibited by the expert-comment of the curator and decided not to share their reflections.

In addition to this first effort Sengers explores the idea of designing for marginal experiences that visitors are less aware of but can induce a process of reflection on a more subconscious level. To avoid a direct confrontation with the dominant museum experience (high level art and expert views) Sengers attempts to design the process of commenting more implicitly. In a second design they create a handheld guide that enables visitors to show their engagement with an artwork. The visitor can push a button on the guide, if he feels engaged by the artwork, thereby leaving a personal electronic footprint on the artwork. Other visitors can read out how many people were engaged by the artwork. In this way a very accessible way to reflect on an artwork is created and also a sense of awareness of other visitors is created. One visitor remarked of the experience: *"I saw that at one object, there was only one other visitor. And I wondered if maybe they were a kindred spirit."*

With this concept Sengers questions the cultural norm that a visitor of a museum is a passive receiver of information. She succeeds in designing a condition in which it was comfortable for users to experience their relationship with the museum in a different way.

Sengers concludes her paper with design strategies for reflective design:

- **Designers should support users in reflecting on their lives:** Technology can be designed to highlight the choices one makes in everyday activities and to offer up new choices that may not have been in one's awareness.
- **Reflection should be folded into a design as an integral part of the experience:** To reflect is a holistic experience. Therefore reflection should be integrated in the whole design process instead of being an add-on.
- **Provide for interpretive flexibility:** Reflective design should allow users to maintain control of and responsibility for the meaning-making process. This can be accomplished in a variety of ways: actively setting out to make the familiar strange, introducing and encouraging ambiguity as a resource and not as a factor to be eliminated, and building open-ended systems where the reflection itself is an irreducible part of the final experience.
- **Provide dynamic feedback to users:** The input that a user gives should be processed into dynamic and meaningful feedback.

The main insight in Sengers' paper that *"bringing unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice"* leads to the insight that designing for the unconscious is possibly an effective way to elicit a reflective process. Although Sengers does not mention this insight in her list of strategies we consider it a relevant strategy for reflective design:

- **Designing for the unconscious is possibly an effective way to elicit a reflective process:** Avoid a direct confrontation that can hinder reflection and design for marginal experiences that appeal to the unconscious.

Sengers does not explain what happens in the brain when somebody is in this unconscious state of processing marginal stimuli. She also does not discuss the process of appraisal of conscious experiences from a cognitive, physiological perspective. Her statements are only substantiated by some well-executed case studies. We elaborate on the process of conscious and unconscious appraisal, decision-making and motivation in section IV where we discuss cognitive processes concerning reflective processes.

According to Donald Norman in his book on *"Emotional design"* [18] there are three levels of design that shape the experience of a user. Visceral, behavioral and reflective.

- **Visceral Design: Appearance.** The visceral appeals to the instinctive nature of people. When the senses are tickled we will instinctively respond to the stimuli. Visceral design is all about immediate emotional impact.
- **Behavioral design: The pleasure and effectiveness of use.** Behavioral design is all about the usability of products. Behavioral design begins with understanding the user needs.
- **Reflective Design: Self-image, personal satisfaction.** Products can be more than the sum of the functions they perform. Their real value can be fulfilling people's emotional needs. The meaning of a product is an important way to express our self and helps building our identity.

Norman points out the difference between behavioral design and reflective design with this example concerning two watches (Figure 2).



Figure 2. Reflective and behavioral design according to Norman.

The left watch displays time in an unusual way. It has to be explained to be understood. But its reflective value lies in the

pleasure of explaining it proudly to our friends and thereby we hope that some of its uniqueness will rub off on us. The right watch is an example of behavioral design that is not aesthetically pleasing nor has a unique reflective design concept. It is designed to tell time in a practical straightforward, affordable way.

We agree on the way Norman differs a usability driven design from a reflective design. However when we consider visceral and reflective design from a reflective perspective we suggest that, complementary to Normans view, a reflective process can also be initiated by an instinctive emotional response. In the section about the psychology of reflective processes we will point out that even unconscious perceived stimuli can play an important role in user experience.

Normans view on reflection is particularly argued from the perspective of the product itself. Norman explains how a product can fulfill emotional needs and builds your identity. He states that *"a reflective design can fulfill people's emotional needs, and one of the most important needs of all is to establish one's self-image"* [18, page 87]. In our study we elaborate a broader view on reflection. In the interplay between user and application a interactive reflective interface should adapt to a users' input. A reflective interface is not a static product. The watch that Norman shows as an example of reflective design transmits meaning in one direction. In our view a reflective interface should be an integrated part of a holistic, interactive process. This interactive, reflective process can lead to emotional fulfillment that fits a user's personal profile.

In their paper on designing for reflection Lars Hallnäs and Johan Redström introduce the term *"slow technology"*, a design strategy for technology aimed at reflection and moments of mental rest rather than efficiency in performance [6]. They consider time to be an important factor in designing for reflection. When approaching design from a usability perspective tools should be created that get the job done, quickly and efficiently. The span of time to get something done should be as short as possible. But time could also be perceived as something to dwell in, thereby encouraging reflection. Slowness in learning, understanding and presence give people time to think and reflect. Hallnäs and Redström call this *"time technology"* that through its "slow" character emphasizes the presence of time and enables reflection.

They introduce slowness and time as key aspects of reflective designs. A "slow" design should have simplicity in material and a subtle complexity in form. The absence of conscious time perception in usability-driven designs leaves fewer opportunities for reflection. Slowness opens up the user for a conscious perception of time that, in its turn, enables reflection.

Another way to induce reflection, according to Hallnäs and Redström, is designing amplified environments. This concerns the design of applications for enlargement and amplification. Like a looking glass these applications can amplify details that otherwise would be overlooked, thereby creating a different

view on a given environment. To conclude their paper they propose two guidelines for slow technology:

- ***Focus on slowness of appearance and presence***
- ***Focus on aesthetics of material and use simple basic tools of modern technology and consider the clear and simple design presence of material***

Although their conceptual view on slowness and time is generally applicable on reflective interface design their second guideline on slow technology is more orientated toward product design and lacks an interactive angle.

In his dissertation about reflective interfaces Bigaro Jones states in that through a reflective interface the user is encouraged to think about the meaning of a given situation and offered an opportunity to profoundly consider options for a reaction [2]. In Jones' words: *"Reflective interfaces encourage the user to think about the space of possible choices they can make, reasons for making that choices and the consequences of their interactions with others."*

Reflective interfaces are appropriate, according to Jones, to promote positive behavioral norms. Reflection creates opportunity for behavioral change. Jones puts this insight in practice by creating a social network site that mimics Facebook. This "Fakebook" [2] is an experimental setup where the behavior of teens concerning cyber bullying is explored. Fakebook looks and operates exactly like Facebook. Like Facebook it can analyze content that is submitted by users but Fakebook analyses the posts to detect negative user interaction (cyber bullying) with an algorithm developed by Jones. It introduces delay and rich dynamic feedback to raise awareness. Users are confronted with their own, potentially offensive, behavior.

Some features of Fakebook are:

- ***Action delays:*** Give a user an alert that his input might be hurtful. Delay the submit-time enabling the user to reconsider his input. Examples in Fakebook are: A submit button with the text: *"Wait 50 seconds to post."* A cancelation button with the text: *"I don't want to say this."* A delay before the message arrives at the receiver, giving the sender the opportunity to cancel the post. These interface items go in effect when offensive messages are detected and are designed in exactly the style of Facebook.
- ***Inform the user of hidden consequences:*** Inform the user of the consequences of sending a post to a large social network: e.g. *"770 people will receive this post."*
- ***Crowd-sourced empathy by sharing stories:*** This feature is targeted towards the receiver of offensive behavior. Sharing stories shows that you are not alone. Stories are matched through a detection algorithm. After viewing a matching story users are presented recommendations about what they should do next.

An extensive user test confirmed the hypothesis that

software intervention using algorithm detection and the reflective interface of Fakebook decreases the distress caused by negative user interaction.

Jones presents a very practical hands-on view on reflective interfaces. Unlike Hallnäs and Redström, who consider slowness and time in a more conceptual way, he implements slowness very literally by introducing action delays. Like Sengers he recognizes that awareness of others can enhance a reflective process even when there is no direct communication between them.

The main purpose of his research is the implementation and testing of his algorithm and to confirm that a reflective interface can really contribute to behavioral change. The goal of our study is more general and focuses on a, generally applicable, set of design guidelines.

Jones' psychological underpinning of his work is brief. In our section on the psychology of reflective processes we elaborate more on the mental processes that enable reflection.

B. The reflective quality of usability heuristics

When discussing related work concerning guidelines for any kind of interaction design it is unavoidable to address heuristics on usability. Every interaction designer would probably agree that usability clears the way for a more profound and complete user experience. But is this also the case if usability is considered from a reflective perspective? In this section one of the most influential lists of usability heuristics is evaluated and assessed for its applicability in the design of reflective interfaces. By exploring the impediments of usability and rephrasing some usability heuristics in a complementary, or even contrary way some guidelines for reflective design are suggested.

A heuristic evaluation is a usability research method that can be conducted by a single expert. The user is not involved, this makes it a time and cost effective way to inspect the usability of a website. A heuristic evaluation is conducted according to a list of heuristics. These heuristics are a set of generally acknowledged usability principles. Heuristics are used to *evaluate* a design. In that sense they differ from a set of design guidelines that can also serve as a *starting point* in a design process.

Jakob Nielsen's "10 Usability Heuristics for User Interface Design" [7] are commonly recognized heuristics for user interface design. These heuristics, conceived in 1995 from a pure usability point of view on HCI, proved to be quite persistent. At present they are still quoted and used as a starting point for elaborating more extensive heuristic lists. In general the field of interaction design moved on to a more encompassing view on HCI where the experience of a user is taken into account. Usability is still considered to be a precondition for a fulfilling user experience but proved to be a too limited view on HCI because the affective side of a user experience is not taken into account.

A relevant question to be asked is: are Nielsen's heuristics also applicable in the design of reflective interfaces, either by their form (a list of principles), execution (executed by a single

expert) and content (focus on usability). In Table 1 we explore each of Nielsen's 10 usability heuristics with respect to their reflective quality.

Table 1. The reflective quality of Nielsen's heuristics.

Jakob Nielsen: 10 usability heuristics [16]	Quanjer: reflective quality of usability heuristics
Visibility of system status The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.	Providing rich feedback Rich feedback is an important feature of reflective interfaces [1] [2]. " <i>Reasonable time</i> " is probably meant to be " <i>as quick as possible</i> ". In reflective interfaces slowness [6] and delay [2] are considered to be a key feature enabling reflection.
Match between system and the real world The system should speak the users' 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.	Deliberate distortion of the real world Although it is important not to alienate the user, reflective interfaces can deliberately distort the real world to create a different perspective [1]. Always following real-world conventions, in a way the user is accustomed to, can impede reflection because it does not allow different interpretations. Presenting real-world conventions in an unconventional context or seemingly illogical order raises questions and enables different interpretations [1] [13] [14].
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.	Control over the meaning-making process A reflective interface allows user control over the meaning-making process [1]. But making mistakes can be a very fruitful source for creativity. Chance and making mistakes is closely related to freedom. Therefore user control and freedom should be interpreted as conditions that encourage reflection. It is impossible to make a

	mistake in a reflective process because any outcome is valid. The system should not correct the user in a constraining way.
Consistency and standards Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.	Inconsistency raises questions In reflective interfaces the users are explicitly encouraged to wonder about the information they get presented. Inconsistency and ambiguity can encourage people to rethink the meaning of information presented to them as long it does not obstruct the flow of interaction. Rigidly following standard platform conventions can impede the reflective process. Presenting the user with new, unexpected options can shake up entrenched views and make users receptive to new perspectives.
Error prevention Even better than good error messages is a careful design that prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.	Unintentional errors lead to frustration A system should work like it is programmed but intentional errors, designed to change the perspective of the user, can encourage reflection.
Recognition rather than recall Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.	Recall to remember Making an effort to recall something can intensify a learning-process and makes information easier to remember ³ . Figuring out a, not so obvious, interface can encourage reflection. But friction and indistinctness should not obstruct the interaction.

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.	Don't let efficiency hinder reflection A reflective interface should be flexible and adapt to the specific needs of a user. When efficiency is only intended to reduce the timespan of an interaction to a minimum, it can also hinder reflection.
Aesthetic and minimalist design Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.	Never impose what is relevant for the user From a designers point of view irrelevancy should be avoided but the designer or system should in their turn never rigidly impose what is relevant for the user. Reflective design allows users to maintain control of and responsibility for the meaning-making process [1].
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.	Use error message as a form of rich feedback Error messages could be designed as a form of rich feedback that encourages the user to reflect. Encourage the user to reflect on errors [2].
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.	A reflective interface should be self explaining A reflective interface should be self-explaining. Extra documentation should be integrated in the interaction and make the reflective process more profound instead of just explaining it.

After evaluating and assessing Nielsen's heuristics for their applicability in the design of reflective interfaces the following general similarities and differences can be defined.

- A heuristic evaluation can be executed from a usability or reflective perspective.
- Guidelines for reflective design should be developed beyond the preconditions of usability.
- Unintentionally disregarding usability rules can lead to frustration. *Intentionally* breaking usability rules,

³ Making an effort to retrieve information from your memory is an efficient learning strategy. Tests enhance later retention more than additional study of the material. This phenomenon is called the testing effect [20].

causing friction, delay and deliberate slowness, can be a reflection-booster.

After a closer look Jakob Nielsen's heuristics indeed prove to be a set of usability-orientated principles. Only two of them are directly applicable to reflective interfaces. But they should be treated as preconditions for reflective design, therefore they are not suitable as guidelines for designing reflective interfaces. They contain no direct applicable design principles that encourage reflection.

The remaining heuristics often proved to be too constraining instead of giving space to reflection. By establishing these impediments and rephrasing some of Nielsen's heuristics in a complementary, sometimes contrary way the following guidelines for reflective design can be suggested:

- **Provide rich feedback** to show the space of possibilities.
- **Use distortion of the real world** to create a different perspective.
- **Use slowness and delay** to enable reflection.
- **Never impose what is relevant for the user** and allow users control over the process of meaning making.
- **Don't correct the user in a constraining way**, making mistakes can be a fruitful source for creativity and learning.
- **Don't follow standard conventions** but present the user with new, unexpected options.
- **Recall to remember**. Making an effort to recall something can intensify a learning-process and makes information easier to remember.

C. Seductive interaction design and user experience

In his book on seductive interaction design [4] Anderson points out that "*usability clears the way for a good experience by eliminating troublesome interface distractions. But great experience stems from something more*" [4, page 10].

A true experience designer should be aware of what people truly motivate and have an insight in what they care for. This awareness for human motivations can, according to Anderson, be used to design effective seductive interactions. Seductive interaction design has some views in common with reflective design. In this section the similarities and differences are explained. The question if a seductive design strategy is also applicable in a reflective design process is also addressed.

To clarify what kind of experiences lead to a seductive interaction Anderson created a "*user experience hierarchy of needs model*" [4, page 12]. He describes six, hierarchical ordered, stages of user experience starting with a functional focus on tasks with the emphasis on products and features, evolving to a focus on experience with the focus on people, activities and context. The six stages in the user experience hierarchy of needs model are:

1. **Meaningful: Has personal significance.**
2. **Pleasurable: memorable experience worth sharing.** How do we design something emotionally engaging?

3. **Convenient: Super easy to use, works like I think.** Is it designed to facilitate a truly convenient interaction?
4. **Usable: Can be used without difficulty.** Is the interaction user-friendly?
5. **Reliable: Is available and accurate.** Will my application/service ever crash? Can I trust the integrity of the data that are presented to me?
6. **Functional: Works as programmed.** Is it an appropriate, functional solution to the problem?

Although not mentioned in his book, there are some similarities between "*The User Experience Hierarchy of Needs*" and Maslow's "*Hierarchy of Needs*" [17]. Maslow describes the different human needs that should be fulfilled to reach ultimate self-actualization:

1. **Self-actualization** is the ability to be creative and use your full potential.
2. Need for **self-esteem** and personal acknowledgement.
3. Need for **social interaction**, love and belonging.
4. Need for **safety and security**.
5. **Physiological** needs (food etc.).

Maslow's "*Hierarchy of Needs*" underpins the idea that basic needs should be satisfied before reaching a true fulfilling user experience that enables meaningful reflections and sense of purpose. Reaching the stage of *self-actualization* (Maslow) and *personal significance* (Anderson) shows a similarity with the outcome of a reflective process. Reflection is a creative process that encourages people to use their full potential. Therefore it can lead to self-actualization. Personal significance evolves out of the ability to reflect on one's direct environment and personal condition. A reflective interface can enable this process. In Table 2 Anderson's views are considered from a reflective perspective. We rephrase elements of Anderson's hierarchy of needs and derive some guidelines for reflective interfaces from them.

Table 2. Anderson's hierarchy of needs considered from a reflective perspective

Anderson: User experience hierarchy of needs [4]	Quanjer: Considering Anderson from a reflective perspective
Meaningful: Has personal significance.	Creating significance Reflection is a process of creating significance.
Pleasurable: memorable experience worth sharing. How can we make something emotionally engaging?	Emotionally engaging A reflective interface should be emotionally engaging, in a positive or negative way. If it is not engaging it will be ignored or quickly abandoned.
Convenient: Super easy to use, works like I think. Is designed to be convenient according to the interaction.	Breaking the rules When breaking conventional usability rules the user can be stimulated to reflect on the

	process of interaction thus creating a new perspective on the content.
Usable: Can be used without difficulty. Is the interaction user-friendly	Deliberately induce friction A reflective interface can deliberately induce friction. Its primal goal is not to remove friction. Friction can be a source of reflection. When an interface does not work as you expect it to do it enables different views.
Reliable: Is available and accurate. Will my application/service ever crash? Can I trust the integrity of the data that are presented to me?	Encourage deeper investigation If data and feedback are presented that are clearly untrustworthy the motivation to reflect will be low. But if data appear to be somewhat unsafe it can encourage deeper investigation and reflection.
Functional: Works as programmed. Functional solutions to a problem.	Create different options The application should work as programmed. But a reflective interface is not one functional solution to a problem. A reflective interface should create options, it does not include one conclusive solution to a problem

The needs that are mentioned in the hierarchies of Anderson and Maslow are stated as fixed preconditions. They must be fulfilled before a next stage can be reached. When evaluating them from a reflective perspective their hierarchic order seems less relevant. We can rephrase some elements of Anderson's hierarchy of needs and compile the following guidelines for reflective design:

- **An effective reflective interface should be emotionally engaging.** If not engaging it will be ignored or quickly abandoned. Engagement can be induced by positive or negative emotions. Thereby negative emotions can also induce a positive reflective process⁴.
- **Friction can be a source of reflection.** When it takes an extra effort to complete an interaction it

⁴ In their paper "Darker Shades of Joy" Fokkinga & Desmet [19] state that when negative emotions induce a positive experience a protective frame is integrated in the experience. Thereby negative emotions, like fear, can also elicit a positive reflective experience. To closely observe a lion can be a thrilling, positive experience. But the experience will become terrifying when the lion escapes from his cage (e.g. protective frame).

can encourage a user to develop different views.

- **Dubiety can lead to reflection.** If data and feedback are presented that are clearly untrustworthy the motivation to reflect is low. But if data appear to be somewhat unsafe it can encourage deeper investigation and reflection.
- **A reflective interface should create different options.** It should not include only one conclusive solution to a problem.

Some insights derived from a seductive design strategy can be applicable in a reflective design process. The emphasis on making something emotionally engaging is an important strategy in designing *effective* reflective interfaces. This notion is further elaborated in the section about *the psychology of a reflective process* where the role of emotions in effective decision-making is described. Effective decision-making is important in the field of behavioral change.

To conclude we state that in reflective design personal significance goes beyond the point of the commercial objectives of seductive design. Conveying a brand identity can engage a user and "seduce" him into meaningful interactions that lead to the purchase of products. Subsequently the user experiences a fulfilled state off mind, thinking that he really needed this product to enhance his personal wellbeing and quality of life.

Reflective design distinguishes itself from commercial seductive design in its objectives. A reflective interface should create conditions that enable a profound assessment of information. This process of reflection does not necessarily lead towards a commercial outcome. Reflective design allows users to maintain control of and responsibility for the meaning-making process [1]. Seduction suggests that a user is involuntarily subjected to commercial intentions.

IV. THE PSYCHOLOGY OF REFLECTIVE PROCESSES: APPRAISAL AND DECISION-MAKING

In the previous sections Sengers' statement that "*designing for the unconscious is an effective way to elicit a reflective process*" [1] is underpinned with some convincing case studies. But the question if it is at all possible to design for the unconscious is not explained from a psychological perspective. The gap in Sengers' line of arguing is filled in this section and underpinned with conclusive evidence from several experiments concerning cognition and emotion.

We found no literature that in particular deals with the psychology of reflection but there are a lot of scientific writings that cover the research on the origin of emotions. When considering reflection from psychological perspective this literature contains some useful views. First we deal with the mental process that leads to an emotion. This process is explained through the work of Joseph LeDoux on "*The Emotional Brain*" [8] that gives an insightful overview on different views on the origin of emotions. The part of the book that deals with appraisal is well applicable on the subject of

reflective design.

Next the role of emotions in decision-making is addressed through the work of neuroscientist Antonio Damasio [9]. The conclusion of this section is that designing an emotional engaging interaction leads to a more effective reflective interface.

A. Cognitive assessment and appraisal

The process of cognitive assessment and appraisal that leads to a certain mental state is thoroughly explored in psychological research concerning the origin of emotions. Joseph LeDoux describes several views on the subject of cognitive assessment and appraisal in his book "The Emotional Brain" [8].

LeDoux explains that social physiologists Schachter and Singer [8, page 48] acknowledged that some kind of mental process should occur to assess the stimuli arising from a certain situation. They state that after a stimulus that causes a bodily arousal we are motivated to make a cognitive assessment of the situation we are in. We assess and label the arousal. The labeling of the arousal determines the emotion we feel.

This leads to the following chain of events:

Stimulus → Arousal → Cognition → Feeling [8, page 51]

Schachter and Singer emphasize the role of cognition in emotion and argue that emotions are a cognitive interpretation of situations but they don't explain what comes in between stimulus and arousal. What generates the response (arousal) remains a question.

According to the appraisal theory by Magda Arnold [8, page 49 - 50] cognitive evaluation of the stimuli themselves fill this gap. She defines appraisal as: "*The mental assessment of the potential harm or benefit of a certain situation.*" [8, page 50] Appraisal leads to an *action tendency*. That implies that only the intent to take action is enough to provoke an emotion. The appraisal process itself occurs unconsciously but its effect, the emotional feeling, is a conscious experience. Only after the conscious feeling it becomes possible to reflect back on the experience and describe the appraisal process. LeDoux explains: "*Arnold's approach assumes that we can, after an emotional experience, gain access to the unconscious appraisal process that gave rise to the emotion.*" [8, page 50]

This leads to the following chain of events:

Stimulus → Appraisal → Action tendency → Feeling [8, page 51]

The action tendency can be compared with an intended change of behavior, one of the possible outcomes of a reflective process. Arnold argues that there is always a partly conscious access to the appraisal process leading to a conscious action tendency. This assumption is open to challenge. Sequent research showed that emotions can also be initiated automatically, without any conscious appraisal [8, page 50].

Social psychologist Robert Zajonc [8, page 53] took this line of thinking a step further and argued that emotion is independent of cognition. Experiments by Zajonc showed that only unconscious registration of stimuli is enough to create simple emotional reactions. In successive experiments Zajonc proved that emotion can be present without the recognition of the stimuli. This implies that you can influence the action tendencies of subjects without them knowing it. That underpins the statement of Sengers that designing for the unconscious can be a plausible strategy to elicit a reflective process.

This leads to the following chain of events:

Stimulus → Unconscious affect → Feeling [8, page 54]

Zajonc controversial statement that feelings can occur completely independent from cognition is still a subject of heated debate. But he irrefutably proved that emotional processing can occur in the absence of conscious awareness. His findings were endorsed by the social psychologist John Bargh who performed many experiments showing that "*emotions, attitudes, goals and intentions can be activated without awareness, and that these can influence the way people think about and act in social situations*" [8, page 63].

In this section we established that a reflective appraisal process might be influenced by the unconscious registration of stimuli and we explained that appraisal and action tendencies lead to a feeling. We stated, according to Arnold's appraisal theory, that an action tendency *precedes* a feeling. Therefore we assume that an emotion is the endpoint of the chain of events. But does it really end there? Or can emotions, in their turn, have an effect on a mental process?

B. The role of emotions in decision-making

In the previous section we discussed the mental process that starts with a stimulus and ends with an emotion or feeling. In this section we consider the effect of emotions on decision-making. Thereby we confirm that emotions, in their turn, can influence a reflective process and should be taken into account when designing reflective interfaces. The ability to make decisions can play an important role in designing reflective interactions that lead to behavioral change.

Professor of neuroscience Antonio Damasio conducted extended research on the connection between emotions and rationality concerning effective decision-making [9]. He studied patients with a defect in social behavior and ability of decision-making. These patients also suffered a brain deviation that caused a reduction in emotional reactivity and feeling. Damasio established a correlation between this impairment in emotional ability and their deviant behavior. This leads to the insight that emotions are not a luxury they are essential to rational thinking and decision-making. Damasio explains that: "*The cold-bloodedness of such patients prevented them from assigning different values to different options, making their decision-making landscape hopelessly flat.*" [9, page 51]

Reasoning and the ability to come to a decision suggests that the decider recognizes a situation which calls for a decision, is aware of different options of action (responses) and can estimate the consequences of those options. During the decision-making process the brain rapidly creates scenarios of possible response options and related. These scenarios are composed of images affected by former experiences. Your mind is not blank at the beginning of a reasoning-process. These images are generated in an overwhelming flow. But how does the brain encompass all these options and decides which images fit the scenario that represents the right decision? A pure rational approach to obtaining the best result would be to keep all emotions out. Objective, rational thinking should not be impeded by passion.

Despite of this extensive flow of possibilities the brain is capable of making complicated decisions in minutes, even in seconds. This would not be possible if the brain had to assess all these images, and possible outcomes in a systematical, rational way. It has to take a shortcut and should be able to quickly assess different emotional values to different options thus making it possible to distinguish one option from another. Here comes Damasio's "*Somatic Marker Hypotheses*" [9, page 173] into play. Damasio argues that before you apply any cost benefit analysis that leads to a beneficial decision something important happens: "*When a bad outcome connected with a given response action comes in to mind, however fleetingly, you experience a unpleasant gut feeling.*" [9, page 173] This is a bodily sensation that Damasio coins as a somatic state. Because this state marks an image he calls it a marker. This somatic marker functions as an automated alarm signal that warns for a negative outcome of a marked option. In this way all the bad options are quickly ruled out and only fewer, more valuable, options remain to be assessed. Somatic markers do not deliberate for us. They aid the deliberation by highlighting options in positive or negative way. It is a system of automated qualification that works well through a collaboration between the rational and the emotional.

Somatic markers are acquired by experience. According to Damasio they were "*created in our brains during the process of education and socializing, by connecting specific classes of stimuli with specific classes of somatic state*" [9, page 177]. Somatic markers can operate on a conscious and unconscious level.

In this section we established that emotions contribute to effective decision-making. Therefore we can confirm that the emphasis on making something emotionally engaging is an important strategy in designing reflective interfaces and is valid from a psychological perspective. A reflective interface, that has a focus on behavioral change, should emotionally appeal to its users. Any behavioral change is usually preceded by a firm decision to change entrenched habits.

V. GUIDELINES FOR DESIGNING REFLECTIVE INTERFACES

In this section guidelines for designing reflective interfaces are elaborated. They are derived from our research that approaches reflective design and reflective interfaces from a divers perspective. Each guideline is clarified and underpinned with examples from our research that encompasses views from the perspective of art, reflective design, experience design, usability heuristics and psychology.

Guidelines for reflective interfaces:

1. ***A reflective interface should be slow and induces delay.*** Slowness and delay are preconditions that allow users to reflect. The use of time delay and slowness to induce a spiritual, reflective process is a key concept in art [13,14]. Time, when perceived as something to dwell in, enables reflection [6]. Slowness in learning, understanding and presence give people time to think and reflect. Creating action delays, that make users aware of their objectionable behavior, encourage behavioral change [2]. This intentional slowness opposes the usability heuristics stating that user feedback should not be delayed [7]. Suggesting that every interaction should be handled as quickly as possible.
2. ***A reflective interface can deform or transforms content to create new perspectives.*** Contrary to usability heuristic that real-world conventions should be followed closely [7] making the familiar strange can be an incitement to reflect [1].
3. ***A reflective interface may magnify details that otherwise would be overlooked.*** An other way to induce reflection is to design amplified environments. This concerns the design of applications that enlarge and amplify properties of given environments [6].
4. ***A reflective interface presents content in a new, unexpected context and can induce dubiety about meaning and entrenched viewpoints.*** The TV Buddha [14] is a striking example of presenting content in a new, unexpected context. This unusual context introduces ambiguity as a resource. This is a fertile ground for reflection because it encourages interpretive flexibility [1].
5. ***A reflective interface should give profound/dynamic feedback on the users actions.*** Profound feedback provides food for thought. Dynamic feedback, enabled by intelligent algorithms [2], is an effective way to start a personalized, meaningful interaction that fits the profile of a single user [1].
6. ***A reflective interface should allow user-control over the process of meaning-making.*** A reflective interface encourages reflection by suggesting different options but never pushes a user in very distinct way. The user should experience reflection as an active, in the moment, and almost intuitive process [1]. This delicate process can be easily disturbed when too much pressure is applied. The user should be encouraged to think about the meaning of a given

situation and offered an opportunity to profoundly consider options for a reaction [2].

7. ***A reflective interface should be designed from a reflective perspective integrated in the whole design process.*** To reflect is a holistic experience. Therefore reflection should be integrated in the whole design process instead of being an add-on [1].
8. ***A reflective interface can deliberately induce friction.*** Its primal goal is not to remove friction. As opposed to usability heuristic [7] friction can be a source of reflection. *Intentionally* breaking usability rules, causing friction, can be a reflection-booster [4].
9. ***A reflective interface can become more effective if it enables or suggests sharing.*** Sharing can be an enhancing condition to reflect in. If you share your reflective thoughts with somebody else it stimulates the reflective process [2]. The awareness of others, potentially kindred spirits to share with, enhances a reflective process [1].
10. ***A reflective interface should emotionally appeal to its users.*** When designing effective reflective interfaces emotions should be taken into account because they enhance an engaging user experience [4] and are important in effective decision-making [9].
11. ***A reflective interface can utilize the possibility of designing for the unconscious.*** Designing for the unconscious can be an effective way to elicit a reflective process [1]. Several experiments [8] show that the action tendencies of subjects can be influenced without them knowing it.
12. ***A reflective interface enables reflection by suggesting different options.*** Reflective interfaces should encourage the user to think about the space of possible choices they can make [2, 4]. Technology can be designed to highlight the choices one makes in everyday activities and to offer new choices that may not have been in the user's awareness [1]. These possibilities should never be rigidly imposed and but should presented as options that are free to explore.
13. ***A reflective interface should never correct the user in a constraining way but allows users to make mistakes.*** This guideline opposes the usability principle that mistakes should be prevented at all cost by eliminating error-prone conditions [7]. Allowing mistakes could be an inducement to design error messages as a form of rich feedback that encourages the user to reflect.
14. ***A reflective interface should not rigidly follow standard conventions but present the user with new, unexpected options.*** Reflective interfaces are about exploring options that a user is not aware of. When standard conventions are rigidly followed [7] there are fewer opportunities for reflection. Like art a reflective interface should be a framework that through its ambiguity and independent nature,

provides a fertile ground for reflective processes [4].

VI. DISCUSSION

In our study we make a contribution to the fields of reflective design and reflective interfaces by conducting an explorative research. Our study results in a list of 14 guidelines for designing reflective interfaces. These guidelines can serve as a reference within the design process of such an interface and can be of use when evaluating interactive applications for their reflective quality.

Our study encompasses views from the perspectives of art, reflective design, experience design, usability heuristics and psychology. By approaching the subject from diverse perspectives we were able to elaborate a list of design guidelines for reflective interfaces that is theoretically grounded.

When discussing the theoretical approach of our study questions were raised about the practical applicability of reflective interfaces. We recognize that our study lacks concrete examples of reflective interfaces that may be developed in subsequent studies. To provide some insight we refer to the examples of reflective interfaces, Fakebook by Jones [1] and the interactive museum guide by Sengers [2], mentioned in section III of this study concerning related studies.

Although our guidelines are theoretically grounded they still should be extensively verified for their practical applicability. In further studies we aim at the validation of our guidelines by designing a reflective prototype-interface. Our guidelines will serve as a main reference during the design process of this reflective interface. By evaluating the effectiveness of our prototype-interface through a user experience study we will evaluate the applicability of the guidelines. In this way we will introduce the user as a main reference by which the applicability of our guidelines will be evaluated. The development of an appropriate user experience research method, that generates empirically valid results, will be part of this further research. We acknowledge that it would be too ambitious to validate all guidelines by designing and testing a single reflective interface. Therefore we will aim at the validation of a limited set of guidelines in our next study.

In general we conclude that reflective interfaces should be designed to *make you think*. They should have an engaging user experience and they should be designed beyond the preconditions that are suggested by a pure usability orientated design. To be flawless and fast can be an obstacle to a profound reflective experience. Deliberate slowness and friction encourage a user to make an extra effort and *make him think*.

ACKNOWLEDGEMENTS

I have greatly benefited from the valuable feedback and enthusiastic support from my thesis advisor Maarten Lamers. I received generous support from my employer, The Hague University of Applied Sciences, during my study of the Media

Technology MSc Programme at Leiden University. I would specially thank Petra Visser for facilitating working conditions that enabled this time consuming study. My college lecturer at The Hague University Jos van Leeuwen gave me valuable, constructive comments and encouraged me in exploring my talents. The discussions with Theo Rooden and Bram Reurings were insightful and contributed to the quality of my thesis. My heartfelt gratitude goes to my wife Patricia for her warm encouragement and to my daughter Yasmin for her patience.

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