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Interaction Design Needs Modified Principles of “Design Affordance” for Navigation Applications

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Dedication

I would like to thank and dedicate my ability to conceptualize this paper to Tim Wood, Professor in the School of Design, and my teammate in the cycling world.

Without his guidance, patience, encouragement, and long conversations about design paradigms and the importance of front-fork travel, my thoughts would remain disorganized and using centered text or even worse, unwritten.

Thesis Committee Approval

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Abstract

It is a common scene for many of us getting from point A to point B these days. One we forget did not exist a little over a decade ago. A phone or device is taken out, a destination is typed into a search box, and a route or several are offered. The user then makes a route decision, places the device within sight, or holds it as they travel. The user relies on provided instructions for most of the route taken and tangential subsequential decision-making. These behaviors are not only accepted as the norm, but our reliance deems them necessary to find our way around. The implications of these behaviors can be observed on a daily basis. As the development of Internet of Things (IOT) unfolds, we have witnessed a new design paradigm that needs addressed – balancing the users' ability to successfully manage contextual information and ambient information. The term, "Affordance" was originally mentioned in 1977 by James Gibson, a psychologist, as the relationship between physical objects and their actionable properties to humans. However, is more known and attributed to Donald Norman, a designer within the interaction design realm as the perceived properties of an interface. This struggle to maintain balance between the two definitions is most seen regarding the GPS navigation experience. Navigation interfaces are typically flooded with functions that are more marketable than usable in the physical space for which they are designed, sometimes leading to hazardous outcomes. A solution is acknowledging that both affordances exist simultaneously, but should be harmoniously cognizant of when and how each should be prioritized. Moving forward, designers of navigation systems should agree on principles that successfully integrate both Norman and Gibson's definition, emphasizing the physical world's properties and supporting our ability to respond quickly and safely.

Keywords

Design Affordance, Human Computer Interaction, Interaction Design, Geospatial Positioning System, Domain Model

Introduction

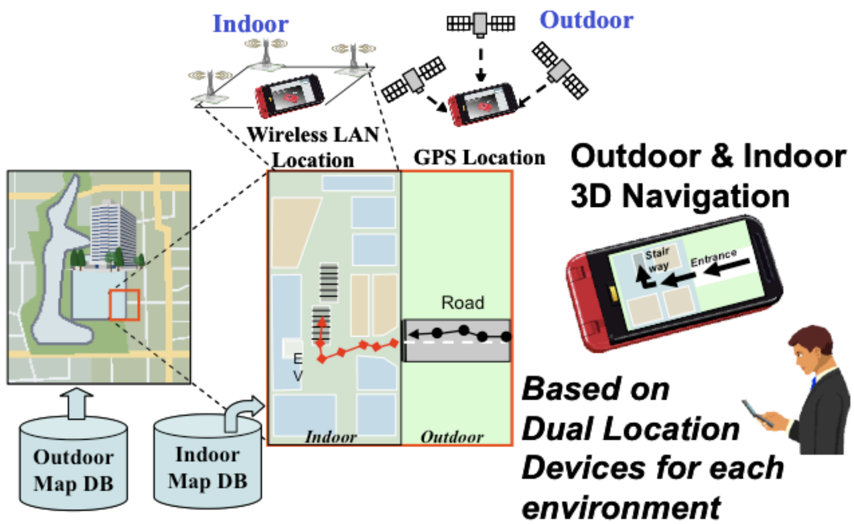
Design Affordance is a term often used within the interaction design realm, but it is generally known as the properties of an object, both actual and perceived. There are two approaches, one by James Gibson coming from a physical (actual) perspective and one according to Don Norman in an interaction (perceived) design context. The term has been somewhat appropriated by the design community often attributing its importance to Norman, who first mentioned affordances in the context of design in his book, “The Design of Everyday Things.” However, the notion of an 'affordance' was conceived by James J. Gibson (1977; 1979), a prominent perceptual psychologist, who originally used the term to describe "...the actionable properties between the world and an actor."[1] An example of Gibson’s definition can be seen in the design of a coffee-mug – If two mugs are side by side, one with a lid and one without, the user can deduct that the coffee mug that comes with a lid affords the necessary properties needed to take their coffee outside, providing protection of its contents and the surrounding environment. In contrast, Norman’s Affordance as applied to interaction design can be seen as the perceived ability to interact with a graphical “button” on a screen or interface because of implied affordances that have been defined by the designer. This can lead the user to believe they can control the outcome with various actions such as, but not limited to; pushing, tapping, sliding it, and so on. One could consider these two viewpoints as giving birth to the emerging field of Human Computer Interaction (HCI) which applies psychological properties to interactions and will be referenced when combining both actual and perceived actions.
For purposes of clarity, when discussing the distinction of these concepts related to navigation, Gibson’s definition will be denoted as “Environmental Design Affordance” and Norman’s will be “Interface Design Affordance” while the general principle will just be denoted as “Affordance.”

A new problem domain and an opportunity for designers

When attempting to describe a problem space, it is necessary to organize the relationships between relevant entities, known as a domain model. To properly communicate this, interaction designers show concepts that include both data and behavior the define a particular domain model. Any domain model must be built upon some conceptualization of the domain which it is representing. The primitive constructs, or concepts, from which a model is built will reflect that conceptualization. An example of

[1] (Norman 2013)

this is shown in fig.1 where Japanese conglomerate company, Hitachi, is shows a simplified domain model of an organization's concept works, under an opensource entity, "Open Geospatial Consortium (OGC). This shows how WIFI and GPS work together to allow the extended benefit for users navigating indoor spaces.



[2]

Fig.1 Shows domain model of users within an indoor environment

It is worth nothing that the images used show the user looking at the platform, not the environment. In this case, it is a handheld device, most likely a phone, while attempting to navigate. In HCI, there is no universally agreed conceptualization on which we can base a model; there is no agreed theory of HCI. For example, there is the question of whether we interact *with* the computer or we interact *through* the computer…[3] forcing us to address design affordances. Navigation using Geospatial Positioning System (GPS) provides a good opportunity to address this question as the very nature of user needs are contrasting. This is a key element that is validates the need to resolve principles for which the HCI community can agree upon.

[2] (Hitachi n.d.)

[3] (Benyon 1996).

Technology Historically Outpaces Optimization

GPS is a relatively new problem space for interface designers, with the first satellite launched in 1978. Prior to its delivery to the average consumer in the 1980's, it had been used only by scientists and government agencies and was considered a top-secret weapon. However, these entities purposefully degraded the accuracy of GPS to gain an edge against competing sovereignties and other conflicts of interest. In 2000, The Defense Department ended this purposeful degradation which it had implemented before the first Gulf War. The technology that relied on GPS suddenly became ten times more accurate overnight for the everyday user, and all kinds of industries--from fishing to forestry to freight management--soon began using it. Personal GPS devices like the TomTom car navigation device became hugely popular shortly after the turn of the century. Within 4 years, the GPS receiver technology got much smaller and cheaper, private companies began pumping out personal GPS products, like the in-car navigation devices from TomTom and Garmin. In 2004, Qualcomm said it had developed and tested "assisted GPS" technology allowing phones to use cellular signal in combination with GPS signal to locate the user to within feet of their actual location.[4]

It was at that time, that the primary users of GPS became pedestrians, cyclists, and drivers.

These were the three main travel modes used when navigating areas although public transit followed soon after.[5] This may explain the flood of interaction models that were quickly implemented to quell the opportunities being discovered without questioning their physical affordance or platform.

The result is that we interact *with* the computer, not *through* the computer, causing significant cognitive dissonance as the navigation experience relies on Norman's Interaction Design Affordance while our existence in the physical realm becomes secondary.

Implications of Exponential Functionalities

Traveling an un-known route has changed significantly with the advent of GPS and the turn-by-turn cue system. Prior to GPS, the immediate environment was a fully-immersive experience that required mental-mapping of orientation, wayfinding, and trial-and-error. Currently, the average user looks at a screen for information regarding the next cue signal point, the proximity to reaching the point, and the direction to take after reaching it. If a user was to open Google maps, these branches of conceptualizations include street infrastructure, public transit information, surrounding merchants,

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[4] (Sullivan 2012)

[5] (Sullivan 2012)

neighboring categorizations, events, and even personalized suggestions based on your browsing history. Simultaneously, depending on their device capabilities and personal settings, the user might also be receiving notifications from other applications. These alert cues require the user to focus on a small visual area and process an interface visually while driving, walking, biking, or any other method of self-propelled movement. Our eyes are unable to see the foreground and background in a similar way due to its neuropathways so this process shifts the environment to the background and the context of the interface takes precedence. A deeper understanding of how humans process information is needed to suggest interaction models that can provide the optimal relationship between Environmental and Interface Design Affordance.

Limitations of Human Processing of Environment

Our desire to feel safe may lead us to think we are more aware of our environment than we actually are. Nonetheless, headlines, statistics, and personal experience proves that unawareness abounds. According to Forbes contributing writer, Tanya Mohn, "Removing eyes from the road for just two seconds doubles the risk for a crash, according to federal research."[6] Safety itself is enough reason to consider an alternative, however, there are other areas that should be considered.
Currently, navigation cues are mostly visual, with optional audio, both which require a shifting focus from the task at hand which is being aware of one's ever-changing surroundings and its Environmental Design Affordance. In a safety and tactical context, this is known as situational awareness. The three elements necessary to maintain situational awareness is: seeing, understanding, and predicting. In the few moments it takes for someone to look at an interface, every element of situational awareness is lost, creating a deficit in several key areas:[7]

I. Level 1 Seeing — perception of the elements in the environment. This is the identification of the key elements or "events" that, in combination, serve to define the situation. This level tags key elements of the situation semantically for higher levels of abstraction in subsequent processing.

[6] (Mohn 2017)
[7] (National Research Council 1998)

II. Level 2 Understanding — comprehension of the current situation. This is the combination of level 1 events into a comprehensive holistic pattern, or tactical situation. This level serves to define the current status in operationally relevant terms in support of rapid decision making
and action.

III. Level 3 Predicting — projection of future status. This is the projection of the current situation into the future in an attempt to predict the evolution of the tactical situation. This level supports short-term planning and option evaluation when time permits.[8]

The Brain's Response to Segmented Cues

Turn by turn cues create a lack of environmental affordance by shifting focus onto segmented commands that cause the user to lose interest in anything outside of the current task. A scenario published by BrainWorld magazine shows how the hippocampus which is the hub of the brain's navigation system. The findings are of a team from the Institute of Behavioral Neuroscience at University College London. It's long been known that the hippocampus, a structure of the brain located in the medial temporal lobe, is responsible for spatial navigation and memory. In the past, some researchers have thought that it encodes the distance to the goal as the crow flies, the Euclidean straight line while others have thought that it maps distance along the paths you can take to reach that goal while planning paths around obstacles. The team discovered the hippocampus actually does both types of mappings, the kind of things that we know in GPS as trip distance and segment detours. However, if GPS directions are faulty or if the environment changes, users are often left without a direction in which to take. The result is freezing, panic, or a search for additional GPS resources, often in the middle of motion.[9] This validates that consistency in segment detours should only be done when actively queuing a system for an answer, keeping the hippocampus actively encoding while allowing for errors.

Human Perception is an Affordance

Human physiology should be taken into account when designing an experience for users. Currently, users must reduce their field of vision to a small interface, either a smartphone or similar device

8 (National Research Council 1998)

9 (Brain World 2019)

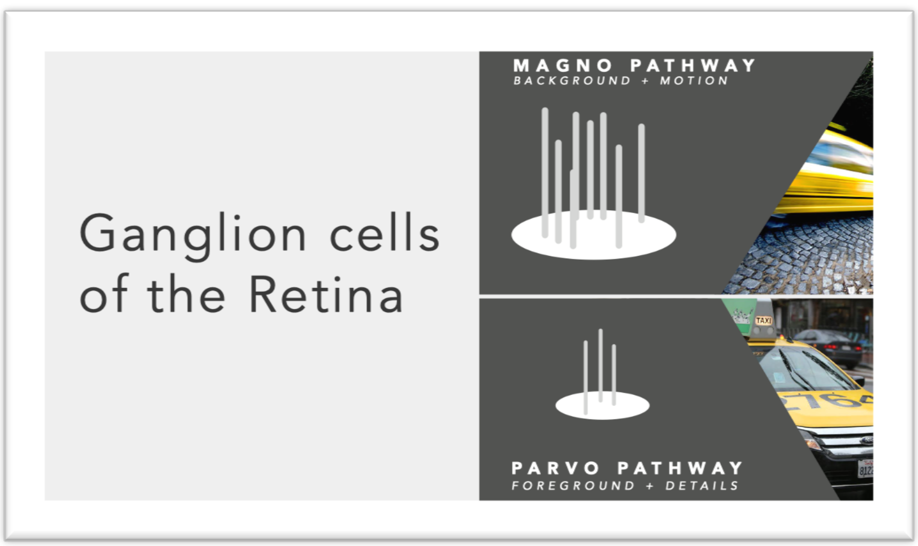
making what was the forefront of attention become the background. If the device is hand-held, it requires information to be received with the head facing down rather than up, which allows at the very least, reception to peripheral vision, such as Google Glass (fig.2). However, with this wearable, the user must focus their field of vision to a very narrow plane within inches of their eyes, causing the environmental to fade into the background.

(Fig.2)

“The prism of Glass is positioned over only the right eye. That means the screen appears to be even more of a ghost than it looks like in these photos, since the binocular picture your brain puts together from your two eyes is absent Glass on the left side. It's hard to get used to, and the effect gets irritating if you use Glass for a long time. Taking breaks is recommended.” [10] This is an unattractive requirement being asked of a user, indicating a gap in design affordance. Furthermore, as exploration of wearables have developed using interface affordances, we have seen an explosion of short-lived smartglass models. Most initiatives are shut down due to investors unable to take the economic risk required to produce. “Intel has certainly made its share of investments in hopes of owning a share of wearable tech, but none have really paid off, and with the category plateauing a bit over the past year, it’s probably a good time to cut its losses. Their most recent product, the Intel Vaunt, seemed promising, but the online glimpse we got of the product didn’t appear to be fully thought out. Of course, companies experiment with hardware prototypes all the time — but most of these things never see the light of day.”[11] This may be attributed to cost since investment interest appears to come from employers looking for ways to increase productivity for specific tasks. If that is the case, then lack of public desirability may lie in the imbalances of affordance, lack of usability, and the preferences of today’s sophisticated users.

[10] (Pachal 2013)
[11] (Heater 2018)

The eye's naturally narrow field of vision has a very specific function as shown in the following article excerpt – "Several physiologically and morphologically distinct types of ganglion cells exist [in the retina]. One, known as the magno cell, responds rapidly to stimulation, has thick axons with more myelin and large receptive fields (i.e., collects information from several cones). Another type known as the parvo cell, has thin axons with less myelin, responds slowly to stimuli and has smaller receptive fields. In the LGN, distinct layers of magno and parvo cells can be identified using several staining methods. Magno cells collect information from all types of cones; hence they detect 'luminance' and can signal motion, stereopsis and depth. The parvo system is mostly used for detection of 'chromatic' modulation, and thus the form and material of an object. Their processing pathways also differ: magno cell information is processed through the 'where' pathway to the parieto-occipital cortex, while information from parvo cells is mostly processed through the 'what' pathway in the inferior temporo-occipital cortex. [12](fig.3) The same article points out that processing speed is faster in the Magno pathway, allowing for a quicker response. It may be deducted that interfaces that have approached directional navigation cues using the parvo pathway might be in opposition to how we most efficiently perceive and process visual information. Future solutions might discover exciting new opportunities when the physiology of sensory perception is included as a design affordance.



(Fig.3 Illustrated example of magno pathways with correlating images of a car (Photographs provided by

[12] (Callaway 2005)

Pexels.com and altered by auther) showing that our peripheral vision is naturally adept at receiving location and motion cues.)

Exploration of Alternate Human Sensory Perception Affordance

Inclusion of sensory affordances might lead to unexpected results. According to neurologists, human's actually have nine senses. Besides hearing, sight, smell, taste, and touch, there is equilibrioception (balance), nociception (pain), proprioception, and kinanesthesia (joint motion and acceleration).[13] For the specific purposes defined here related to navigation, none of them uncovered any definitive results, but future exploration should be taken into account when considering alternate stimuli.

The notes derived here were either with direct observation or experimentation and while visiting an exhibition, “Designing for Senses” at the Cooper-Hewitt Museum in New York City in the Fall of 2018. Organized by Ellen Lupton, senior curator of contemporary design, and Andrea Lipps, assistant curator of contemporary design, the exhibition includes work by more than 65 designers and teams and reveals how sensory design can solve problems and enhance life for all people, including those with sensory disabilities. The exhibit showed how contemporary designers are experimenting with materials, technology, and embracing the differing needs and experiences of users, in order to heighten sensory awareness and improve daily life. [14] The benefit of approaching accessibility as a design tool gives options for everyone, regardless of how they interact with their environment. An audio excerpt from “UX Podcast #196,” titled “Accessibility for Designers,” released on October 25, 2018, brings this to light by about how parents are essentially one-armed for 3 years or more and how accessibility solutions are beneficial for those with temporary situations as well.

“Across all industries and disciplines, designers are avidly seeking ways to stimulate our sensory responses to solve problems of access and enrich our interactions with the world,” said Cooper Hewitt Director, Caroline Baumann. “The [exhibition and its contributors] shares their discoveries and invites personal revelation of the extraordinary capacity of the senses to inform and delight. Within the inclusive environment created for the exhibition, there will be over 40 touchable objects, as well as services, such as audio and visual descriptions of the works on view, to ensure the exhibition will be welcoming to visitors of all abilities, an important step forward in our ongoing commitment to making Cooper Hewitt accessible to everyone.”[15] Although less than nine senses were explored at this particular

[13] (Tomi Nukarinen 2014)

[15] " (Baumann 2018)

event, the following lists those that are considered to have potential value related to navigation cues from first-hand observations. They are all valuable, particularly from a conceptual perspective, but unrefined in terms of validating a user. An example of one of the most fascinating experiences was an exhibit linked to smell and a phrase that described a common human experience.

> "…Six low white pillars glow with light. The pillars are about 10 inches square and 30 inches high. This piece is called Dialect for a New Era (0104). The top of each pillar is inscribed with a text naming a unique emotion. Here's what the first says, "The feeling for someone once loved but no longer." This text also appears in braille on the back of each of pillar. On the right side of the pillar is a button. When I press the button, the pillar glows more brightly, and a delicate scent is released. I bend down to smell it. Think about it. In daily life, we often associate a smell with a special place or person, and that smell becomes a part of our memory. This piece invites us to build new memories."[16]

The goal of a designer in this position is to acknowledge potential usage or affordance while being willing to objectively eliminate those that are not confirming of desired outcomes. This can be seen in the following self-reported experiences from this exhibition:

- **Smell:** An interesting and lesser-utilized sense, smell taps into the memory center allowing a user to heighten their recollection of an event. However, it is highly subjective and not likely to give a clear direction. It would also be reliant on a user's ability to be unreactive to allergens and other environmental factors – Does not appear to be a reliable affordance

- **Tactile:** Haptics are currently a common tactic to alert a user to an event. However, it currently doesn't have a currently language for the masses. Attentional cueing using haptics has been shown to decrease reaction times [14] compared to visual cues. In another study [9] using audio cues, conflicting message semantics and sound-source location led to an increased error rate. [17] Its benefit is that it can

[16] (Baumann 2018)

[17] " (Nukarinen, et al. 2014)

be used to alert a user to an event, then another sense can be used to deliver more complex information in a non-obtrusive manner" – Sense appears to be a reliable affordance within constraints

- **Sound:** Sound can mimic similar qualities as haptics, but is not inclusive to all – Sense appears to be a reliable affordance for the majority, but may exclude the majority from interacting with others or be in conflict with other audiological cues

- **Peripheral Vision:** Several experiments and testing of products showed that utilizing the visual periphery was similar to receiving information from the environment, also used in theoretical approaches such as invisible (ubiquitous) computing in the early 1990's – Sense appears to be a reliable affordance for most people

These were examples of first-person observation and how it is applied from a related field of expertise. However, if a consortium agreed to adopt relevant principles that bridge the contrasting views of affordance, exciting discoveries may appear.

Conclusion

Interaction design principles may find a bridge between Gibson's and Norman's affordance by integrating perception. To do this successfully, principles of affordance should include physiological properties of the majority and provide error forgiveness for nominal differences. This should hopefully translate into a minimum info needed to have confidence in a path. The desired outcome is to guide the user through the computer, not with it. This means the computer's behavior should be ubiquitous until a human query demands an answer, then the classic definitions of Interaction Design Affordance apply. Use a telescopic model of guidance, with general cues, providing the minimum information needed until more is required. An example could be that the use of haptics appears to be useful as general alerts, allowing the user to stay engaged in Gibson's definition if necessary, then peripheral visuals proved directional cues, followed by specific confirmations as is shown in the realm of interaction design. Ideally, navigation would be as effortless as nature's encoding of orientation in our fellow animals. Being able to find untapped abilities are key to finding an optimal relationship between Environmental Design Affordance and Interface Design Affordance.

In conclusion, the process of discovery will not culminate in a perfect solution, but it will come closer to finding the integrity of our experience.

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