

Sound in Product Design

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Preface

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Abstract

This paper examines sound as an element of product experience by surveying how sound and audition contribute to usefulness, usability, and desirableness. Sound is a useful tool for enabling and augmenting product interactions, but one for which few resources exist for the practicing designer to turn to. Those resources that do exist tend to focus on particular uses of sound, while I argue that sound must be considered first as an element of interaction and experience.

INTRODUCTION

This paper examines sound as an element of product experience. Sound is a useful tool for enabling and augmenting product interactions, but one for which few resources exist for the practicing designer to turn to. The topic is particularly relevant at the current stage of technological development, because high quality sound can now for the first time be cheaply included in almost any product. I believe that practicing designers, many of whom make decisions about product sounds (or that preclude the use of sound), can benefit from exploring how non-visual interactions contribute to and effect product experience.

Historically, sound has rarely received great attention from product designers and the design community at large. This is not surprising, given that Interaction Design as a discipline arose largely from the fields of human-computer interaction (itself based in computer science), and communication design (which has traditionally been concerned with issues of visual display and aesthetics). Neither of these realms of study has a strong history of working with sensory modalities other than vision. My personal experience has been that modern products rarely realize the full potential of sound to enable engaging product experiences.

When design professionals have examined sound, the focus has most often been on how sound can be used to transmit information, rather than how it affects the gestalt of product interaction. In the 1970's, for example, Deatherage (a human factors researcher) published an early framework for considering sounds in human-operated equipment. His guidelines focus strictly on the use of sound for functional purposes and rest largely on the notion that sound is most appropriate as a means of transmitting information while relieving the eyes [1].

In the 1980's sound began to receive more widespread attention, beginning with the work of Sarah Bly. In 1982, Bly demonstrated the use of data sonification techniques and experimentally determined that sonic representation could improve people's ability to find patterns in certain data [2].

In 1989 a special issue of the journal Human-Computer Interaction was devoted to non-speech sound at the interface. The issue contained an introduction by Bill Buxton and three important articles by Bill Gaver, Meera Blattner et. al, and Alistair Edwards. Gavers' article detailed the SonicFinder, an auditory overlay for the Apple Macintosh operating system that revolved around the use of everyday listening skills (dubbed "auditory icons") to transmit information at the interface [3]. Blattner et al introduced the concept of "earcons" - single pitches or rhythmic sequences of pitches used to represent information[4]. Finally, Edwards detailed the design and

testing of an auditory word processing program for blind users [5]. All of these designs focused on methods for transmitting discrete information with sound rather than discussing sound as means for creating better products.¹

In the 1990's research into sound focused primarily on computer interfaces and remained an inquiry into its functional potential. Beginning in 1993 the International Community for Auditory Display held annual meetings, publishing the proceedings of their first conference in a volume edited by Gregory Kramer. This publication, which remains a key resource today, contained articles related to psychoacoustics, data sonification, auditory icons, earcons, and sound synthesis methods [6]. All of the articles, however, were concerned with how to use sound, rather than developing a framework for considering sound as an element of experience.

Other research has also provided interesting frameworks for discussing sound. Ferrington has proposed a set of five categories of information that can be presented with sound, including physical activities, invisible structures (thing that cannot be seen), dynamic changes, abnormal structures (invisible structures that are not functioning as expected), and events in the world (spatial information) [7]. Macauley et al. revised these categories to include visible entities and event, hidden entities/event, imagined entities (considering what a sound might mean), patterns of events, the passing of time, emotion, and position in space [8]. Both of these frameworks center on the transmission of information.

Too little research, however, has approached the questions of designing with sound from a holistic perspective. That is, though great progress has been made in examining how sound contributes to products in a variety of specific ways, there has been very little written on how sound can positively impact the gestalt of product experience. If we consider, instead, the design community's treatment of visual interfaces, we find a focus on the way people interact with products. Great emphasis is routinely given to visual interfaces as a tool for creating engaging interactions and experiences. I believe that by framing the issue of sound in products through the useful-usable-desirable lens, we can begin to better understand the role of sound as an element of product interaction and thus see how it contributes to overall product experience.

It is worth noting that this approach is not meant to be empirical—I have not conducted experiments or formal case studies regarding how sound is best used (as many of the authors mentioned above have). I believe, however, that existing research lacks appropriate theoretical framing.

¹ This is not to say that no mind was paid to why sound should be used. Gaver, notably, began his paper with a section titled "Why Use Sound?" The focus of his paper, however, was on how sound could be used to provide information, rather than how it improved the product experience.

Designers need a way to think about sound as an element of experience when designing. With a deeper understanding of sound as a component of experience, designers will be better equipped to make good use of this powerful tool.

The useful-usable-desirable dimensions are an effective perspective for constructing a holistic picture of gestalt product experience because of the way each dimension overlaps, contributes to, and influences the others and because of the impact each framing makes on its own. By considering the three dimensions together and looking at how they overlap in regards to sound, we can paint a clearer picture of audition's role in products. The terms do not represent categories, but rather are a means for designers to place their thinking about a design. An Eames Lounge chair can be considered useful insofar as it affords sitting, usable because it is comfortable and small enough to fit through the average home doorway, and desirable because it is beautiful. None of these stands alone, however. As Don Norman has argued, for example, beauty actually improves users' perception of usability [9]. Jonathan Cagan and Craig Vogel (who popularized the useful-usable-desirable framework), have argued that a product is only truly valuable when it excels in all three areas [10].

This paper examines the many ways in which sound can be used to create or promote usefulness, usability, and desirability in products, with a focus on how the interplay between the three creates engaging interactions. I cite research where it exists and give examples (both good and bad) as often as possible. It is my hope that after reading this paper the reader will feel better equipped to consider sound and audition while designing. For the purposes of illustration only, this paper is separated into sections focused on usefulness, usability, and desirableness. As previously mentioned, however, the dimensions should be considered simultaneously and jointly in the actual design process.

Sound and Usefulness

Merriam-Webster defines useful as “capable of being put to use; especially: serviceable for an end or purpose.” Alternatively, Cagan and Vogel have defined a useful product as “one that satisfies a human need, is capable of being produced at reasonable cost, and has a clear market” [10]. In design, useful might be considered the basest aspect of products because it is entirely relative to context. A scrap of cloth may be a useful filter if one is lost in the desert and comes across a dirty puddle, but would never be considered so in a normal situation. Furthermore, usefulness is a vague concept because one can reasonably take a broad definition of the term. A souvenir bauble, for instance, may be considered useful because one likes it. It performs the function of sitting on a

shelf collecting dust and stirring certain emotions and memories when gazed upon.

On the other hand, usefulness is potentially the most important aspect of any product. If a product truly serves no purpose, then it cannot, by definition, be usable and will be desirable to very few. I define usefulness in regards to products as “serving a particular needed function.” That is, for a product to be useful it must serve as a tool for a specific and required purpose.

Sound is an important tool for creating useful products. Sound can be used alone and can also augment other modalities to allow functionality that could not otherwise occur. In order to best understand how sound can contribute to usefulness, it is helpful to first examine some unique properties of sound and audition.

Stephen Brewster, a prolific researcher of sound in digital interfaces, has proposed a number of “advantages offered by sound,” that elucidate sound’s functional capacity. One of the most well-known aspects of sound is that it is attention grabbing and does not require focus: people can choose not to look at something, but it is much more difficult to avoid hearing it [11]. Our ears are always on, even (to some extent) while sleeping. This aspect of audition no doubt helped us survive as a species in earlier stages of our development, and continues to offer important opportunities for product designers today.

In particular, the “always on” nature of sound means that it serves as a highly effective medium for alarms and alerts. From the toaster in the kitchen, to fire alarms and phone calls, designers have taken advantage of sound as a way to inform users that some event has occurred that may require immediate attention. Generally speaking, this use of sound has fallen into two categories: alerts signaling completion of an operation, and alarms drawing attention to an immediate concern. The first category includes products such as microwaves, 1960’s Teletype machines (which rang a bell after a transmission was completed), and teakettles. The second category includes fire alarms, ambulance sirens, and alarm clocks. Sonic alarms work well because sound does not require focus or line-of-sight. Without sound, we would not see that an alarm had gone off until we actually looked at it.

Perhaps because alarms and alerts are one of the most common uses of sound, they are also the most widely abused. Anyone who has used a PC has undoubtedly suffered the jarring noise of a Windows alert. More often than not, these alert sounds accompany a modal dialog box that pops up in front of whatever program is currently active. In such cases, the visual interface suffices to alert the user, making the sonic alert redundant. Redundancy in alerts is only appropriate when there is substantial reason to believe that the user may not otherwise notice the alert message, which is clearly not an issue when a modal dialog box pops up over a piece of software

that a user is currently engaged with.

The Windows example also illustrates the interdependent nature of usefulness, usability, and desirableness. Cooper and Reimann have pointed out that error alert noises act as “a public announcement of a user’s failure” because they are “negative audible feedback” [12]. Many alert sounds, which serve a specific function, therefore reduce the desirability of a software product (because no one wants their failures publicly announced), and may even harm usability if users go out of their way to avoid them.

A much better implementation of sound as alert can be heard in Google’s Gmail. Gmail, a web-based email application that allows a user’s contacts to initiate a chat session any time one is logged on, makes a sound (redundant to a simultaneous visual alert) when a chat message arrives. The sonic alert is appropriate in this case because people often keep their email open while they work in other applications (and thus are unlikely to see the visual alert). Furthermore, the sound represents a positive rather than negative alert. In this example, sound is used to serve the function of alerting a user of an immediate concern, and in so doing also increases the usability of the application (by making it easier to perceive the alert).

The “always on” nature of our ears also means that humans are very good at ignoring sounds that they do not want to pay attention to (what Brewster has called habituation) [11]. John Cage is said to have once sat in an anechoic chamber for some time. When he exited he remarked to the engineer on duty that he heard two distinct sounds – one high and one low. The engineer told him that the high-pitched sound was his nervous system and the low one his circulatory system. Most of us, however, rarely (if ever) perceive these sounds because we have learned from birth to ignore them and are usually surrounded by other louder sounds regardless. The implication of our propensity for ignoring sounds is that sound can be a useful medium for providing ambient information because a well-designed continuous sound is often not noticeable until it changes or stops.

Automobile engines, for example, produce a wide range of sounds that one rarely pays attention to. Sometimes, however, they produce unusual sounds, signaling that a trip to the repair shop is needed. Another example is the clicking of a computer’s hard drive as the disk is accessed. This sound is rarely noticeable, but can be listened for at will to know whether the computer is reading or writing to disk. The use of ambient sound to gain information is actually a basic fact of human psychology. Our ears constantly scan our physical environment, ignoring sounds that provide little information and alerting us to ones that might signal something more interesting.

In a functional manner, ambient sound is most commonly found in mechanical products.

Sound, after all, is only vibrations in the air, and so anything with moving parts will produce some sound. Ambient sound is often how we discover and diagnose mechanical problems, be it in a moped or a laser printer. Skilled mechanics, for example, can often properly diagnose an engine problem from the sound alone. In this way, sound serves the purpose of providing users with information that cannot be easily obtained by any other means. Again, this use of sound may also be considered an aspect of usability because it makes solving these mechanical problems easier, or even desirability because consumers are likely to prefer a product that can be fixed easily over one that cannot.

It should be mentioned that the ambient use of sound for functional purposes can have a formidable negative impact on a product's desirability as well. If ambient sounds are not providing desired information, then they quickly become noise. For this reason designers must be very careful when designing ambient sound. Such sounds must be acoustically designed to minimize the risk of becoming noise and should generally turn themselves off if the information being provided is unlikely to remain continually helpful. Cooper has argued that the reason users complain of annoyance from sounds is that most interface sounds are used almost exclusively for negative feedback [12]. Alternatively, Brewster has argued that loudness of interface sounds is primarily to blame [11].

Another aspect of sound and audition that proves useful is its "superior temporal resolution" [6]. That is, people are capable of perceiving shorter duration sound events than visual. Animations generally run at thirty frames per second because humans cannot readily perceive visual stimuli that are shorter. The human ear, however, easily perceives sonic events of less than 10 milliseconds in length. Perhaps because of this, humans can sometimes react faster to auditory stimuli than to visual. Our auditory system is thus well suited to real-time monitoring of information for which reaction time is a factor.

Sound is extremely effective at imbuing products with emotion. This aspect of sound is closely related to desirability, but may be considered a function as well. Video games have used the emotionality of sound to great advantage. The simple music of Space Invaders sped up as the player progressed through the game, creating a purposefully heightened state of anxiety in the player and adding intensity to the experience of play. More modern 3D and virtual reality games use recognizable sound effects to inform players of events occurring outside of their direct field of virtual vision and also make use of music to enhance the emotion of in-game situations. Sound in these examples, serves the users' need for intense engagement with a game.

Thus sound is a great tool for creating useful products because it enables purposes that are

otherwise difficult or impossible to facilitate. Sound can grab attention in ways that are impractical via other sensory modalities, serving effectively as an alert or alarm, can be used to display real-time events too short to be perceived by the eye, is well suited to serving up information ambiently, can engender specific emotional response with surprising accuracy, and provide information that is impractical to display visually.

Sound and Usability

According to Cagan and Vogel “a usable product is one that is easy to operate, easy to learn how to operate, and reliable” [10]. The Usability Professionals’ Association defines it as “the degree to which something - software, hardware or anything else - is easy to use and a good fit for the people who use it” [13]. There are many definitions of usability, but almost all center around ease of use and, when relevant, efficiency.

Sound has the potential to make many products easier and more efficient to use. In particular, sound is a wonderful mechanism for giving feedback and providing predictive information, complements graphic user interfaces well, and can make products more accessible to the visually impaired.

Humans have used hearing to obtain feedback as long as we have been a species. Auditory feedback is present in any physical product with which we interact: we know when we have finished tearing a paper towel off of a roll from the sound as much as the sight and touch; we know that a bottle of Windex is working from the squirting sound that it makes when we pull its lever; we know that we are indeed scrolling on our ipod from the clicking of the wheel.²

Jonathan Grudin, a Principal Researcher at Microsoft, relates the following story regarding sound and feedback in digital products in the early 1980’s: “Computer keyboards no longer clicked the way mechanical and electric typewriter keyboards did, but people expected the click, so we programmed the computer to make a clicking sound. The question that arose was, when someone tried to type text into a read-only field, should one click or not? By not clicking you could signal that the key wasn’t accepted, but you would violate the mechanical key metaphor. Which would people prefer? ... it was decided to issue the click (preserving the illusion it was a mechanical sound) followed by an error-alert “beep!” to indicate that they key was not selected. The concern was that silence would lead a user to feel they hadn’t hit the key hard enough, or that the key was broken, or something” [14].

Part of what is enlightening about Grudin’s story is the multiple levels of feedback that

² Interestingly, the scroll wheel on many iPods is designed to produce both a physical clicking sound and an electronically generated one, thus providing feedback to the user whether or not they are wearing headphones.

were provided with sound. Grudin and his team designed the system to produce sound as feedback that a key was clicked and that the keystroke could not be accepted (using a different timbre).

Since the time of Grudin's story, technology has advanced and designers can now take advantage of digital technology to produce almost any sound in any situation. The result is that designers can now create products that offer multimodal feedback rich in information content, making products significantly easier to use.

Brewster and Clarke, for example, have shown that earcons are an effective way of reducing selection errors in a simple tool palette. In their article, Brewster and Clarke describe an experimental interface for a typical graphics program. Tool selection in programs such as Adobe Illustrator, they point out, is problematic because users' full visual attention is given to the drawing in progress rather than the cursor or palette. As a result, people using such programs frequently select a tool other than the one intended and begin an action before realizing the error. Brewster's interface contained a toolbar that was "sonically enhanced" to provide auditory feedback regarding which tool was selected whenever there was a change. The experiment showed that earcons did indeed improve usability as measured by error and success rates [15].

Brewster and Clarke's experiment is particularly interesting because it elucidates how sound can improve usability in a relatively common situation; sound can make products easier to use whenever a user is focused on a visual task but requires additional information. Sound could, for example, make high-end cameras more usable by providing light-meter information while the user is focused on framing a picture (rather than forcing them to look elsewhere in the viewfinder as such cameras currently do).

A much simpler use of sound to increase usability is found in many appliances such as microwaves, coffee makers, cell phones, and touch screen mobile devices. These products, which often have flat physical buttons that do not provide significant haptic feedback or produce an audible sound as a natural consequence of being pressed, generally beep to inform the user that they have been activated. This type of beeping is similarly found in grocery store scanners, which beep to let the cashier know that a UPC has been read and processed. Sound makes use of these products more efficient because the user's focus can move to where it is needed to begin the next action. In the case of phones and microwaves, this means that we can continue looking at the keypad in order to find the next button that must be pressed without referring to the visual display to check that we have indeed pressed the last button successfully. In the case of supermarket scanners, it means that cashiers can be looking towards the next item on the conveyor belt instead of watching the register display to confirm that the last item was successfully scanned. It is hard to

overstate the importance of this very simple mechanism – sound can (and generally should) be used to provide feedback whenever users are engaged in tasks that require their hands (and thus their eyes) to be constantly moving onto a new action. This principle is increasingly important now, as touch screens become prevalent. In most touch screens, haptic feedback is entirely lacking and one's fingers visually obscure whatever object is being pressed – sound is thus the only practical way to provide proper feedback.

Audible feedback is often misused however. Microsoft Office installs with all sounds turned off by default, likely because the included sounds (most of which take the form of redundant feedback) proved so unpopular with users. Cooper and Reimann have argued that sound has traditionally been misused in interfaces because it most often signals something negative. In the physical world sound almost always occurs as an indicator of success. The solution, they propose, is not less sound but more: computers should offer “constant, small, audible cues just like our keyboards,” and use silence to signal problems [12].

Brewster has pointed out that sound is an effective tool for augmenting visual interfaces for several reasons. First, sound can reduce the cognitive load on a user's visual system. As computer screens become larger and multi-screen displays become common, users are expected to attend to larger and larger amounts of visual information. Appropriate use of sound can reduce the amount of information required on screen and simultaneously spread the cognitive load between senses. Using sound in this way can be particularly helpful when designing mobile devices, which often have very small screens to which users are unable to give their full visual attention [11]. Sound can thus be used to make products with visual interfaces less cumbersome by providing alternative forms and channels of information.

Sound is also a good way to enhance usability by providing predictive information. Though products designed to use sound in this way are uncommon, many mechanical products do so inadvertently. An air conditioner, for example, may start to rumble in an unusual way long before actual malfunction occurs. If the sounds it makes change, one is likely to notice and call a repairman. A designed example of sound used to provide predictive information is the consumer smoke detector. These simple household alarms often begin chirping as their batteries wear down, alerting the user to replace them lest it lose its ability to sense smoke. Without this use of sound, smoke detectors would hardly be usable because one would be unlikely to notice when their power ran out.

Finally, sound can be used to make products usable for the visually impaired. In 1989, for example, Alistair Edwards demonstrated an “auditory interface for blind users.” Edwards' design,

called Soundtrack, is a word processor in which “tones are used to communicate imprecise information quickly and [synthesized] speech is used to give more precise information more slowly.” Though Edwards’ principal conclusion was that there was more work to do and recent work on interfaces for the blind has focused more on haptics, multimodal feedback can greatly assist users with partial visual impairment [5].

Sound and Desirability

Finally, sound is a powerful mechanism for making products desirable (and undesirable). Vogel defines a desirable product as “one whose technology, function, appearance, and market positioning make customers want to own it.” Alternatively, Merriam-Webster defines desirable as “having pleasing qualities or properties.” For my purposes, I consider a desirable product one that people want to own. Sound is a potent force for making products desirable because, due to its nature, it can stir emotions in users that might not otherwise occur. Sound can also give products a character that people desire and instill a richness that is often lacking in digital products. Last but not least, sound is a powerful means for enabling personalization.

One group of products that frequently takes advantage of music to create emotional response is children’s toys. A quick glance at the Fischer-Price website turns up numerous examples, from “Singing Birthday Elmo” to “Little Super-Star Sing Along Stage.” Research around sonic toys has shown that children find them engaging, and often respond to sonic stimuli with great interest [17], [18].

Video games also take advantage of sound to stir emotion, often in strikingly different ways. Fantasy role playing games, for example, often contain classical scores written by established composers to manipulate players’ emotions, though the audience of these games rarely listens to orchestral music otherwise. In another way, horror games will often utilize creepy sound effects (such as distant screams and footsteps) that have no bearing on actual game play, but that heighten the player’s sense of anxiety. This is an issue of desirability (rather than function) because emotional stimulation is a key reason people play video games. A 2007 report by the British Board of Film Classification (which assigns age ratings to video games in the UK) found that “people play games to escape from every day life and to escape to a world of adventure without risk” and that “games provide a sense of achievement.” These emotional responses are in part reinforced through sound and music.

For an example not centered on play, one can look to a spa or massage parlor. These service outlets almost universally play slow ambient music intended to calm the customer because re-

laxation is a large part of why people visit a masseuse. Similarly, an entire range of products exists with the sole purpose of relaxing people through sound, from “Soothing Sounds” music albums to tabletop Zen fountains. In these examples, sound makes the product desirable because of the emotions it stirs. On the other hand, the use of sound for relaxation is the function of the product, and so is a manifestation of usefulness as well.

Sound is also an important medium for giving products character. Character refers to the intangible qualities of something that give it its unique nature. A classic example is the roar of a Harley Davidson motorcycle. Though the sound is partially a consequential result of the combustion engine, and plays a functional role in alerting other vehicles of the motorcycle’s presence, it need not be nearly as loud or full sounding to accomplish either purpose. A Harley just wouldn’t be a Harley, however, without a deafening rumble; such is sonic character.

A good example of sound as character in digital products is the 1970’s computer game Pong. Pong made a repetitive beeping noise during play that served no functional purpose (the game could be played equally well with the sound turned off), did not aid in learning or playing the game, and that was too simple to stir a specific emotional response. Pong simply wouldn’t be Pong without the sounds, however, and its signature sound remains highly recognizable today. Ambient sound is also commonly used by retail stores, which play a particular kind of music to help flavor their brand. Starbucks has taken this to an extreme, publishing albums of the music played in their stores, perhaps as a tool for securing brand loyalty. Similarly, nightclubs often base much of their brand in the music they play, using the sounds of their establishment as a primary lure to customers. Sound is thus used as a tool for constructing a desirable brand.

A final example of sound as character is that of a car door. Auto manufacturers have found that the sound a car door makes when closed is important to consumers as an indicator of vehicle quality. As a result, companies have done much research into the acoustics of car doors in order to design a sound that resonates well with potential buyers.³

It should also be noted that sound acts as a source of character to some degree regardless of whether it is intended to. This means that designers must always think about how sounds will affect a user’s feelings about a product or risk including sounds that may give a negative impression of character. Many examples can be found among the annals of failed video games; because sound is an important element to electronic games, it quickly ruins an entire game experience

³ For an in-depth look at how people respond to the sound of a car door see “Analysis of a Car Door Closing Sound Quality” in *Applied Acoustics* Volume 69, Issue 1 (January 2008). For a non-mechanical and non-digital example, think of fine wine glasses, which are expected to create pure beautiful tones when clinked together.

when done badly.

Sound is also an important way to add richness to products. Richness is a fuzzy term I use to describe the feeling that using a product is an experience worth remembering. In practice, richness is difficult to measure or predict, but plays an important role in how desirable a product it. An example of a truly rich product might be a Steinway Piano. Steinway's are beautiful to look at, feel perfectly put-together under the pianist's fingers, produce rich beautiful tones, and even give off a faint smell of wood, oil, and metal. Richness, then, has much to do with proper engagement of multiple sensory modalities, an area digital products have traditionally been lacking in.

This is not to say, however, that any sound will make a product richer – sound choices must be made very carefully and designed to be appropriate to the product. Furthermore, richness, as defined here, may not be appropriate in products such as productivity software, where the primary concern is function and efficiency. In consumer products, however, great opportunities exist to increase richness through sound. Imagine, for instance, that a microwave produced beautiful resonant sounds instead of a simple beeping. Such a microwave would undoubtedly feel richer and better designed than the beeping boxes many of us are accustomed to.

Finally, sound is an incredibly potent tool for allowing user customization in digital products. Customization generally refers to users changing the visual appearance of a product (whether it be software or a physical object), but applies also to the sounds of a product. Dan Saffer has pointed out that designing for customization is an important way to “facilitate a tighter bond between users and their tools” because users gain greater emotional attachment through the process and results [19]. The potential for customization can thus make products desirable because users want to own products with which they expect to form a close bond.

A great example of customization through sound in software is the MySpace social networking site. On MySpace, users can pick a selection of songs for their personal home page from any band also on MySpace. The result is that visitors to that page are greeted with music of the page owner's choosing. This feature has proved incredibly popular – it is in fact quite difficult to find a personal page on MySpace that does not include music (though it is not included by default).

Another example of customization through sound is cell phone ring tones. In recent years, as cell phones have become capable of playing high quality downloaded audio clips, custom ring tones have become an industry by themselves. The market for mobile ringtones in the United States, for example, generated more than \$500 million in 2007. Now, a market is growing in ringbacks – custom tones played to the caller when one's phone is dialed. Even phones that do not

support the downloading of ringtones generally come with a selection of different ringtones for the user to choose from. As anyone who has spent time in a college lecture hall can attest, customized ringtones are now the norm.

As these examples show, people gladly use music to customize their products. It is also interesting to note that the sounds in MySpace and cell phones are all sounds that other people are likely to hear. Customized sound in products is thus used as a form of outward facing self-expression. The ability to customize a product's sounds with personally selected music is thus a powerful tool for enhancing a product's desirability.

Conclusion

Sound can contribute to product experience in myriad ways, but is too often overlooked in the modern practice of experience design. If designers are to make more effective use of audition then they must begin considering sound holistically. Prior research has not examined sound from the perspective of product experience, and I believe that this is why sound still plays a relatively minor role in most products and design processes. The design of digital products has traditionally relegated the consideration of sound to the end of the design process. In order to best take advantage of the possibilities sound has to offer, designers should begin considering the sound as an element of user experience at the concept-generation stage.

As I have discussed above, sound and audition have much to contribute to products in the diverse realms of usefulness, usability, and desirableness. The trick however, is to consider audition equitably with vision (and other modalities) when defining a design's solution space. By approaching multiple senses as equal contributors to product experience, and combining knowledge about what each modality can bring to a design, designers will enable more engaging and fully realized product experiences and interactions.

In future work, I hope to develop simple methods and frameworks designers can use to help in considering audition (and other non-visual sensory modalities) during the normal design process. I believe that looking at common examples, as I have done in this article, is a start, but designers would benefit further by having distinct mental tools and models that can be used to ensure proper consideration of multiple sensory modalities when searching for a design solution.

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