Living with Hyper-reality

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Abstract. Hyper-reality describes distributed computing interfaces that weave existing environments with additional channels of sensory feedback to enhance everyday activities without confusing users. To be intuitive and non-intrusive these interfaces use illusionary pre-attentive content that is co-located with the objects and surfaces of a space and synchronous with a user's actions. Interfaces for an office, a laboratory, a kitchen and a public hallway are presented along with user studies suggesting that augmenting sensory feedback has the potential to simplify tasks and make them safer, while expanding the potential for interaction with everyday environments.

1 Introduction

In the early 1980s French social theorist Jean Baudrillard coined the term 'hyper-reality' to describe places that feel more real than the real world by blending an existing environment with simulated sensations [4]. A decade later Mark Weiser predicted a future of 'ubiquitous computing' in which intelligent machines distributed throughout the real world could sense and serve our everyday needs [34]. Since them many kinds of reality-based interaction have been proposed that seek to make digital interfaces more natural by distributing them through the objects and spaces of the real world. Virtual reality, augmented reality, tangible interfaces and ambient displays all propose means for adding new channels of digital information to the real world without overwhelming users. We are becoming accustomed to representation as a growing part of our lives. Much of our work and play occurs through computer interfaces. Projectors, television and computer monitors are becoming larger and the quality of simulated content more illusionary. It is becoming possible to merge the real world with simulations that enhance our actions and create new sensory experiences. At the same time, many of the tasks we perform on a daily basis are under-represented and lack feedback. The electric devices we rely on use simple sounds, lights and alphanumeric displays to inform us. Few of the appliances in our homes and offices can attract our attention when needed, leading to mistakes or just plain waste. In the modern kitchen, for example, mitigating the dirt and smell of cooking has correspondingly muted visual and tactile feedback, both useful to cooks. But enhancing feedback from everyday tasks is not only useful – it can be expansive, with the potential to make chores more attractive and to lend value to neglected resources. Reality-based interaction can have a real impact on the way we interpret the world around us and the actions we take. Hyperreality interfaces describes a merging of mundane tasks with intuitive, immersive interfaces that lend additional sensory experience. In the continuum traditionally used to characterize reality-based interaction, where virtual reality is at one extreme and reality at the other, hyper-reality can be seen as extending the spectrum of

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how ‘real’ an experience feels by superimposing sensory simulation based on the existing environment (see Fig. 1). Informed by the status of people and tools in a space, hyper-reality interfaces magnify experience of everyday events in a manner that is intuitively understood at a sensory level. By mapping this intuitive sensory information directly to the objects and surfaces of everyday spaces, hyper-reality interfaces can provide greater confidence and control of basic tasks without interfering with others. Because much information is undesirable, these interfaces are designed based on the attention and comprehension of users to be intuitive and non-intrusive. Unlike Augmented Reality, hyper-reality is based solely on the real world, and only provides feedback rooted in the experience – not from external sources. For this reason, it can be considered more ‘real’ than ‘reality,’ especially when used in everyday spaces that are lacking sensory information. Overlaying a task as mundane as using a sink with sensory channels of light or sound can make users more conscious of their actions and have wide-ranging impact – from making the task more pleasant to reducing water waste or promoting better hygiene – without detracting from the task at hand. A number of hyper-reality interfaces for everyday environments have been designed over the past three years. Evaluations of these augmented sensory environments suggest that many mundane tasks could benefit from enhanced sensory feedback to become easier, more pleasurable and to motivate new behaviors.

Fig. 1. Hyperreality describes interfaces that enhance sensory perception of everyday experiences by layering additional channels of feedback

2 Related Work

Ubiquitous computing is making it possible to distribute computational functionality throughout the objects and spaces of the real world in ways that can be useful, non-distracting and expansive. These interfaces types range from totally artificial (virtual reality) to entirely physical (tangible media). They suggest that distributed interfaces can be easy to interpret so long as they are co-located, pre-attentive, and synchronous. In turn, illusionary interfaces can even expand on our sensory and perceptual cognition to promote new behaviors and effect new sensations.

Augmented Reality (AR) seeks to overlay the everyday world with useful information that is directly mapped to the objects and places it refers to. This is typically accomplished by wearing a head-mounted display that can draw text and graphics in the user’s field of view. Such task-intensive interfaces have been proposed for technicians repairing printers, astronauts on spacewalks or even surgeons during an operation [13,14]. Augmented Reality has the advantage of being ‘co-located’ or directly overlaid on a user’s focus of attention, so that it is easy to understand what a specific piece of information refers to. Information can also be projected on the surfaces of a space, making augmented reality suitable for public use by multiple users [29]. But projecting information in the form of text and graphics onto the real world drawbacks: it is cognitively intensive, requiring focused attention on the task, and cannot be scaled. In the *Augmented Reality Kitchen*, graphics and text were projected on the countertops and appliances of a residential kitchen to assist and orient users through a recipe [8]. Users in a pilot study performed recipes more poorly when information was projected all around the environment as compared with following a hand-held recipe, in part because of the cognitive weight of distributed text and graphics and because users could not interpret sequential tasks simultaneously. The main benefit of AR is that it can place information where it can be intuitively understood: in the Media Lab's Counter-Intelligence lab, the temperature of meat in the oven is projected directly onto the food, in Microsoft's kitchen of the future, users can measure out how much flour is needed for a recipe by completely filling in a projected circle on the countertop [27].

Ambient displays offer a means to distribute information in everyday spaces without overwhelming users by communicating pre-attentively. *Pinwheels* are simple paper fans distributed through architectural space that spin to reflect traffic on the local computer server [21]. The *Stock Orb* is a glass bulb that glows a different color according to the performance of the stock market. Ambient displays are designed to be 'glance-able' or 'pre-attentive,' so that users can gather their information without needing to disrupt their principal task [1]. They are often placed at the periphery of vision, providing subtle information in the way that a window lets you remain conscious of the time of day and weather outside without requiring you to interrupt your work. Ambient displays are so subtle that they can also be difficult to notice, let alone comprehend: before an ambient display can be useful, a user must (1)know *that* it exists (2)know *what* it refers to and (3)know *how* to interpret the information [18]. For this reason ambient interfaces are often private, intended to appear decorative to all but their owners. But with intuitive, co-located content, ambient displays can enrich everyday consciousness without interfering with a primary task.

One solution to making interfaces intuitive and informative at the same time are Tangible User Interfaces (TUIs), where everyday objects are imbued with computational power [22]. One reason TUIs are so intuitive to learn is that they provide synchronous, co-located feedback directly mapped to the manipulation of commonplace objects. In *musicBottles*, empty glass bottles serve as 'containers' of digital information that can be physically un-corked to reveal a musical track [23]. In *Urp*, the wooden models of an architect are augmented with projected shadows allowing already useful objects to take on an added layer of information and experience [32]. Because synchronous audio-visual feedback occurs seamlessly with manipulation of the objects (bottles, models), even novice users can understand the relationship of their physical actions and the computer's augmentations. Applying such synchronous sensory feedback to many mundane actions can increase a user's confidence in the task they are performing, even when the feedback is mediated through novel channels of experience.

Reality-based computer interaction also suggests that computers can enrich our everyday lives by transforming mundane tasks into immersive experiences with expansive consequences. Virtual Reality (VR), in which are immersed in a totally artificial world through head-tracking display goggles, has been demonstrated to have significant effect on the perception of pain and fear. Studies show that burn patients can undergo wound treatments with substantially less pain when they are playing a VR game that takes place in a snowy world [17]. This case demonstrates the power of synesthesia or mapping one sense to another (soothing vision to tactile pain). Similar techniques have been demonstrated effective at reducing pain during chemotherapy, and even to help alleviate fear of flying, heights and spiders [30]. Reality-based interfaces can also be illusionary, with the potential to impact the way we perceive and interact on a daily basis. *InStink* uses computer-dispensed perfumes to enrich communication, so that you can smell dinner cooking at home from the office [26]. In *CounterActive*, a kitchen counter projected with recipe tutorials also had the ability to set a unique mood for each meal through sound and video [25]. *Nebula* is a bedroom ceiling projector that can more effectively soothe people to and from sleep by immersing them in a virtual sunset or dawn [28]. Reality-based interaction can also entice new behaviors by enriching everyday experiences, from guiding museum visits [35] to helping kids learn new recipes at home [25]. In one project, the immersive nature of AR is exploited to transform the daily walk to work into a real-world video game [11]. By making an everyday chore fun, such interfaces can encourage people to walk more often, cook at home or visit museums. Because ambient displays operate almost subconsciously, they have also been proposed to subtly motivate lifestyle changes leading to resource conservation, healthy habits and social contact [19,20]. One informal study by the makers of the *Stock Orb* notes that owners of the device check stock quotes less often on their computers, but they trade stocks more often, suggesting that ambient information can be persuasive by keeping users conscious of neglected information while not entirely focused on it [2]. Many persuasive techniques can be effective at motivating behavior change resulting in resource conservation and improved health and hygiene [12,15]. By taking advantage of reality-based interaction, interactive environments can motivate new behaviors without being distracting or confusing.

3 Design

Hyperreality interfaces seek to provide intuitive feedback that is not distracting and has the potential to motivate new behaviors enjoyably. The hypothesis is that overlaying sensory information on everyday actions can make people more conscious of processes in their environment as well as their own actions, from which they may choose to take on different behaviors. By carefully designing distributed interfaces to be co-located, synchronous, pre-attentive and illusionary they can more easily be accepted and provide positive benefits without distracting or confusing from the task at hand. This paper presents four hyper-realities that have been implemented and are being evaluated, beginning with a case study of a faucet. In every case, the system consists of an everyday experience measured by sensors and overlaid with digitally mediated sensory feedback (see Fig. 2).

3.1 HeatSink

In the kitchen, users have come to depend on remote controls and indicators to know the temperature of food and water or the status of the stove. For example, how often do we scald ourselves at the faucet or wait arbitrarily for tap water to reach a desired

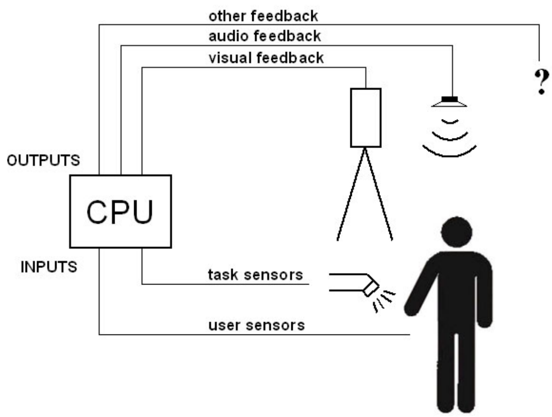

Fig. 2. Hyper-reality architecture: sensors detect the actions of a user and overlay the experience with additional channels of sensory feedback

Fig. 3. *HeatSink* makes the temperature of tap water visible by projecting colored light into the stream

temperature? *HeatSink* is a simple solid-state circuit that projects colored light into the stream of tap water to indicate its temperature intuitively: red for hot fading to blue for cold. Taking a cue from projected augmented reality interfaces, the projection of colored light directly into the stream proves more successful than remote indicators like the control knob because the information is overlaid directly on the user's focus of attention (see Fig. 3). During design, one iteration was considered that maps temperature to a full red-green-blue spectrum like the *Stock Orb*. The final choice of simple red and blue was based on the fact that people do not intuitively understand the temperature of 'green' water; their main concern is to determine whether the water is colder or hotter than their hands before touching it. By using various intensities of only two colors, *HeatSink* displays only the minimum essential information and does not inconvenience the task at hand or require prior knowledge.

In a study, 16 novice users aged 18-48 were asked to fill cups alternately with very hot and very cold water with or without the aid of the *HeatSink*. Observation and questionnaire answers reveal that over 90% (15/16, $p<.05$) understood the colored light during their first use and were able to fill containers with hot or cold water without touching the stream, suggesting that this example of increased sensory feedback was able to motivate behavior change almost instantly. In addition to performing its function, the device has been seen by hundreds of visitors to the lab and their comments have helped understand why it is so effective. The synchronous illumination and illusory color make it immediately apparent what is going on. It is comforting to have feedback on something you are doing, even if you could find the information our other ways. Finally, the lack of a need to touch the water makes itself evident when you see the light. This simple device prompted the development of more interfaces for the sink (*SmartSink*), the kitchen in general (*Cooking with the Elements*) and public spaces (*gurgle*). Since its first public presentation in 2004 [5], similar systems have been put in production by at least one faucet manufacturer [16].

3.2 SmartSink

Fresh water is one of our most important resources, yet the way drinking water is distributed effortlessly makes it likely to be ignored or wasted. Interaction with water can have serious consequences for health and hygiene as well – proper hand-washing is the most effective way to spread infection [10], yet many health care workers do not wash their hands as often as they should (less than half the time according to some studies [33]). I was part of an interdisciplinary team that sought to discover new interface possibilities for water with the *SmartSink*: a platform for experimentation consisting of a working, sensor-laden sink installed in a laboratory [3,6] (See Fig. 4). Digital video cameras mounted to the faucet are used to identify the kind of action being performed (washing hands, filling a container, washing fruits, etc…) through image recognition. Based on the action being performed, lights in the stream of water and a small speaker provide positive feedback to try and motivate water conservation,

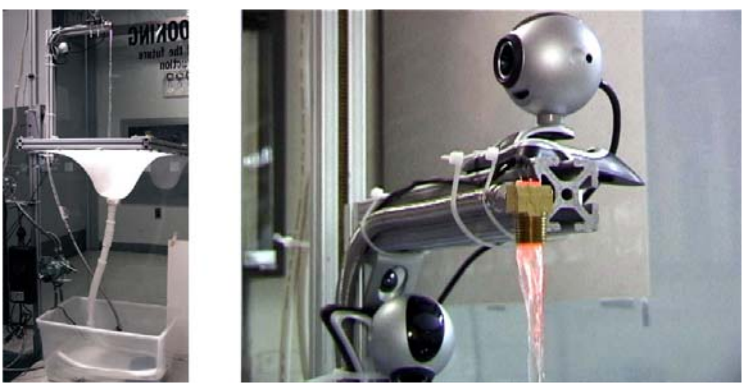

Fig. 4. *SmartSink* showing the research platform (left) and a detail of the faucet with digital video cameras for image understanding (right)

or proper hand-washing, depending on the context. Informal testing of this sink in the lab has revealed that light in the faucet and music or voice feedback are considered pleasant, not annoying or intrusive. By dedicating so much feedback to the sink and water itself, *SmartSink* makes people aware of various water-related issues, while the use of positive feedback alone as reward keeps the system from being irritating. For example, the sink congratulates good water conservation by playing a short piece of music, saying 'thank you,' or making a show of colored light in the water. Discussions with professionals from the health care and food service industry, however, reveal that more strict feedback would be desirable in critical 'clean room' application – one example has the door to an operating room on an electric lock, which can only be opened once satisfactory hand-washing is recorded. In a home or office environment, however, *SmartSink* could serve as a fun way to teach proper hygiene as well as a daily reminder about the preciousness of water.

3.3 Cooking with the Elements

> I am a deaf individual, as in I cannot hear at all and use no assistive listening devices. I have always been a little annoyed that I do not get the full sensory information of all my household appliances. For example, I never know when the microwave is finished, or when the stove timer beeps. I could purchase signaling systems which involve pagers and whatnot that beep when a pre-recorded tone is detected, and such. But in my opinion, a sensory-rich environment is much better and more natural than wearing a pager. I have an overhead fluorescent light that likes to flicker just slightly when my washing machine kicks from the filling-up to the agitate phase, and flickers again (from just a coincidental power diversion) when the machine stops. I enjoy this sensory information much more than a pager buzz.
>
> -Candace Myers

The modern kitchen is a technological marvel that combines the elements of fire, water, ice and earth in a compact hygienic space. The modern aesthetic combined with advances in hygienic materials have resulted in a space that can be surprisingly devoid of sensory experience, considering its function. *Cooking with the Elements* is a hyperreality that maps intuitive multimedia textures to the countertops of a conventional kitchen to enrich sensory feedback and inform tasks in the space [7]. Common problems such as knowing if the oven is hot or keeping the refrigerator door open too long can be intuitively annotated with dynamic audiovisual textures projected onto the surfaces of the appliances themselves.

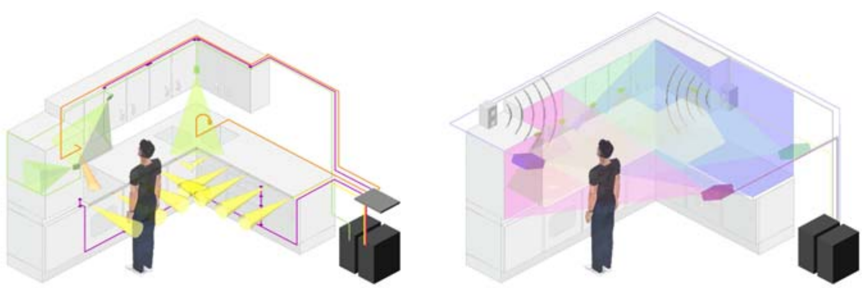

Fig. 5. Cooking with the Elements inputs (left) include proximity, temperature, motion and flow sensors while the outputs (right) consist of three tiled projections with stereo speakers

Cooking with the Elements is a networked ubiquitous computing environment in which sensors and effectors cover every part of a residential kitchen replica at the Media Lab. Proximity sensors situated along the countertop edge locate users while temperature and water sensors and micro-switches detect the status of the cabinets, countertops, sink, and appliances. Projectors seamlessly display on the countertops, appliances and cabinets while stereo speakers offer directional sound (see Fig. 5). As with *musicBottles*, tangible interaction with various appliances in the space releases synchronous, co-located sound and light projections that complement the experience intuitively. The projections are pre-attentive and *illusionistic*, using only readily-comprehended imagery in large projections at the periphery of vision. When someone opens the refrigerator, the sound of a cold wind plays and a projection of snow appears on the door. The snow accumulates to give an impression of how long the door stays open and how much energy is wasted. When the electric range is on or the stove reaches desired temperature, a dynamic fire is projected on the backsplash along with the crackling sound of a wood fire. If the sink is left running, a projected pool of water grows to cover the countertop while the sound of a bubbling creek fills the room (see Fig. 6).

Depending on where users are located, these displays grow or shrink to remain in the periphery of their attention and never to detract from their current task. The proximity sensors along the countertop edge provide a good idea of whether someone is using the kitchen or not. If they are, the display grows until it surrounds them on the countertop. An IR thermometer above the range can detect if the surface temperature of food is adequate. If the dish requires attention, a projection of fire grows to approach the user while remaining in the periphery of her vision. If this doesn't get noticed, the sound of crackling fire plays (See Fig. 7). The system also works if no one is in the room: in case a user forgets the water running or the stove on, the displays grow to fill the room so that anyone walking by the kitchen is immediately aware that something is wrong. Although the displayed textures only convey limited information (hot, cold, wet) they seek to do so in a completely intuitive manner that is always accessible and never distracting. Cooking with the Elements enriches the sensory nature of cooking and returns some of the feedback that was lost when kitchens became modern and hermetic.

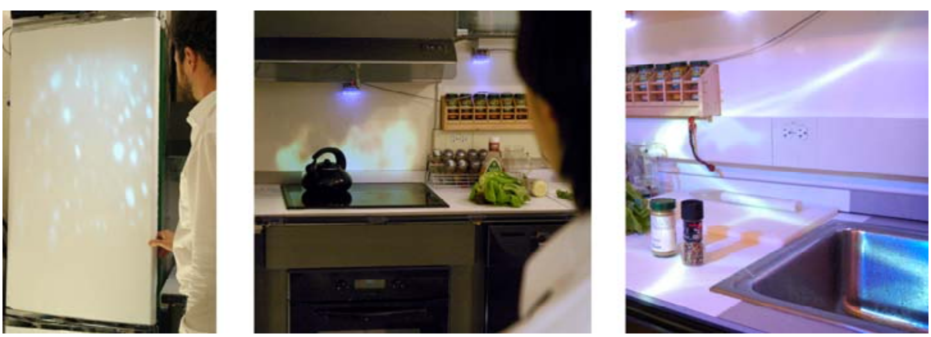

Fig. 6. Cooking with the Elements overlays simulated feedback experience on the refrigerator (left), cook-top (middle), and sink (right)

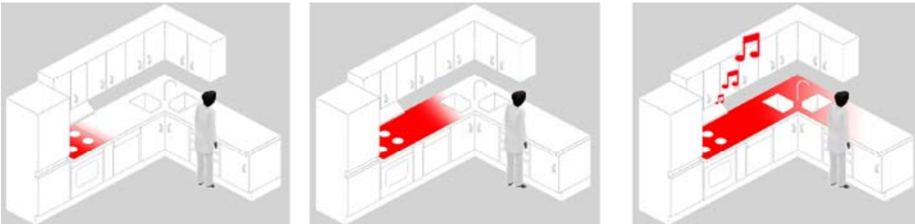

Fig. 7. Illustration showing how ambient information grows to alert users in an intuitive, ambient manner: when sensors measure that the food on the cook-top needs attention, a projection grows to fill the countertop before a subtle acoustic reminder

User studies of *Cooking with the Elements* suggest that enhanced sensory feedback can make everyday tasks more easy to perform and keep certain types of mistakes from occurring. For example, the modern cook-top of the kitchen in the study is made of black glass, devoid of any indication of its temperature aside from some miniature light-emitting diodes. A study was conducted in which 16 novice users aged 18-48 were asked to write if they thought the cook-top was hot or cold while standing a few feet away. In a study, less than 20% (3/16, $p<.05$) of people could determine that the cook-top was hot when standing a few feet away. With the projected fire, on the other hand, almost 90% (15/16, $p<.05$) of people assumed the cook-top was hot. This simple example reveals that modern appliances can under-inform users as to their status. In a more subjective study, users were asked to retrieve an item from the freezer with or without the projection and sound of a blizzard and write what they felt. Nearly half of users (7/16) reported feeling cold or rushed to close the door when the simulated storm was playing, suggesting that such feedback could motivate people to change their behavior by amplifying sensory experience. The sense of touch was overlaid with the two additional channels of sight and sound to make an experience effectively feel colder, and the urgency of closing the refrigerator door greater. Finally, the interfaces were evaluated in terms of hedonics, or how desirable they are. *HeatSink* and the cook-top were preferred, probably because their function was more immediately perceptible to users, whereas the refrigerator was slightly less desirable, probably because it made some users actually feel cold.

3.4 Gurgle

Do you drink enough water? Many times dehydration can set in without any noticeable symptoms [31]. Fellow Media Lab researcher Ernesto Arroyo and I conceived an interface for motivating people hurrying down a public hallway to stop and take a drink from a water fountain. *gurgle* is an interactive installation for the water fountains on the MIT campus, where they are often relegated to dingy nooks. When someone walks by the drinking fountain, a shimmering blue light entices them to approach. If they take a drink, they are rewarded with a sound-and-light show: a watery reflection fills the entire space along with the sound of a babbling brook. Proximity sensors have been installed on site for several months, so that usage data can be obtained from the water fountain with and without *gurgle*. The system randomizes feedback, so that the importance of light and sound can be better understood. The architecture is modular, so that many water fountains can be augmented at low cost. It consists of sensors to detect the actions of people and the status of the machine (in this case the drinking fountain), feedback through audio and video projection, and a built-in microcontroller that directs feedback while serving to log user preference. Implemented over the long term, these interfaces will have to provide feedback on a varying schedule, trying to maintain the novelty of the experience so that it continues to be effective without becoming oppressive. Currently one version of *gurgle* is installed at a public fountain on the MIT campus (see Fig. 8) and another is slated to be installed in the lobby of a mixed-use high-rise.

Fig. 8. *gurgle* augments the refreshing experience of drinking from a hallway water fountain to entice people to stay hydrated

4 Conclusion

Many experiences and environments do not provide enough feedback to be fully valued and understood. The spaces we inhabit can be overlaid with sounds, images and other sensations through ubiquitous sensors and displays. Information can be distributed throughout everyday spaces is it is carefully designed to be easily understood and non-intrusive. Co-located projection of illusionary information operating synchronously with a user's actions helps informative environments remain intuitive. Immersive, intuitive feedback can have transformative effect on the physiological perception of a space. Neglected spaces and tasks can become immersive and enriching, and new environments can be made easier to approach. By simply magnifying the feedback that occurs during everyday activities, users can be made more conscious of positive or negative behaviors. The hyper-realities described in this paper only enhance sensations related to architectural spaces, but future interfaces could also enhance our perception of people and social situations as well – in the way that a monitor speaker informs a musician about how her sound is perceived by the audience. Ubiquitous computing can make the world around us richer and more beautiful by expanding our sensory perception of the everyday.

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