Our response to the decision letter:

First of all, we would like to thank the editor and the reviewers for insightful and valuable comments. Our revisions are described as follows.

*******************************************************

Editor: 1
Comments to the Author:
The reviewers found the work to be interesting, with several strengths; but it is not acceptable in its current form for two main reasons:

1. The submission differs little from the combination of two papers published at Ubicomp, and one written for a demo at Ubicomp (it is not clear whether that appeared in the conference proceedings). The readership of IEEE Pervasive and the proceedings of Ubicomp overlap substantially, so there is not much to be said for repeating work in this magazine without a significant addition.

   1. [Our response]: All major additions are marked as underline in the revised paper. As you can see, we have added substantial amount of new materials which do not appear in any of our previous papers at UBICOMP 2007. The major new materials are
   ◦ For the playful tray, we have added description of our new prototype – the Fishing Game Tray. It was developed on top of a mobile phone platform, and the weight sensing module became a Bluetooth phone accessory. In addition, a new penguin fishing game was created to run on the small screen of a mobile phone. The Fishing Game Tray addressed several problems in our previous Racing Game Tray prototype in the UBICOMP 2007 paper. Some of these fixed problems were also raised by the reviewers, including cleanability (reviewer #1), boredom (reviewers #1/#3) from repeatedly playing the same game, etc.
   ◦ We have completely rewritten Section 4 “Design Considerations”, which is focused on three elements of playfulness: volition, performance capability, and habituation. These design considerations summarized principally from our two different studies (the Playful Tray and Playful Toothbrush) and correspond better to our Play-based Occupational Therapy Model described in Section 2.
   ◦ Section 5 “Design and Technical Challenges” have also been modified and expanded with one more challenge item on “Regress and retention of modified behaviors”

   Note that the above changes are on top of many small changes requested by reviewers. Additionally, given the word count limitation, we had to remove the description of our Mug-Tree (the water-drinking behavior) in order to free up word space for these new materials.

2. The reviewers felt that certain aspects of the work need strengthening, including: bringing out more of the design rationale (which is supposed to be a main difference between the submitted paper and the Ubicomp paper); strengthening the evaluation, or at least modifying the statements of what the evaluation showed; including study results or reasoning about the efficacy of the technology over time.

   1. [Our response]: Please see our responses and revisions addressing these reviewers’ concerns as follows.

   In sum, we would expect substantive additions over the Ubicomp papers in a major revision of the paper, taking into account all the points made in the reviews.

*******************************************************

Reviews

Reviewer: 1
Comments:
Overall, I really enjoyed this manuscript. The work is clever and timely. Not only is persuasive computing a popular topic in pervasive/ubiquitous computing right now, but the authors have chosen to focus on a user population that is novel when compared to other work going on in persuasive computing—children. We know from some of the work at GA Tech that there is an interest in applying pervasive computing to help children with autism (though the focus seems to be more on helping the caregivers/teachers of autistic children). The authors have designed some clever ways of using pervasive computing for the children themselves, including those with autism.

2. [Our response]: Thank you for this positive comment.

Given that I see the contribution of this piece to be much more about design than evaluation, I think this piece should be accepted for publication, though I do have some suggestions for improvement:

- There are many terms/concepts that should be briefly described, as I don't believe many readers will be familiar with them (e.g., "play-based occupational therapy" in the first subsection of the introduction; the "critical ingredients of play" at the beginning of section II; "model of human occupation" in the second paragraph of section II; "volition, performance capacity, and habituation" in the second paragraph of section II; and "Acquisitional theory" at the bottom of page 2). The authors do a good job of briefly explaining intrinsic motivation, internal control, and suspension of reality on page 2; I think a similar approach should be applied to the terms listed above.

3. [Our response]: We have revised to provide explanation for the following terms: “play-based occupational therapy”, “critical ingredients of play”, “model of human occupation”, “volition, performance capacity, and habituation”, and “Acquisitional theory”.
- “play-based occupational therapy”: We have revised the end of 1st paragraph of Section 1 to give a definition for play-based occupational therapy: “The term play-based occupational therapy refers to the use of a child occupation, i.e., play, to cultivate general skills and abilities needed to perform daily functional activities [1].”
- “critical ingredients of play”: the word “ingredients” is perhaps confusing, so we have rephrased it with “elements” in 1st paragraph of Section 2 - “critical elements of play”.
- “model of human occupation” and “volition, performance capacity, and habituation”: We have revised the 2nd paragraph of section 2 to define these terms explicitly – “According to the model of human occupation (MOHO) [5], occupation is essential for human self-organization. The human is conceptualized as a system comprised of three subsystems: volition, habituation and performance capacity. Volition motivates occupational behavior. Habituation organizes occupational behavior into patterns or routines. Performance capability refers to physical and mental abilities to perform the occupational behavior.”
- “Acquisitional theory”: For clarification, we have changed acquisitional theory to “acquisitional view” and also described what we mean by “acquisitional view” in the 4th paragraph of Section 2: “According to the acquisitional view, child behavior is a response to an environment [7]. Further, how the environment interacts with the behavior of the child, e.g., by providing positive or negative reinforcement, influences skill acquisition.”

- The playful tray's pilot user study results discussed on page 4 seem a little strong for the method employed. The results suggested that the Playful Tray has those effects, it did not really SHOW it, given the very limited number of meals that were observed for a limited number of participants. This could easily be fixed by rewording.

4. [Our response]: This is a very good point. “showed” has been reworded to “suggested” in the 3rd paragraph under the “Playful Toothbrush” heading in Section 3.

- Fig 2a & 2b: Can a better resolution graphic be provided of the playful tray's screens? One of the big advantages of a design paper in IEEE Pervasive magazine is that the magazine is printed in color. Currently, it's difficult to read the white text in Figure 2a, and both 2a & 2b are a little blurry.
5. [Our response]: We have turned the white text in Fig. 3(a) (Fig. 3(a) is the same as Fig 2(a) in the previous version) to the black text, so it is more visible. There is no white text in other Figures. We have also provide higher resolution pictures in the Figures.

- Regarding the Playful Toothbrush, some other potential design and technical challenges seem to be how parents or other household inhabitants might feel about having a camera in the bathroom, what the cleanability of the system is like (which is pretty important for bathrooms--actually, cleanability seems important to all three projects), and how the humid environment of the bathroom affects the system.

6. [Our response]: The presence of a camera in a bathroom does raise privacy concern. To address the camera privacy issue, we have added the following in 2nd paragraph under the subheading “Playful Toothbrush” in Section 3: “Because of the privacy concerns raised by the presence of a camera in a bathroom, the camera had a suction hook for easy attachment to and detachment from the bathroom mirror, enabling a parent to quickly remove and store the camera after each brushing session, which typically lasted only 2~3 minutes.”

For the cleanability issue, we have added a new playful tray prototype called the Fishing Game Tray in Section 3 and in Figs. 2(c), (f), (d), and (e). It addresses the cleanability issue by having a protective Placement sleeve (shown in Figure 2) that is removable from the load sensing module. Below is the added text in the 3rd paragraph under the subheading “Playful Tray:…” in Section 3: “(2) The Racing Game Tray was also difficult to clean after eating. To address this issue, the Fishing Game Tray was redesigned with a lightweight, foldable and protective placemat sleeve (Fig. 2(d)) which can be removed from the load sensing module (Fig. 2(f)) for ease of washing and cleaning after meals.”

For the playful toothbrush, the LED brush extension shown in Fig. 4(b) is water resistant and can be detached from the brush handle. In other words, the brush and the LED brush extension can be cleaned separately.

The humidity is a valid concern for any electronic devices in the bathroom. This can be resolved by using water/vapor resistant packaging materials for the Playful Toothbrush system (the whole set).

- The manuscript is definitely readable, but would benefit from a copy-editing pass as there are minor typos/grammatical mistakes throughout the manuscript.

7. [Our response]: We have used a professional proof-reader to correct our numerous writing mistakes.

I hope the authors are planning to continue evaluating these projects, as the prototypes could benefit from seeing how they are used in situ over longer periods of time (weeks to months). Such studies could help to address potential challenges such as boredom--e.g., do the children get bored with these designs over time? Do the designs need to change every couple of months to sustain interest? Longer-term in situ studies would also enable the authors to make stronger claims about the impact of their systems on behavior change, which is ultimately their goal.

8. [Our response]: Thank you for this valuable suggestion. We agree with that long-term in-situ user studies are needed to strengthen claims of our system, and we currently have a plan to conduct such long-term user studies. We have also added this suggestion as a part of our future work in Section 6.

As for the boredom issue, Reviewer #3 also raised this issue when a child plays the same game repeatedly. Please see our response #15 below.

Reviewer: 2

Recommendation: (2) Author Should Prepare A Major Revision For A Second Review
This paper provides an overview of work carried out using a mix of pervasive technologies to aid in occupational therapy, in particular, in engage children to modify their behaviours in everyday tasks such as eating, drinking and cleaning their teeth.

The paper is generally well written and poses real world problems that can be addressed using novel technological setups.

9. [Our response]: Thanks for the positive comment.

While the paper is clearly of interest to the journal's readership I believe it needs some revision before publishing. Namely, the rationale for the designs and the evaluation (particularly for the tray) are very sparse. Did the authors design in collaboration with a therapist? What was the rationale for the design? For example, eating is normally encouraged as a social event and you suggest an isolated task? In addition the child’s posture in the image looks very poor when using the system?

10. [Our response]: Yes, both the playful tray and the playful toothbrush were designed in collaboration with pediatric occupational therapist. We added a new sentence at the end of 1st paragraph of Section 3. “Both projects involved collaboration between pediatric occupational therapists and computer scientists at both the design and evaluation stages.”

   On design rationale, in addition to the almost completely rewritten Section 4 “Design consideration”, we also added the 2nd paragraph under the subheading “Playful Tray” in Section 3 to elaborate our design rationale for the Playful Tray: “The design attempts to improve eating behavior specifically targeting those children whose long eating behavior was caused by not paying sufficient attention to eating or by frequently talking to other people. Although eating is normally considered a social event, excessive non-eating related activities such as those exhibited by children who eat very slowly can be problematic. Therefore, the playful games were designed to encourage the child to focus on eating without reducing the possibility of social interaction.”. Additionally, a new sentence was added at the end of the 3rd paragraph under the same subheading: “To encourage parental-child interaction, a parent can participate in the game by choosing another animal or penguin to compete with the child.”

   We also added the result of user study regarding social behavior in the last paragraph of the Playful Tray part: “Finally, social behavior frequency, defined as behavior directed toward the parent but not directly related to feeding, was increased in one of the child-parent pairs.”

The evaluation sections need more detail. How was the technology evaluated? With whom? How many times? What happens when they stop using it? I would be worried about these omissions but having skimmed the authors UbiComp paper, that they submitted for comparison, it is clear that they have carried out some interesting work but not reported it clearly in this overview.

11. [Our response]: We have added more details describing our user study procedure (evaluation) and results, including the test subjects, the number of times, etc. However, due to the word count limitation of this article, we really could not put in all the details we would like. For readers who are interested in more details, we refer to other articles in the paper. We hope that our revised description has sufficient details – if not, please let us know and we will try to add more details. Below is the added text in Section 3: “In a pilot user study, four child-parent pairs played the Racing Game Tray [10]. The four children were 4 to 7 years old; two were diagnosed with Asperger syndrome, one had high function autism and one had no specific diagnosis. All four participating parents complained of excessively long meals (30 minutes to over one hour) after the children reached the age of self-feeding. Upon obtaining informed consent from the parents, the user study involved video-recording the eating activities of four parent-child pairs without the Racing Game Tray then video-recording the four pairs using the Racing Game Tray within one week. The meals were familiar foods prepared by parents. For more details on the user study procedure, we refer interested readers to [10]. The pilot user study revealed an average 33% reduction in the duration of meals. Children
were more focused on eating during mealtime with an average 20% reduction in non-feeding behaviors when using the Playful Tray. Finally, social behavior frequency, defined as behavior directed toward the parent but not directly related to feeding, was increased in one of the child-parent pairs.”

Below is the added text in Section 3 on evaluation for the Playful Toothbrush: “A three-week user study examined use of the system by thirteen children aged 72-82 months. Since the participating kindergarten school requires children to brush their teeth after meals or snacks, tooth brushing is a habitual activity. The Playful Toothbrush system was installed at the restroom sink where the children normally brushed their teeth. The trial user study consisted of the following four phases. In the pretest, children were asked to brush their teeth using their own toothbrushes (i.e., without the Playful Toothbrush) for one day. In the training phase, children used the Playful Toothbrush for 5 days. In post-test and subsequent one-week follow-up, children were again asked to brush their teeth using their own toothbrushes over two- and one-day periods. Video cameras were set up to record brushing sessions. Effectiveness of tooth brushing and the number of brushing strokes were measured. Brushing effectiveness was determined by a plaque disclosing dye. The ratio of tooth surfaces exhibiting plaque before and after brushing was determined for each child. The comparative results indicated that after using the Playful Toothbrush, the average percentage of cleaning effect (computed by subtracting the before-plaque indices from the after-plaque indices) doubled from 32% (without using the Playful Toothbrush) to 67%, and the average number of brushing strokes increased from 190 strokes to 248. The one-week follow-up results suggested that both teeth cleaning effectiveness and number of brushing strokes were maintained.”

“What happens when they stop using it?": We have added an additional design challenge item “Regression and retention on modified behaviors” in the last paragraph of Section 5: “According to the play-based occupational therapy model, children using the proposed playful designs can acquire better brushing skills and eating habits in a short time. However, a valid concern is the behaviors may fade away when they are no longer reinforced. For example, a child may hurry to finish brushing to play or sleep. Therefore, it is suggested that parents let their children use the Playful Toothbrush at home to assure proper brushing until children are old enough to assume responsibility for their own dental care. Further research is needed to determine the long-term effects of the Playful Tray/Toothbrush and the retention of the effects. This issue also raises the related question of whether behavior modification technology should be deployed permanently or temporarily (i.e., long-term installation in an environment or short-term installation with an expectation of quick removal after the desirable behavioral changes take place). We believe that deployment length is both application- and user-dependent. An analogy is the use of a walker for an elderly person suffering from a destabilizing disability (which may be permanent) vs. a walker for a toddler learning to walk (which is normally temporary).”

In design considerations the authors mention the three elements of play- intrinsic motivation, internal control and suspension of reality – I felt that these could have been brought out more in the main body of the paper.

12. [Our response]: This is a very good point. We have re-organized the description of design considerations on the three elements of play in the paper to bring them out more in the main body of the paper. These design considerations were rewritten completely and in much greater details in Section 4, which focuses specifically on these three elements of play – intrinsic motivation, internal control, and suspension of reality. At the same time, to avoid unnecessary repetition, some old descriptions of the design considerations were removed from Section 3.

The design and technical challenges were well thought through and seemed very relevant.

13. [Our response]: Thanks for this positive comment.

I would therefore suggest a rewrite taking these comments in to consideration.
Reviewer: 3

Recommendation: (2) Author Should Prepare A Major Revision For A Second Review

Comments:
The authors present a review of three projects in which embedding technology in a normal, family setting, can help train children to perform tasks (in the context of play) that they may otherwise not want to do. They simply and clearly stated the MOHO framework and how it informs the design and implementation choices of three tools (tray, toothbrush, mug).

The description of the theory and the tools were adequate. Given that the studies for formative (that is, not long term), I expected to read about the issues that were common, such as customization and unpredictable child behaviors. There were no surprises. In reading the paper, I want to know whether the children continued with the modified behavior AFTER they have used the tools. The authors gave a very nice comparison of the cleaning effects between children who used the toothbrush and those who don't. But, do they brush their teeth better a month after they used the enhanced toothbrush?

14. [Our response]: This point was also raised by reviewer #2. We have added more description on 3-week user study procedure and results of our Playful Toothbrush in Section 3 (see the 2nd and 3rd paragraphs of response #11). In the user study, a one-week follow-up test was performed with the Playful Toothbrush. The result of this one-week follow-up suggested that the skills children learned retained one week after using the Playful Toothbrush.

The reviewer may further raise the “fresh memory issue”, since testing was done only one week later. Our explanation was added “Regression and retention on modified behaviors” in the last paragraph of Section 5: “According to the play-based occupational therapy model, children using the proposed playful designs can acquire better brushing skills and eating habits in a short time. However, a valid concern is the behaviors may fade away when they are no longer reinforced. For example, a child may hurry to finish brushing to play or sleep. Therefore, it is suggested that parents let their children use the Playful Toothbrush at home to assure proper brushing until children are old enough to assume responsibility for their own dental care. Further research is needed to determine the long-term effects of the Playful Tray/Toothbrush and the retention of the effects. This issue also raises the related question of whether behavior modification technology should be deployed permanently or temporarily (i.e., long-term installation in an environment or short-term installation with an expectation of quick removal after the desirable behavioral changes take place). We believe that deployment length is both application- and user-dependent. An analogy is the use of a walker for an elderly person suffering from a destabilizing disability (which may be permanent) vs. a walker for a toddler learning to walk (which is normally temporary).”

In addition, the authors do not comment on "boredom." After the novelty has worn off, would the effectiveness wear off? Particularly for children, we can imagine that the tools may become boring BEFORE the desired behavioral changes take place.

15. [Our response]: Yes, boredom from repeatedly playing the same game is an issue. Our new Fishing Game Tray adopted a new design that allows new games to be downloaded. To address this boredom issue, we have added the following text in the 4th paragraph under the subheading “Playful Tray” in Section 3: “(3) A final issue was that children eventually became bored with the game. To address this issue, a smart phone was adopted as a game platform (Figs. 2(c) and (e)) for Internet connectivity, which enables parents to download new games from a website until the desired behavioral changes take place. Since this design utilizes the smart phone hardware and software as the game runtime environment, the weight sensing module becomes a Bluetooth accessory that wirelessly reports weight change readings to the game running on the phone.”

This paper contributes marginally more than what had already been described in the authors' previous
papers, with the exception of the explicit design challenges. I recommend that, in the least, the paper be revised, to include significantly more new information.

16. [Our response]: This comment is also reflected in the editor’s 1st comment. Please see our reply to the editor’s 1st comment above.