Training Technology Probes Across Fitness Practices: Yoga, Circus and Weightlifting

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Abstract
Wearable technology for sports and fitness have increased in popularity in the last decade, but most technological solutions in research are designed for a single specific fitness practice and target group. Towards validating a design approach and resulting wearable designs across several fitness practices, we used three wearable Training Technology Probes (TTPs) originally designed for, and tested in, the context of Yoga and Circus training. They were used in a design activity with the goal of exploring and opening up the design space of technology for weightlifting. Our exploration proved fruitful and substantiated the versatility, adaptability and usefulness of the TTPs on account of their design features. Here we present initial insights from deploying the TTPs in that domain. The TTPs served as probing tools, helping to surface goals and challenges of weightlifting exercises, leading to interesting design iterations that will inform future work.

Author Keywords
Training Technology Probes; Physical Training; Fitness; Weightlifting; Sports; Bodystorming; Augmented Feedback; Wearables.
CSS Concepts
- Human-centered computing~Empirical studies in interaction design

Introduction
The use of wearable and interactive technology to support sports and fitness practices and skill development has been gaining traction in HCI in the past decade [13]. They have been used to support social, cognitive, emotional and physical aspects of the training [13]. A plethora of research prototypes exist for the latter in a variety of fitness practices and sports (e.g. swimming [1], cycling [3], running [21], martial arts [4]). Yet, most of these are designed to support particular features of one single specific practice.

Our research group develops wearable technology to support trainees and instructors [9,12,16,17,18,19]. This technology is designed to be versatile and of value in different exercises, which has proven also useful for wearing it in different positions on the body, and for target groups with diverse skills and needs sharing common challenges (see [9,16,19]).

Here we take a step forwards towards exploring the versatility, adaptability, and usefulness of these wearable designs, and understanding the key underlying design features behind them. In an early design exploration of a project developing technology support for weightlifting, we used three Training Technology Probes (TTPs) (see Figure 1,2,3) developed in previous projects for Yoga for adults [16] and circus training for children with mild motor issues [9,19]. They had similar design features, such as an open-ended functionality and simple interactivity; which augmented several physiological sensations in an open-ended and non-assessing way.

Together with 2 experienced weightlifters, we ran a 3,5h bodystorming with probes [12] workshop in a local gym, to explore potential future technology for weightlifting. This served to physically explore the TTPs in different weightlifting and strength training exercises, proving them useful to support several exercises. It also helped surface values, goals and challenges of weightlifting and identify important design considerations and potential design iterations, which will be useful to deploy the future weightlifting wearables. The insights paved the way for future work.

We contribute with 1) preliminary results showing the capacity of the TTPs to work as probing tools in training domains other than those for which they were initially designed; 2) a reflection of the TTP’s design features responsible for the TTPs versatility and adaptability within and outside the fitness practice for which they were originally designed; 3) new uses for existing TTPs for weightlifting, which will inform future work in the domain. This work constitutes a first step towards validating our design approach for developing wearable technology that can be used across several training practices and target groups, which can inspire designers working with wearables for training.

Our Approach to Technology Design
The collection of Training Technology Probes (TTPs) that we used in the design exploration reported here were designed as part of previous projects creating technology support for Yoga [16] and circus training [9,19]. They share similar design drivers and design features that made the TTPs versatile and adaptable
within their fitness practice, i.e. they were useful and valuable for different exercises and trainees.

First, all our TTPs follow the design strategy of **exteriorizing proprioceptive information** [9,16,17]: translating physiological sensations usually accessible to the proprioceptive and vestibular senses [14], to feedback typically accessed through the exteroceptive senses (particularly vision, hearing, and touch—senses that people can better access, understand, and act upon).

The TTPs provide **open-ended augmented feedback**: the representations are non-assessing and do not impose a particular meaning; trainees and instructors can endow them with their own and adapt it.

All our TTPs are minimalist probes, **technically and functionally simple**. They do not require technical skills to use them and do not add complex sensory information, which can become obtrusive [9]. This has made them easy to integrate in the fitness practice.

Finally, all our TTPs are **attachable in different ways and to different body parts**, and even objects. Hence they can be used for different body types, and in different exercises for different purposes [9,16].

All of these made the TTPs flexible and adaptable to different exercises, trainees, and needs [9,16]. Some, like the Laser TTP, were even used and found useful in two different practices (yoga and circus training)[9,16]. Hence, we suspected that the design features above would make the TTPs versatile enough to be adapted to, and useful in, other fitness practices and for other target groups, which we set out to explore here.

**Existing TTPs for Yoga and Circus Training**
Here we describe 3 TTPs explored in the weightlifting explorations within the context of their original project.

**Enlightened Yoga: Laser TTP**
Enlightened Yoga is technology-supported Yoga class in which technology is used to help instruct and give feedback about movement and posture, which is especially challenging with beginner trainees [16]. The Laser TTP (see Figure 1) was designed to visually augment the instructor’s and trainees’ movements. It was included in 16 different Yoga exercises, and was found useful by the instructor to communicate intricate postures and by the trainees to understand them.

**Super Trouper: FrontBalance TTP and Movement TTP**
Super Trouper is a technology-supported circus training course for children with mild motor challenges. To engage them in the physical activity, and to support them develop proprioceptive awareness [9], we designed a collection of TTPs, such as: the FrontBalance TTP (Figure 2), used in acrobatics, aerials, juggling, and balancing exercises (see [9,19]). The children and instructors found it useful to raise postural awareness and improve motor control.

The Movement TTP (Figure 3), augments movement pace (via changes in acceleration) through audiovisual feedback. It was used in acrobatics and juggling exercises, and it was found useful to support awareness and control of movement pace (see [9,12,19]).

We also brought the Laser TTP to some Super Trouper training sessions, and we observed that instructors used it in warm-up games (e.g. making children wear the TTP on different body parts and make their
Exploratory Workshop in Weightlifting

Recreational weightlifting is one of the most popular fitness practices [2]. It involves exercises in which weights (e.g. barbells, dumbbells, kettlebells or machines) are lifted in repetitions in a prescribed manner [2,15]. Technology interventions for weightlifting are common in HCI [5], but most focus on automatically recognize exercises and repetitions, are bulky, or confined to a lab setting [5]. To open up the design space of technology to support weightlifting, we followed a Research through Design [6] approach.

The three TTPs above were brought into an early ideation workshop with the twofold goal of identifying opportunities for design, and probing the versatility of our TTPs in another domain. Together with 2 experienced weightlifters (P1, +5 years of experience; P2, +10 years of experience) we engaged in a 3,5h embodied exploration [10,11] of the TTPs, trying them in different exercises (e.g. squats, planks, chest press, overhead press, bicep curl, triceps pull, step up).

We video recorded the workshop, and conducted a video-analysis [7] focusing on: identifying potential TTP uses and values for weightlifting and future TTPs’ iterations; and noting relevant aspects and challenges specific of weightlifting.

Results and Insights

During the workshop, typically a participant would bring up a challenge they had experienced, or saw others experience, when performing an exercise. Then, we would explore if, and how, any of the TTPs could be used in that exercise and for that challenge, and what value (if any) it provided. This surfaced new challenges in that exercise, led to explore a similar TTP use in a different exercise, and yielded important design iterations. Often, the participants would purposely perform an exercise wrong, to probe how well a TTP could augment the mistake and guide action. Switching between prototypes to explore the same issue was also frequent. In the following, we summarize design insights resulting from the embodied exploration of our existing TTPs in weightlifting.

Existing TTPs: Uses and Values in Weightlifting and Future Iterations

Using TTPs in Exercises: For the sake of scope, we will not report on all uses of each TTP in each exercise. Instead, we will describe the uses that participants and us designers found most interesting for each TTP, and the design iterations we identified they would need before fully deploying them in weightlifting.

The Laser TTP was found particularly useful to augment posture and amplify errors. For instance, wrong back posture during planks (Figure 4). Participants found that the projection of the Laser TTP would benefit from more degrees of freedom, i.e. from projecting at more angles.

The FrontBalance TTP was found particularly useful to augment undesired misalignments in exercises where body symmetry was required. For instance, in squats with the TTP worn on the hips, it helped participants detect tilt in the hips when getting into the squat position (Figure 5). Participants discussed that the TTP projection follow lines on the floor, ceiling, etc.) and to help children focus on the exercise while doing floor acrobatics (e.g. looking at the projection on a wall as focusing and balancing trick, see [9,19]).
would need a higher sensitivity, i.e. to react to smaller amounts of tilt, which would allow them to notice slighter misalignments that are important for weightlifting, given how they can negatively affect the technique and potentially lead to injuries or imbalances. They suggested that the TTP could also reflect tilt on other axis, to be able to reflect more misalignments (see Figure 6). Finally, they commented they would need a different attachment (e.g. pins to attach the TTP directly to the clothes, to improve situations like in Figure 7) to be able to use it in more exercises.

The Movement TTP was found particularly useful to signal rushed, uncontrolled movement execution, for instance, during a bicep curl (see Figure 8). It was also found useful for exercises that required explosive movements (see Figure 9), to ensure they were performed with enough acceleration. The participants also brought up the need for a higher sensitivity for this TTP to be able to reflect smaller accelerations.

**Forefronting Weightlifting’s Values, Goals and Challenges for Technology Deployment**

Deploying the TTPs to probe their use in weightlifting helped us designers and participants to surface and discuss challenges, values and goals of the practice that spoke of potential domain-specific technology requirements.

**Safety:** Discussions mostly revolved around how to perform the exercises in a safe and correct way. This is of paramount importance in weightlifting, to avoid injuries and maximize gains [15]. Deploying the TTPs surfaced issues regarding the inclusion of wearables for weightlifting. For instance, a recurring concern related to gaze and bodily constraints: where to position the TTP to avoid making trainees adopt undesired head positions to look at them, or overall detrimental bodily postures that could compromise the safety of the exercise. Gaze concerns were present in our early Yoga and Circus explorations (see [9,16]), but in relation to comfort and ease of use, rather than safety.

**Error identification and correction:** The focus on safety and correct execution was present all throughout the exploration of potential uses of the TTPs. As illustrated before, all the explored uses (both those presented here and the rest) revolved around employing the TTPs as means to identify errors and use their augmented feedback to help trainees correct them. This stands in contrast to our previous deployments of the TTPs in Yoga, and even more so in circus training, where the main value of the TTPs was often less normative: raising awareness on physiological processes [9], augment instruction [16], or offer an engaging and playful experience [9].

**Catering and adapting to correct performances that change dynamically:** The new and strong focus on error identification and correction surfaced potential challenges for technology inclusion in the domain. What constitutes a correct performance of an exercise is highly contextual, and depends on skill level and bodily capabilities [8]. It might change throughout sessions, and with heavier weights. For example, when trying out the Movement TTP for the bicep curl, P2 mentioned that maintaining a constant pace becomes more challenging with heavier weights, and he might have to resort to partially use the movement momentum between repetitions. This prompted discussions: while that was not as desirable as a controlled movement, it was not strictly an incorrect performance, nor posed safety
constraints. Hence questions regarding how technology can adapt to different correct performances emerged.

**Error prioritization:** Selecting and prioritizing which errors technology should help augment was a common discussion when exploring the best use of a TTP. Weightlifting exercises require of complex techniques, which inevitably open for multiple kinds of errors (posture, body alignment, movement trajectory, pace [2]). Using wearables to tackle every single error could be obtrusive. As such, in our explorations we prioritized errors for how common we thought they were, based on our previous experience; and in terms of how critical they were to perform the exercise correctly and safely. For instance, a proper back posture is central in planks, and as such, the Laser TTP helped augment that in a nuanced way. The bicep curl is a simpler exercise, technique-wise, that opens up for less postural errors. In it, the pace and control of the movement become important, and the Movement TTP augmented that.

**Conclusion and Future Work**
Our goal was to explore what employing the TTPs to probe a new domain could yield. Initial insights show that 1) we found new uses of the existing TTPs in weightlifting, adding to those in Yoga [16] and circus training [9,19]; 2) early evaluation of the existing TTPs in the new domain revealed important iterations that they should undergo before further deploying them in weightlifting; and 3) the TTPs helped to surface important values, goals and challenges of the practice in regards to technology development. These offered us designers with a rich array of options to continue our design work, sensitizing us to important values, goals and challenges of the practice.

For instance, future work will include iterating the current TTPs based on the feedback, design their future use in weightlifting and field-test them with real users. We have already taken some steps towards this goal: we have iterated the Laser TTP, resulting in BodyLights (see Figure 10), which design and testing we will present in a CHI’20 full paper [20] (which briefly refers to, but does not cover, the early explorations that we present here, neither the insights nor other TTPs).

**Contribution**
Previous works with the TTPs [9,16,19] have shown that their common design features (exteriorizing proprioceptive sensations, technical and functional simplicity, open-endedness) make them versatile in terms of exercises, and adaptable to different trainees within the practice of Yoga [16] or circus training [9,19]. This paper shows the potential of the TTPs to be versatile across exercises of different fitness practices, and their capacity to be adapted to not only different trainees but different target groups altogether. This work also substantiates the capacity of the TTPs to work as probing and ideation tools in training domains other than those for which they were initially designed.

This work constitutes a first step for validating our design approach and design features to develop wearable technology to be used across several training practices.

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