"Annoying, but in a Nice Way": *An Inquiry into the Experience of Frictional Feedback*

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There is increasing interest in the potential use of interactive technologies as a means to motivate attitudinal and behavioral change. At the heart of this function is the provision of feedback, such as steps taken, kilowatt-hours used, or liters of water consumed. Often, however, this feedback involves a mere visualization—an appeal aimed at turning meaning into action. The present paper suggests an alternative approach: feedback designed to create situated friction, which then inspires reflection and meaning-making. Such *frictional feedback* attempts to disrupt routines and to imply alternative courses of action. At the same time, it should be experienced as acceptable and meaningful. The present case explores the experience of frictional feedback through the *Never Hungry Caterpillar*, a device designed to avoid the energy wastage caused by keeping electronic equipment in standby mode. We compared individuals' perceptions of and experiences with the Caterpillar with those associated with a regular power strip with a switch. While both objects embodied similar intentions, the Caterpillar was perceived as more powerful in terms of potential change, and as more affective and ambiguous ("annoying, but in a nice way"). Accordingly, liking of both objects was similar. However, while the power strip was valued for its practicality, the Caterpillar was valued for its potential to create positive and meaningful friction.

Keywords **–** Design for Change, Environmental Design, Sustainability, Human–Computer Interaction, Interaction Design, Case Study

Relevance to Design Practice **–** The *Never Hungry Caterpillar* is an in-depth case study of the experience of *frictional feedback*, a variant of feedback designed to interrupt routines in order to inspire reflection, facilitate meaning-making and, ultimately, change behavior.

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Introduction

Environmental issues, such as reducing avoidable energy consumption, require people to change their attitudes and behavior. For example, studies estimated that 26–36% of a household's energy consumption is subject to variations in everyday individual behavior (Wood & Newborough, 2003). Conserving energy is thus not only a matter of advanced insulation or heating technology. It is a way of living. People who care about energy consumption must question and reconsider their most convenient and pleasurable routines, such as taking long, hot showers or luxuriating in cool, air-conditioned breezes.

While general information about energy conservation and appeals to behave accordingly are abundant (for example, in Germany: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2015; Federal Government, 2013), people's behavior is not always in line with their knowledge or intentions. At the end of the day, the longing for a hot shower after a cold and stressful day may trump more abstract, future-oriented concerns for the environment. To remedy this, designers and researchers recently began to explore the roles that interactive technologies can play in supporting behavioral and attitudinal change in general (Dorrestijn & Verbeek, 2013; Fogg, 2003), and in the context of sustainability (Blevis, 2007; DiSalvo & Sengers, 2010) or psychological wellbeing (e.g., Hassenzahl et al., 2013).

At the heart of supporting and motivating change through interactive technologies is the provision of feedback (for overviews see Froehlich & Findlater, 2010; Pierce, Odom, & Blevis, 2008). Individualized feedback is expected to lead to insight, self-reflection and, ultimately, change in attitude and behavior (e.g., Holmes, 2007; Lilley, 2009). Some concepts focus primarily on awareness, such as Gustafsson and Gyllenswärd's (2005) well-known *Power Aware Cord* (see Figure 1), which visualizes the flow of energy by means of dynamic glowing patterns on the cord itself. This feedback, however, is not goal-oriented, since the glowing patterns do not suggest a way to reduce energy consumption. On the contrary, their intrinsic beauty may even provoke *more* consumption.

Other concepts already monitor and present data in such a way as to imply appropriate goals (e.g., Arroyo, Bonanni, & Selker, 2005; Broms et al., 2010; Jönsson, Broms, & Katzeff, 2010; Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011).

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For example, the *Flower Lamp* (see Figure 2) has the shape of a flower, which "blooms" (i.e., the petals open) if the energy consumption of the household decreases. In contrast to the Power Aware Cord, this concept aestheticizes the saving of energy rather than its use. In addition, the flower and its blooming are reminiscent of nature and life, thus creating a shift from the mere display of energy consumption to the goal of protecting the environment. To give a further example: For their *Fish'n'Steps*, Lin, Mamykina, and Lindtner (2006) used a pedometer to count the steps taken by a person in a day and later presented the data in the form of a digital fish in an aquarium. Instead of displaying the number of steps taken or the ratio of actual to intended steps, they let the fish appear happy, healthy, and growing, if the intended number of steps had been achieved. The authors chose a representation of data that was reminiscent of the goal of being healthy through more exercise. The desired behavior (one's own physical activity) was matched to a corresponding symbolic feedback (the health of a virtual fish). Thus the actual format of the feedback was no longer "neutral," but deliberately chosen to activate desirable underlying motives, such as care, self-care, and health.

With both Flower Lamp and Fish'n'Steps, the form of feedback is only loosely related to the overarching goals, such as protection of nature or individual health. However, since feedback will inevitably structure the response to it, it can be used in even more goal-oriented ways. For example, the *Shower Calendar* (Laschke et al., 2011), a water usage visualization for a shower, visualized 60 liters of water as a large dot. When showering, the dot became smaller until it almost disappeared. The dot remaining after a shower became part of a larger, calendar-based visualization (see Figure 3).

This design embodied a number of conceptual choices concerning the feedback: First, it showed real-time usage of the resource: with each liter of water going down the drain, the dot became smaller. Second, it presented low water usage as the desired outcome by making the visualization richer and more colorful when the user came closer to achieving that outcome, so that the less water was consumed, the larger were the remaining dots. Third, the calendar-like structure emphasized behavioral change over a longer period of time. People may have good reasons to now and then use more water than usual. By focusing on the reduction of water usage over time, and thereby letting a single transgression appear less problematic, the whole system became more understanding of people's lifeworld. Obviously, while still being a feedback system, it was carefully designed to convey particular messages: Less water usage is desirable (by reduced aesthetic appeal the more water was used); every single shower is an opportunity to save (by providing real-time feedback); the general pattern over time is what counts most (by providing a calendar-like structure displaying behavior over the course of a whole year).

While such carefully designed, meaningful feedback definitely has an effect (Darby, 2001; Froehlich & Findlater, 2010), it still remains largely focused on forming "good intentions" and not so much on implementing those intentions. Psychologically, a felt need for change in behavior or attitude is motivated by a perceived gap between an individual's actual self and idealized

Figure 1. The Power Aware Cord by Gustafsson & Gyllenswärd. (Photo by Carl Dahlstedt, reprinted with permission).

Figure 2. Flower Lamp by Sofia Lagerkvist (see Mazé, 2011, p. 83). (Photo by Frontdesign.se, reprinted with permission).

Figure 3. The Shower Calendar and an idealized improvement over the course of one year.

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self (e.g., Carver & Scheier, 1990). To close this gap, individuals set personal goals, such as "I want to be more environmentally friendly." Obviously, those "good intentions" are valuable steps towards change, and feedback-oriented interactive systems may play a crucial role in inspiring people to actually form intentions. According to Gollwitzer (1999), intentions address the question of "what" to achieve, but not so much of "how" to implement action in daily life. To complicate matters, the "how" is often shaped by deeply ingrained routines, regulated on a procedural, operational level, which is more or less immune to informational interventions (Verplanken & Wood, 2006). Thus, feedback systems often lack the power to interrupt and shape the "how." They remain "rhetorical," however carefully designed. They embody a top-down approach, which engages users on a reflective–cognitive level (e.g., "I should conserve energy to protect the environment"), but does not further support the implementation of those intentions in real situations. Fish'n'Steps, for example, presented its feedback—an either sad or happy fish—after they day was over. When its owner realized that the fish was sad and not growing because the owner had taken fewer steps than intended during the day, the damage was already done. One user even remarked: "I didn't want to check on it, because I knew it was going to be sad" (Lin et al., 2006, p. 274). The only response to this situation is to form the next well-meant intention—presumably, to walk more the next day—to make the fish happy again. Obviously, the story of caring about a fish may be more effective in inspiring (self-)care-oriented intentions than the simple display of a number of steps taken. Both, however, lack power to influence the specific choices made during the day, such as the one between walking up or down the stairs and taking the elevator. They leave identification and implementation of the "how" to its users. The Shower Calendar provides situated, real-time feedback, opening up the possibility to adjust action the moment it is carried out. This might inspire situated strategies to save water, such as turning it off when soaping. However, the Shower Calendar also remains primarily rhetorical, with only limited outreach to facilitate the actual *implementation* of intentions.

In this paper, we explore an extended approach. While feedback remains at the heart of it, we attempt to situate the feedback even more. Specifically, we envision a feedback able to interrupt highly situated, unwanted routines. Instead of informing and appealing to create abstract goal intentions, which then may or may not be translated into situated action (top-down, rhetorical), we explore creating situated interventions that embody the desired behavior to some extent and lead to the inference of particular goal intentions (bottom-up). Meaning-making becomes triggered by one's own situated action rather than by abstract information.

Consequently, we understand interaction as a bidirectional process, a "material dialogue" with the world through stuff (Crilly, 2010; Dunne, 2006; Redström, 2008). Stuff inevitably shapes practices and ways of living through the actions it affords, the actions it makes more difficult, and the meaning and knowledge it encapsulates (Dourish, 2004; Reckwitz, 2002; İhde, 2008; Tenner, 1997; Verbeek, 2011). On the one hand, people implement their goals by interacting with stuff. For example, they intend to save energy, and thus deliberately use the power switch on a power strip to avoid standby consumption by connected devices. On the other hand, the power strip itself shapes behavior, for example by providing a power switch in the first place. In fact, a more convenient power strip would just sense standby and switch off all connected devices automatically, liberating its user from a tedious task. While this solution may lead to the most efficient avoidance of standby, it removes an important chance for reflection. It is an example of "solutionism" (Morozov, 2013), which limits choice and, thus, a sense of agency, resulting in "infantilism" and a diminished sense of personal responsibility (Selinger, Sadowski, & Seager, 2015). In contrast, a power strip featuring a green power switch labeled "eco-friendly," for example, may prompt thoughts about energy consumption. But obviously, labeling a switch is rhetorical and unlikely to impact routines much. From our perspective, it simply lacks the *friction* to break a routine. Friction seems necessary to make people stop, think, and ultimately change. Ideally, the way friction is introduced already implies a particular action in line with the intended goal. One may imagine a power strip that responds to standby with a shrill alarm. This will certainly create some friction; however, the link between a shrill sound and the desire to conserve energy is arbitrary. In itself, an alarm is devoid of meaning beyond signaling a problem. It would be better to create *frictional feedback*, an alarm able to attract attention, to disrupt an unwanted routine, while at the same time conveying relevant meaning.

In sum, we argue that behavioral change requires feedback that goes beyond simple quantification and the finely tuned, but rhetorical. It requires situated, frictional feedback, able to break routines and to inspire reflection and meaning-making in line with the goals intended. This is a bottom-up approach (in contrast to the rhetorical, top-down approach of, for example, appeals), necessitating the careful design of friction. The purpose of the present paper is to explore this notion through a case study. The *Never Hungry Caterpillar* (Laschke, Hassenzahl, & Diefenbach, 2011) is an extension cord designed to encourage change regarding the energy consumption of devices in standby mode. We report a study of people's experience of being confronted with frictional feedback, with a focus on detailed insights into meaning-making, emotional responses, and acceptance.

Standby Power Consumption and the Never Hungry Caterpillar

In Germany, devices in standby mode consume at least 20 billion kilowatt-hours per year (Federal Environment Agency, 2008; Rath et al., 1999). The Never Hungry Caterpillar (see Figure 4, and the video introduction at https://vimeo.com/133579013) attempts to counteract this. It has three modes: During normal energy consumption by the connected appliance, it breathes slowly. If the appliance is switched to standby, however, the Caterpillar starts to twist awkwardly, as if in pain. This is the friction designed to interrupt the unthinking use of standby. We further chose a representation reminiscent of a living thing (a caterpillar) to create a link between the abstract concept of energy/power, and

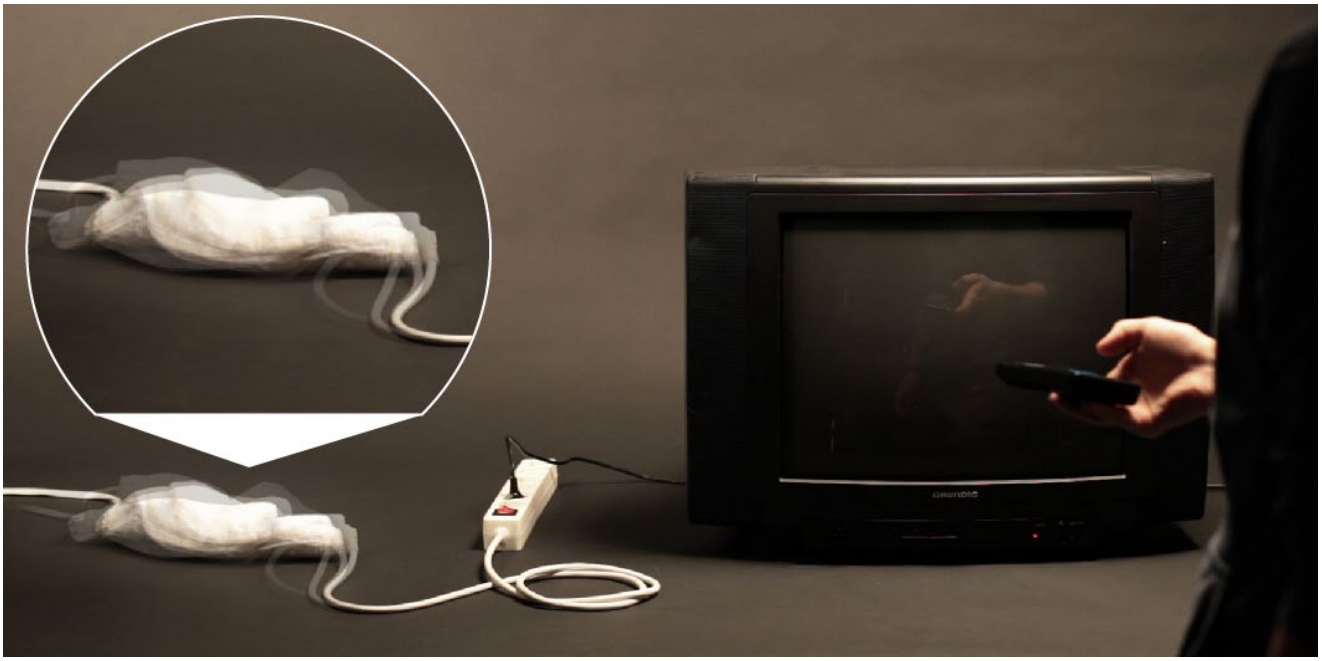

Figure 4. The Never Hungry Caterpillar.

the consequences for the environment of producing and using energy. The Caterpillar in pain touches upon people's tendency to help and take care of living things. The awkward twisting is akin to an alarm, but supposedly linked to a care motive, similar to Lin et al.'s (2006) little fish. The Caterpillar's "pain" can be eased by disconnecting the appliance entirely, which makes it—and the environment—feel better, and it finally falls asleep. Caring about the Caterpillar becomes synonymous with caring about the environment.

Technically, the Caterpillar consists of two servomotors, a regular extension cable and structural elements. All components were encapsulated in a white textile bag at the female end of the cable (see Figure 5). A microcontroller (Arduino) and a CT current sensor (efergy.com) were placed at the male end of the cable. The Caterpillar consumes approximately 0.09 kWh per day.

In the following, we describe an empirical exploration of people's emerging feelings, thoughts and evaluations when confronted with the Never Hungry Caterpillar, and contrast them to the experience of using a regular power strip with a switch.

Empirical Exploration

Participants and Procedure

Forty individuals (27 women) participated in the study. Participants were students with different backgrounds recruited on the campus of a German university. The median age of the sample was 24 years (M = 24.7, SD = 5.2, min = 19, max = 41). No compensation was given for participation in the study.

The study focused on the participants' emerging thoughts and feelings, that is, the experience of being confronted with the Caterpillar. To get an idea of the specific characteristics of the Caterpillar experience, we compared it to the experience generated by a regular power strip with a switch (see Figure 6). The power strip offers a switch to disconnect all devices from the power source as a rather convenient way to avoid standby. Consequently, such power strips are often suggested as energy saving devices (e.g., German Energy Agency, 1996; International Energy Agency, 2001). However, while a power strip offers functionality in line with the goal to save energy by avoiding standby, it is not

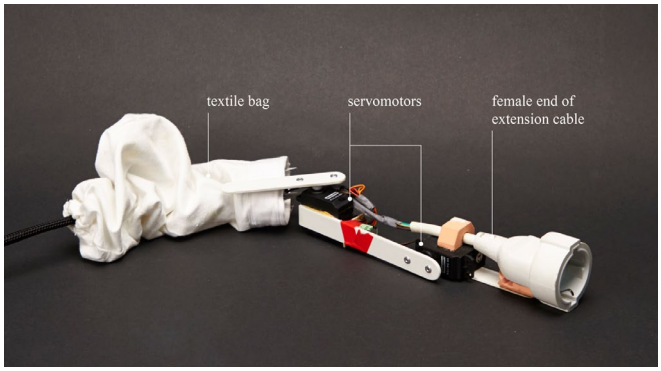

Figure 5. Technical components of the Caterpillar.

Figure 6. A power strip with switch.

designed to actively convey that message through friction. In contrast, the Caterpillar offers frictional feedback in line with the goal of avoiding standby. Accordingly, we expected differences in the experience of the Caterpillar and the conventional power strip, based on the differences in the designed dialogue (i.e., interaction) between object and user.

The study was carried out in individual sessions lasting about 30 minutes. We created a living-room atmosphere with a couch in front of a television (TV) set (see Figure 7). Participants were told that we were interested in their personal experience of watching a video, with and without sound. No reference was made to sustainability. The whole study was deliberately framed as a study focusing on the perception, understanding and memory of a video clip.

Participants were led into the laboratory by the experimenter and asked to sit in front of the TV, which was switched off completely (i.e., not in standby mode). For participants in the conventional power strip group, the TV was connected to a regular power strip with switch. For participants in the Caterpillar group, the Caterpillar was additionally connected between the wall outlet and the power strip. In the presence of the participant, the experimenter powered up the TV by first using the switch on the power strip, then the TV switch, and finally the remote control. This was suggested to be part of the preparation for the experiment. In this way we ensured that all participants saw at least once all possible ways of switching off the TV (i.e., to standby with the remote control, or to fully disconnected by the switches on the TV and the power strip). Participants were told that the experimenter would then leave the room and start the video from the outside, so that participants could fully concentrate. The experimenter asked the participants to watch the video and to adjust the sound by remote control according to text messages displayed in the video ("Please switch the sound on," "Please switch the sound off"). Participants were asked to switch off the TV after the video ended and to meet the experimenter next door.

Obviously, an emerging experience can be influenced by many aspects. One possibly relevant aspect in the present case is individual attitude towards nature conservation and energy saving. To avoid triggering effects of social desirability by openly asking questions about energy saving behavior, we chose to manipulate attitudes experimentally by situational activation (i.e., priming). Specifically, concerns about nature were primed by watching an excerpt from the trailer for *Earth*, a movie by Tasioulis, Tidmarsh, Fothergill and Linfield (2007), as the video clip. The trailer was enriched with slogans to activate a pro-environmental attitude (e.g., "A nature that is important for us"). In the neutral condition, participants watched a video unrelated to sustainability (the music video of the song "Help" by the Beatles). The videos were of equal length (2.24 min). After watching the clip (either *Earth* or "Help"), participants switched off the TV. They individually chose the way of switching off, either to standby, using the remote control, or entirely, using the TV switch and/or the power strip switch. In the caterpillar condition the Caterpillar started to move, as described earlier, when the TV was switched to standby. In the power strip condition, nothing happened. The participants then met the experimenter in an adjacent room.

Upon meeting, we revealed the real purpose of the study (i.e., experience of the Caterpillar or of the power strip, depending on condition). Participants were asked to reflect on the power strip or the Caterpillar in the course of a semi-structured in-depth interview, followed by a brief questionnaire. Note that four participants in the caterpillar group used the power switch at the TV or power strip. Thus they did not experience the Caterpillar's response to standby. To get feedback from these participants as well, the experimenter demonstrated the Caterpillar before the interview.

The interview focused on four perspectives: (1) initial thoughts and feelings (e.g., "What were your first thoughts and feelings about the Caterpillar/power strip?"); (2) character (e.g., "How would you characterize the Caterpillar/power strip?"); (3) liking (e.g., "Do you like the Caterpillar/power strip? If yes, why? If not, why not?"); and (4) intention and form of dialogue ("Do you feel that the Caterpillar/power strip has a message for you?"; "Do you like the way in which the Caterpillar/power strip 'talks' to you?"; "What do you think about concepts using such a form of communication in general?"). Interviews were audio recorded, transcribed, and then grouped and categorized by the first author using qualitative content analysis (Mayring, 2004).

Figure 7. Study setting.

We also explored the "perceived potential for change" with a questionnaire (Heidecker, Diefenbach, Creutz, Laschke, & Hassenzahl, 2010). It consisted of 12 items, capturing envisioned consequences of using a thing (power strip, Caterpillar) regarding behavioral change, motivation, change in worldview, compliance, attitude change and learning, i.e., the central facets of persuasive technologies (Fogg, 2003). Sample items are "The object provides a feeling that my actions can make a difference," "The object inspires me to change my behavior," "The object helps in making the right decisions," or "The object lets me perceive my own behavior consciously" (all items were originally in German). For each statement, participants rated the degree of agreement on a five-point scale ranging from "completely agree" to "completely disagree." Internal consistency was high (Cronbach's $\alpha = .92$). By averaging all 12 items, we calculated a score for "perceived potential for change." Finally, participants were debriefed and thanked for their participation.

To summarize, we employed a 2 × 2 between-subjects research design, with the factors concept (Caterpillar, power strip) and priming (nature, neutral). Participants were randomly assigned to one of the four conditions. The study's main goal was to characterize and compare the experience emerging from being confronted with the Caterpillar compared to a regular power strip.

Results and Discussion

We start by presenting results concerning "perceived potential for change," followed by "initial thoughts and feelings," "character," "liking," and "intention." Within each perspective, we compare the Caterpillar to the regular power strip. In general, we present categories, the number of responses they summarize, and some verbatim examples. Note that a single participant could provide several responses. Accordingly, the number of responses may differ for each perspective, and may exceed the number of participants. In addition, we categorized responses mentioned only once as "idiosyncratic." We further subsumed all responses from those categories that represented less than 5% of all responses, as "miscellaneous." Both operations were done to make the findings more concise.

Perceived Potential for Change

An analysis of variance with concept (Caterpillar, power strip) and priming (nature, neutral) as between-subjects factors, and perceived potential for change as the measure, revealed a main effect of concept, $F(1, 36) = 4.35$, $p < .05$, $\eta^2 = .11$. The potential for change associated with the Caterpillar was perceived as higher ($M = 2.27$) than the potential associated with the power strip ($M = 1.76$). There was a further main effect of priming, $F(1, 36) = 7.89$, $p < .01$, $\eta^2 = .18$, indicating that potential for change was perceived as generally higher when being made aware of environmental issues in the nature priming condition ($M = 2.36$) compared to the neutral priming condition ($M = 1.67$). However, no interaction effect became apparent.

Thus, as expected, participants attributed a significantly higher potential for change to the Caterpillar compared to the power strip. While priming "nature" also increased the perceived potential (compared to a "neutral" prime), the absence of any interaction of concept with prime rendered attitude towards the environment unimportant as a moderator of how the Caterpillar was experienced. This mirrored a previous finding (Heidecker et al., 2010), where general attitudes towards saving energy failed to moderate perceived potential to change. Due to this, in the later qualitative analyses we refrained from further addressing differences in the priming condition.

Initial Thoughts and Feelings

The Caterpillar led not only to substantially more initial responses (41 of 50 responses, 82%, $\chi^2(1) = 20.48$, $p < .001$), but also to more affective initial responses. For the Caterpillar, 88% (36 of 41) of all responses were affective (e.g., "irritating," "funny," "interesting"), compared with only 22% (2 of 9) for the power strip.

Terms used to describe initial feelings and thoughts regarding the Caterpillar included "annoying" (7 of 41, 17%), "irritating" (7 of 41, 17%), "interesting" (5 of 41, 12%), "animal-like" (5 of 41, 12%), "funny" (4 of 41, 10%), and "cute" (2 of 41, 5%). (The remaining 11 of 41, 27%, were idiosyncratic.) One participant said: "I said to myself, 'What an interesting little mouse that is!'" (P1); whereas another participant said: "This thing annoyed me immensely by making this noise and twisting around hectically" (P8). Thus the Caterpillar was interesting, funny and cute, but at the same time irritating and annoying (6 out of 25, 15%). Some participants even explicitly referred to this seeming contradiction.

While all participants in the Caterpillar group provided first thoughts and feelings, participants in the power strip group where rather puzzled by the question. One participant remarked: "Feelings towards a power strip? It distributes electricity. I do not have any feelings towards a power strip" (P30). Another participant stated: "My feelings about a power strip? I have none. These are things I take note of, but do not place value on" (P33). Consequently, only nine responses were given. These emphasized the power strip's functional features through terms like "safe" (3 of 9, 33%) and "convenient" (2 of 9, 22%). One participant declared: "It is convenient . . . I can rig up certain systems in my house" (P30). Of the idiosyncratic responses (4 of 9, 44%), two were affective: "ugly" and "annoying."

In sum, compared to the nondescript, uninterested and "cool" responses of participants towards the power strip, the Caterpillar elicited more intense "warm," affective responses. These responses, however, were ambiguous (e.g., interesting and annoying at the same time).

Character

Overall, participants used 162 terms to characterize the two objects (Caterpillar: 90; power strip: 72).

The Caterpillar was characterized as "animal-like" (17 of 90, 19%), "annoying" (11 of 90, 12%), "congenial" (8 of 90, 9%), "agile" (7 of 90, 8%), "modest" (7 of 90, 8%), and "didactic" (5 of 90, 6%). (Idiosyncratic: 15 of 90, 17%; miscellaneous: 20 of 90, 22%.) The ambivalence already noted above became

apparent again. One participant stated: "I would not describe it [the Caterpillar] as impolite or annoying. OK, while I was watching TV it kind of annoyed me. But I don't think of it as an annoyance. If my mother gives me advice, I do not consider her to be annoying, although the advice may annoy me. In the end it is all to my benefit" (P8). Another participant gave this description: "It is annoying, but in a nice way" (P13).

In contrast, the power strip was characterized as "modest" (13 of 72, 18%), "boring" (7 of 72, 10%), "useful" (7 of 72, 10%), "reliable" (5 of 72, 7%), and "ugly" (4 of 72, 6%). For example, one participant said: "It is not really complicated. Multifunctional. It is able to multitask. . . . It is reliable and easy to handle" (P33). Some responses explicitly addressed the difficulties of characterizing the power strip (8 of 72, 11%). One participant remarked: "No idea. It is an object" (P38), and another participant said: "Mh? A power strip? No idea? . . . It is an 'acquaintance' I can use here and there, but I have nothing more to deal with. Just a product between two other products" (P22). The remaining responses were idiosyncratic (8 of 72, 11%) or miscellaneous (20 of 72, 28%).

All in all, while the Caterpillar was perceived as a little animal, "annoying, but in a nice way," the power strip remained functional and reliable, but grey and drab in character.

Liking

Statements on liking were coded regarding valence (positive, negative, without preference) and reasons for liking.

There was no difference in liking between the Caterpillar and the power strip (Caterpillar: 16 positive, 1 negative, and 3 without preference, of 20; power strip: 14 positive, 5 negative, and 1 without preference, of 20). Altogether, 49 reasons for liking were given, 23 for the Caterpillar and 26 for the socket.

One major reason for liking the Caterpillar was the underlying intention to "let me save energy" (10 of 23, 43%). Participants also found the Caterpillar "positively annoying" (4 of 23, 17%) and "funny" (2 of 23, 9%). (Idiosyncratic: 2 of 23, 9%; miscellaneous: 5 of 23, 22%.) The positive framing of annoyance is remarkable. It underlines the friction-rich, but in overall terms valuable experience of interacting with the Caterpillar. A participant quite clearly described her ambivalent liking of the Caterpillar: "I rather associate bad characteristics with it [the Caterpillar]. Maybe based on association with a snake or rodent. . . . But if I think about the intention of the device retrospectively, I would reconsider it as positive. That is definitely a contradiction" (P18). Another participant stated: "It is funny. Funny, but at the same time annoying" (P5).

In contrast, the main reason for liking the power strip was its practicality (11 of 26, 42%). As one participant stated: "It is practical. I can connect multiple things. And it is an extension" (P32). Another explained: "Outwardly it is not that pretty. But the idea is good. Normally, one socket in a room is not enough. With the power strip you can connect multiple things. It is practical" (P34). Others' statements referred to beauty (6 of 26, 23%), such as its color or plainness. (Idiosyncratic: 2 of 26, 8%; miscellaneous: 7 of 26, 27%.) In general, the power strip did not stimulate deeper reflection or feelings of ambivalence. Only one person said that he liked the power strip because of its potential to save energy by using its switch.

While there was no overall difference between the participants' degrees of liking for the Caterpillar and for the power strip, each was appreciated for different reasons. The Caterpillar was liked for its support in "letting one save energy," and the positively ambivalent feeling it created. The power strip was liked for its practicality, its functionality of duplicating power outlets.

Intention

Participants perceived the Caterpillar as being intended to "improve behavior so as to be more energy efficient" (16 of 20, 80%). A participant stated: "It shows that electricity is flowing. It is remarkable that it moves so forcefully while it [the TV] is in standby. It is probably intended to make you switch off the TV entirely" (P20). Another participant suggested: "It complains about you not switching off [the TV] entirely" (P12). Yet another participant also pointed out: "In daily life it would lead to one switching the TV off entirely or would raise one's awareness of appliances that are not entirely disconnected" (P18). Only three participants (of 20, 15%) did not perceive any intention after they interacted with the Caterpillar. (Idiosyncratic: 1 of 20, 5%.)

The intention behind the power strip remained fuzzy. Many participants assumed the purely practical (10 of 20, 50%). A participant remarked: "It is a functional device for me. With or without a switch—this makes no difference. It simply increases the number of sockets" (P8). Another participant underlined convenience: "[Intention?] That I can use several technical devices simultaneously, due to the several opportunities to connect the plugs. With the switch you can switch them on and off. You can disconnect and connect the plugs, as you like. It is very flexible" (P35). Only seven mentioned the perceived intention to "improve behavior to be more energy efficient" (7 of 20, 35%), in most cases rather indirectly: "If I switch it off, I can save energy. . . . I do not know if it [the power strip] tells me this message, but it is often mentioned in that context" (P29). The remaining 15% (3 of 20, 15%) did not see any further intentions. The Caterpillar conveyed the specific intention to change behavior to be more energy efficient (i.e., to avoid standby), while the intention behind the power strip remained unclear.

Summary and Conclusion

Table 1 summarizes the differences in experiences of the Caterpillar and the power strip.

The experience created by the Caterpillar clearly differed from the experience created by the power strip. The Caterpillar evoked emotional ("warm") and ambiguous responses, whereas the power strip was perceived as rather unemotional ("cold") and functional. The Caterpillar was a cute, funny, but also slightly annoying animal-like thing with the obvious intention of making people think about energy wastage through the use of standby power. Its potential to change current behavior was regarded as higher compared to the power strip. The power strip, on the

Table 1. Differences between the Caterpillar and the power strip.

	The Never Hungry Caterpillar	Power strip with switch
Perceived potential for change	High	Low
Initial thoughts and feelings	Affective ("warm"), ambiguous	Non-affective responses ("cool"), neutral
Character	Animalistic, positively annoying	Modest, boring, but useful
Liking	High Liking was based on: intention to save energy, positive annoyance	High Liking was based on: practical, aesthetic concerns, such as color or plainness
Intention	Clear message of improving energy-saving	Fuzzy message

other hand, was "modest" and "boring," but "useful" in terms of distributing power. While existent, its relationship with the intention to save energy is not especially apparent to people. Only a few participants reflected on the power strip's potential energy-saving function. All in all, the power strip was rather perceived as a neutral piece of technology, while the Caterpillar was annoying, but in a positive way. It was able to create a relationship with its users. Its obvious affective ambiguity did not impact liking much. While the power strip was liked for its functionality, the Caterpillar was liked for its naïve attempt to improve people's behavior. It is a positively annoying thing, providing situated *frictional feedback*, which serves as an emphatic starting point for further reflection and meaning-making.

We believe friction to be an important element to instigate change. While many sustainability issues appear global, they always require local solutions. And while one may rely solely on the technical (e.g., more energy-efficient devices), it seems only plausible that we have to change our behavior as well. Given that we largely rely on routines to guide everyday behavior, rhetorical interactive feedback may not be enough (Verplanken & Wood, 2006). It remains abstract, simply too remote from relevant everyday situations. Of course, the abstractness of feedback is rather a continuum since a "happy fish" (Lin et al., 2006) or a cute "polar bear" jumping from ice floe to ice floe (Froehlich et al., 2009) are more affective displays than the average consumed kilowatt-hour per hour. Similarly, the recommendation to avoid standby by using a power strip with a switch is more situated than the simple appeal to "save energy." However, many forms of feedback lack the capability to physically and conceptually disrupt routine behavior in a given situation and to use this friction as a starting point for reflection and meaning-making.

Situated friction is annoying. It literally disrupts automatic behavior at times when one may have neither the time nor the desire to be interrupted. It forces reflection upon us. While this is clearly against our predominant culture (and ideology) of convenience, it nevertheless seems a necessary step for change. However, too much friction is likely to lead to reactance (Brehm, 1966). Instead of focusing on the actual message (e.g., to avoid standby), people focus on the fact that something (i.e., a communicator) is restricting their personal freedom. This may even lead to them engaging in exactly the behavior that one wanted them to abandon. What is needed is a design strategy that helps to turn friction into something positive, perceived as a resource to support change rather than as a restriction. Our notion (Hassenzahl & Laschke, 2015) of an *aesthetic of friction* assumes that to facilitate insight, frictional feedback needs expressive qualities—it needs to be able to tell a story. The thing itself bonds with its user through its naivety and understanding. Both characteristics make the communicator appear more likable, presumably leading to less reactance (see also Silvia, 2005). These desired qualities are apparent in the Caterpillar. It creates friction (is annoying), but remains likeable through its naivety (its cuteness). In addition, it is able to tell a clear story of its purpose (to avoid standby) and this story is in line with the meaning it tries to evoke. Standing in for the environment, the Caterpillar suffers as much as the environment would if it could do so. The finding that overall, participants believed the Caterpillar to have greater potential to change their behavior, can be understood as a first tentative support of the design strategy employed.

Note that frictional feedback is certainly not the end of the story. We believe in incorporating friction and alternative behaviors as intimately as possible into everyday interaction. A recent example is the *Keymoment* (Laschke, Diefenbach, Schneider, & Hassenzahl, 2014), a key holder mounted to the wall in a hallway, next to the front door. It holds a person's bicycle and car keys, side by side but on separate hooks. If the car key is taken, Keymoment throws out the bike key, which then falls to the floor. The person may pick up the bike key while holding on to the car key with the other hand, which creates a carefully designed, quite tangible moment of choice: being health conscious and environmentally friendly by using the bike, or being comfy and potentially wasteful by using the car. This moment is created by deliberately introducing friction into a routine through a mundane key holder. Unlike the Caterpillar, which remains essentially a feedback object, Keymoment attempts to reshape action and instigate meaning-making through a more complex designed interaction. Another example of more complete reshaping of actions in line with environmental goals is the *Laundry Lamp* (see Broms, Bång, & Hjelm, 2009). It features a drying-rack-like structure as its lampshade. On one hand this is reflective, since it hopefully leads to the insight that while one may think of a lamp primarily as a source of light, it may actually be a source of heat (depending on the lighting technology used). On the other hand it is indicative, since the drying-rack-like structure in itself suggests a particular use of that heat in a particular situation, such as drying kitchen towels. Both concepts, Keymoment and Laundry Lamp, do not stop at the level of feedback. They more fully involve their users in meaning-making and change by offering situated

alternative courses of action (riding the bike, using the heat) and providing choice. However, while Keymoment employs friction as a crucial element, Laundry Lamp does so to a lesser extent. One may argue that since a naked lightbulb is something people do not enjoy much, they will load the lightshade with towels, thereby using the energy used for lighting more efficiently. However, this is far removed from the explicit friction that Keymoment embodies. All in all, while these examples show that friction could and should be employed in richer, more complete ways than mere feedback, we still believe that feedback will remain an important area of application.

Of course, the present study is limited in several ways. A major concern is whether frictional feedback is actually more efficient than other types of feedback. While it is desirable to explore this in future studies, the present work leaves the question open. In fact, it had a more modest goal, namely to explore the differences in experiences created, depending on the way feedback is given. First, the difference was profound, emphasizing the importance of the "how" from an experiential perspective. Second, the particular experience of the Caterpillar was in line with expectations. It hints at the relationship between perceived potential for change and particular experiential qualities. As a case study, it supports our notion of an aesthetic of friction, and at least renders further explorations and studies worthwhile.

We believe studies such as the present one to be important especially from a design perspective. While in human–computer interaction the notion of "objective improvement"—that is, the ability to prove that a certain object is superior to another in terms of a measurable outcome, such as saved energy in kilowatt-hours—is prevalent, the relevant studies are often quite vague about the design strategies employed and the experience created. While impact definitely matters, the way we create this impact, the "how," is important too. This seems especially true for the complex field of change. An outcome-oriented perspective may favor presumably high-impact strategies without being aware of the experiential costs of these strategies. In other words, to prohibit standby mode in appliances may be considered the most effective in terms of energy saving, but it remains completely unpredictable how such a strategy may impact the individual. The prevalence of rebound effects of technology-based solutions, such as energy-saving light bulbs in Europe, supports this skepticism. When designing interactive technologies for change, a glance at the experiential side of interacting with those technologies seems worthwhile, to complement questions about mere effectiveness.

To conclude, the design case presented here highlights the potential and the challenges of designing frictional feedback to break up routines and to encourage reflection and meaning-making. We explored a strategy to make feedback "annoying, but in a nice way," resulting in an object that we may call a "pleasurable troublemaker" (Hassenzahl & Laschke, 2015). Further research will explore the underlying principles and aesthetics of pleasurable troublemakers and study their effects in longitudinal and in-situ studies. Moreover, further case studies (i.e., materialized concepts and approaches) will explore the impact of objects such as the Never Hungry Caterpillar on an experiential and behavioral level. The goal is to better understand how to assist people in becoming the person they want to be, be it with regard to environmental issues, personal health, or any domain in which a person's own intentions and their everyday behavior are in conflict with each other.

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Appendix

Video screenshot	*Title and link*
	The Never Hungry Caterpillar URL: https://vimeo.com/133579013 (The video is referenced in this paper. It explains the Never Hungry Caterpillar)