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The effect of digital rewards on the motivation of children to perform everyday health behavior

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ABSTRACT

Information technology can serve as a powerful tool for promoting children's learning. In this context, digital, symbolic rewards are frequently employed to enhance task performance. However, it has been observed that once rewards are removed, intrinsic motivation to perform a task may decrease below baseline levels, a phenomenon referred to as motivation crowding. There is a lack of consensus among researchers under which circumstances motivation crowding happens among children. Here, a field experiment with three distinct groups tests the presence or absence of motivation crowding. This paper reports the findings from the cluster randomized field study that investigated a digital health intervention guiding and rewarding children to engage in everyday health behaviors. Behavioral data from 254 children between the ages of three and six was collected over a five-week period. The results provide empirical evidence that digital rewards successfully helped children adapt everyday health behaviors and refute motivation crowding among children in the context of digital rewards. The findings are important for advancing the use of motivation crowding theory in children, for providing insights into children's behavior, and helping researchers develop digital motivational cues for children. At the same time, the digital intervention outlined in the paper embodies an effective and scalable measure for engaging children in health prevention behavior.

1. Introduction

During the first decade of life, humans undergo a significant learning process that encompasses a variety of skills (Gesell et al., 1946; Thompson, 2001), ranging from basic motoric skills to behavior in social context to establishing health-related habits. As children engage with their surroundings, they repeatedly experience positive or negative reinforcement, which shapes their behavior patterns (Miltenberger & Crosland, 2014). Positive reinforcement is often provided through extrinsic rewards. However, the use of extrinsic rewards may not only have positive effects. While extrinsic rewards initially appear to reinforce the desired behavior, the phenomenon of motivation crowding suggests that the introduction of extrinsic rewards may lead to a decline in intrinsic motivation once the reward is no longer present, ultimately resulting in reduced task performance (Frey & Jegen, 2001). While the task is initially enjoyed, the pleasure of engaging in the task is attributed to the presence of the reward, rather than the activity itself (Deci, 1973). In the field of digital technology, symbolic rewards are a commonly employed tool for promoting behavior change (Evans et al., 2022; Lewis et al., 2016). The concept of motivation crowding in the context of those digital rewards has been explored within the literature for selected use cases (Flüchter & Wortmann, 2014; Liu & Feng, 2015; Qiao et al., 2017; Wu, 2019). Psychology research has long explored motivation crowding theory before it was applied to digital applications, often studying the phenomenon with children and in laboratory settings (Deci et al., 1999). However, research on motivation crowding in a digital context has exclusively focused on adults. Children differ from adults in that they are inherently driven by a natural curiosity, known as mastery motivation, leading to the establishment of motivational patterns from an early age (Carlton & Winsler, 1998). As technology influences life and learning early in life (Ronimus et al., 2014) and given the distinct ways in which children develop and learn (Kuhn & Pease, 2006), it is helpful to specifically investigate the potential impact of digital rewards on children's motivation. This is especially important because digital rewards are an

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integral part of digital learning tools, which are currently experiencing a major upswing in the education space (Fadhli et al., 2020; Lamrani & Abdelwahed, 2020; Nand et al., 2019). While digital learning tools are employed in a variety of domains, one promising application of digital learning (if designed properly) is health literacy building (Dunn & Hazzard, 2019). Information systems can support young children in learning everyday health behavior. Since it is unclear how digital rewards affect the motivation of children learning everyday behavior, the paper presents a study that aims to examine motivation crowding specifically in a digital reward system for young children. Thus, we ask the following research question:

Do digital rewards for everyday health behavior lead to motivation crowding in young children?

The overall aim of addressing this question is to make a theoretical contribution to the motivation crowding theory for children and to contribute to future theory-driven design of digital learning interventions. To answer the posed research question, we study handwashing behavior because of its relevancy for disease prevention (Luby et al., 2005) and because it is possible to measure the behavior with IT without unintentionally influencing the children. Importantly, handwashing represents an ideal theoretical test case because young children are naturally motivated by mastery-oriented activities that allow environmental control (i.e., agency over the water, soap, and handwashing process) and provide appropriate challenge (Carlton & Winsler, 1998), making it possible to observe whether digital rewards crowd out this natural motivation. By examining handwashing behavior of children with the help of a field experiment, we can generate theoretical insights that have not yet been explored due to the dominance of laboratory research studying the phenomenon. Examining handwashing and thus health behavior elevates the current spectrum of studies researching digital rewards, as those focus on gamification and learning games.

While the focus of the field study is to contribute to theoretical knowledge, the investigation of the use case itself is also valuable. Studying health prevention behavior of children and hand hygiene in specific ways to improve it is highly relevant, given the gravity of infectious diseases of children on their development, family dynamics and broader society ("author citation"). When sick, not only children do have to stay at home, but caregivers often must take leave from their jobs as well. Many times, the caregiving responsibility is shouldered by women, exacerbating existing gender-based inequalities in the workforce. To mitigate this hardship, it is imperative to implement both childcare concepts for sick children and preventive health solutions. The establishment of a good handwashing routine or healthy behavior in general during early childhood holds significant advantages, given that the health practices learned during young years tend to be sustained throughout one's lifespan (Forrest & Riley, 2004; Center on the Developing Child, 2010).

We developed a digital feedback system for young children that uses digital rewards to promote good hand hygiene among children to investigate and influence handwashing behavior. We tested the intervention in a real-world setting and demonstrated its practical relevance in a field study. This way we examined how the digital reward provided by our solution affects children's hand washing performance.

The research presented in this paper is structured as follows: In the next section, we define motivation crowding, provide an overview on the concept of motivation in information systems and child research and develop hypotheses regarding our research question. Afterwards, we propose a feedback system to improve handwashing behavior of children in day care centers by introducing the experimental design of our pre-registered cluster randomized controlled field study to evaluate the efficacy of the artifact in practice. We then elaborate on the implications of the result in light of motivation crowding theory and our hypotheses. Finally, we discuss implications, limitations, and future research avenues before concluding with a summary of our results.

2. Theoretical background and hypotheses development

The concept of intrinsically motivated tasks refers to activities that individuals perform purely for their inherent interest or enjoyment in the task itself (Deci, 1973). Motivation crowding theory pertains to the impact of extrinsic rewards on intrinsic motivation. The theory posits that extrinsic rewards can undermine initial intrinsic motivation and subsequently lead to adverse impact on the rewarded behavior once the reward is no longer present. Researchers have shown long-standing interest in the reinforcing effect of extrinsic rewards on behavior, with the earliest descriptions of unintended consequences appearing in literature in the 1970s (Deci, 1971; Titmuss, 1970, pp. 162–165). While economists and psychologists have been actively engaged in discussions about motivation crowding and its impact since early on (Deci et al., 2001; Festré & Garrouste, 2015), it is also a research topic in other disciplines nowadays, such as IS research, as the following paragraphs depict.

2.1. Motivation in information systems and Human-Computer Interaction research

The concept of intrinsic and extrinsic motivation has been investigated in several application fields in the Information Systems and Human-Computer Interaction literature, e.g., in gamification (Hu et al., 2023; Liu et al., 2017; Mekler et al., 2017), social Q&A communities (Zhao et al., 2016), and open-source software development (von Krogh et al, 2012). Because information systems can deliver salient and timely rewards, both motivation and motivation crowding are relevant phenomena in this research. The exploration of motivation crowding is currently limited to specific domains. For example, motivation crowding has been investigated in the context of online product reviews (Wu, 2019), user-generated content platforms (Liang et al., 2018; Liu & Feng, 2015), different pro-social behaviors rewarded with monetary incentives (Qiao et al., 2017), and feedback to promote sustainable travel behavior (Flüchter & Wortmann, 2014). Motivation crowding in the context of information technology and pre-school children has received no attention, despite the large potential for child education. With their technical possibilities, information systems can guide children while performing an action without the presence of a teacher and are therefore a good tool for learning everyday tasks. Furthermore, information systems are highly scalable, and real-time data processing enables IS to play out performance-contingent rewards to children during or right after an action. Even more sophisticated approaches, such as automatic motivator selection based on individual user characteristics and preferences (Siyam & Abdallah, 2023), have been proposed. However, it is unclear how those unique features of digital rewards affect motivation of children, i.e., how potential motivation crowding effects appear in the context of digital rewards.

Information technology provides a valuable opportunity to investigate motivation crowding effects in real-world settings, as they enable the collection of extensive data. In particular, IT can serve as an effective research tool for studying behavior, as it allows for the measurement of long-term effects in field experiments, which can complement findings from laboratory experiments and observational studies (Goes, 2013). Therefore, conducting research using IT as a measurement tool holds the potential to generate novel insights into motivation crowding through field studies.

2.2. Motivation crowding and its role in child learning

Throughout their learning journey, children experience constant reinforcement from their environment, which influences their behavior (Miltenberger & Crosland, 2014). Extrinsic rewards are a frequently used means for positive reinforcement. However, while extrinsic rewards might reinforce the incentivized behavior when the reward is given, they can also lead to a reduction of the child's intrinsic motivation to perform a task when the reward is no longer present (Deci et al.,

1999).

Whether children show the same motivation crowding effects as adults remains unclear, as developmental research presents conflicting evidence about how young children process incentive information. Some studies suggest young children make fundamentally different inferences about rewards than adults, e.g., due to distinct reward-seeking strategies which focus more on exploration than generalization when compared to adults (Liquin & Gopnik, 2022; Schulz et al., 2019). Additionally, young children show limitations in understanding ulterior motives behind incentives (Butzin & Dozier, 1986), suggesting they may not understand the controlling or evaluative aspects that could undermine intrinsic motivation. However, other research indicates that even young children can make sophisticated inferences about incentives and their implications, suggesting their motivational responses may be more similar to adults than previously assumed (Ma et al., 2020, 2023). This uncertainty about whether motivation crowding effects occur similarly in young children requires direct study in this population.

Since nearly all studies on children and motivation crowding effects are conducted in laboratory settings (Deci et al., 1999; Esteves-Sorenson & Broce, 2020), not only the timespan of observations but also the investigated activities are limited to those that are sufficiently observable in the laboratories. Research on motivation crowding among children due to tangible (material and symbolic) rewards is mostly conducted in the context of playful activities, e.g., mazes, building blocks, drawing (Deci et al., 1999; Esteves-Sorenson & Broce, 2020). Studies that build on motivation crowding at the interface of children and health are rare. Two field studies have examined rewards for healthy eating behavior: Cooke et al. (2011) randomly assigned 422 children to receive either tangible rewards (stickers), social rewards (praise), or no rewards for tasting a disliked vegetable. They found that both reward types increased vegetable intake during the intervention and maintained increased consumption three months post-intervention, with no evidence of undermined intrinsic motivation. Loewenstein et al. (2016) provided tokens (worth $0.25) to 8000 elementary students for consuming fruits or vegetables during lunch for 3 or 5 weeks. The fraction of children eating vegetables doubled during the incentive period and remained above baseline two months after rewards ended, suggesting habit formation rather than motivation crowding. However, their transferability is limited: repeated taste exposure itself increases food acceptance independent of rewards and may have confounded motivation crowding effects (Cooke et al., 2011). Further, observer presence during the meals may have influenced behavior (Loewenstein et al., 2016), and many children have low initial intrinsic motivation for eating vegetables, making it unclear whether rewards undermine existing motivation (Cooke et al., 2011).

For many other use cases, this looks different. Young children, in general, are eager to learn, curious by nature and like play-based learning (Keung & Cheung, 2019). Unlike adults, who distinguish between social and economic contexts when interpreting rewards (Heyman & Ariely, 2004), young children may have not yet developed sophisticated frameworks for interpreting the meaning behind different types of rewards and incentives, as they focus primarily on immediate rewards and punishments rather than understanding deeper social meanings (Kohlberg, 1984) and have a limited understanding of monetary incentives (Strauss, 1952). Consequently, many activities have the potential to trigger motivation crowding when working with children (Deci et al., 1999). In our study, we specifically investigate motivation crowding in the context of handwashing. Handwashing, if performed without obligation in a playful setting, is a task that is typically enjoyable for children due to its interactive nature involving water and soap. However, the introduction of extrinsic rewards may undermine the intrinsic enjoyment associated with handwashing. Examining motivation crowding in the context of handwashing is not only theoretically interesting but also holds practical relevance, as it is an essential health activity for individuals of all ages and plays a crucial role in preventing the spread of diseases (Lau et al., 2012).

To conclude, though many publications around children's motivation crowding exist, it is unclear how digital rewards for health-related behavior impact the motivation of children. Gaining more knowledge about contexts that promote motivation crowding is important if the potential of digital rewards is to be fully exploited to support children in learning everyday health behavior.

2.3. Hypotheses regarding the effect of digital rewards on children's motivation

Based on motivation crowding theory and existing literature on digital interventions with children, we developed four competing hypotheses that systematically examine both the immediate effects of digital rewards and instructions, and their longer-term consequences when withdrawn. These hypotheses allow us to distinguish between motivation crowding effects and alternative explanations such as habit formation.

Generally, rewarding reinforces behavior by increasing extrinsic motivation, at least in the short term (Esteves-Sorenson & Broce, 2020). Likewise, previous research has demonstrated the beneficial effects of digital rewards on motivation and performance (Groening & Binnewies, 2019; Kundisch & Von Rechenberg, 2017), and of rewards as a tool to improve short term motivation in children (Karniol & Ross, 1977; Loveland & Olley, 1979). This leads us to our first hypothesis.

H1. The presence of digital rewards has a positive impact on the task performance of children regarding the rewarded activity.

We believe that latest with the removal of the external reward the undermined intrinsic motivation comes visible with a decreased task performance (Esteves-Sorenson & Broce, 2020). While the activity was previously performed by children because of norms and out of curiosity, according to theory, they now may want to be rewarded for it and might be primarily extrinsically motivated. Thus, motivation crowding happens as soon as the reward is withdrawn, lowering task performance. We expect this outcome in two cases: when the reward is expected (due to the presence of the system that formerly provided rewards, now only providing instructions) and when the system is completely absent.

H2a. Withdrawing the digital reward sharply decreases task performance, even below the baseline level.

The negative effect of rewards on children's performance and motivation have mostly been investigated in short laboratory experiments, often conducted in a single session (Deci et al., 1999). However, two more recent long-term studies on exercising (Acland & Levy, 2015; Charness & Gneezy, 2009) found no evidence of long-term crowding out of intrinsic motivation - the positive effects of rewards persisted after the interventions ended. Instead, both studies proposed habit formation as a counteracting force to motivational crowding - rewards helped to reinforce sustainable behavior. We therefore formulate a competing hypothesis to H2a.

H2b. After withdrawing the digital reward task performance stays above baseline level.

While the first two hypotheses refer to the case in which rewards are provided, we expect different outcomes for the sole provision of instructions, captured in hypothesis three and four. While the instructions are in place, we anticipate an increase in intrinsic motivation and thus task performance. This hypothesis is based on theory suggesting that engaging children in captivating and appropriately challenging learning activities can enhance their intrinsic motivation (Cordova & Lepper, 1996; Deci et al., 1981), as opposed to relying on external rewards. Specifically, gamified instructions can boost intrinsic motivation in young children (Habgood & Ainsworth, 2011) and digital instructions can improve learning without negative effects on motivation in online games (Erhel & Jamet, 2013).

H3. A digital intervention without rewards (only instructions) will still have a positive impact on task performance, although this impact will be smaller compared to the intervention with rewards.

We anticipate that the provision of instructions will not only increase intrinsic motivation while the instructions are in place, but also hypothesize that the motivation and task performance will be (partially) sustained even after the instructions are withdrawn. Again, habit formation may explain the persistent improvement in performance and we assume that no motivation crowding occurs when the digital instructions are withdrawn (in contrast to withdrawing the reward, see H2).

H4. Withdrawing the digital intervention without rewards will lead to a slight decrease in task performance, but this decrease will not fall below the baseline level.

Together, these hypotheses provide a framework for testing motivation crowding theory against alternative explanations in the context of digital health interventions for young children. Confirming or refuting our set of hypotheses will provide an extensive picture on child behavior in the context of digital rewards, which is relevant for the design of motivational cues in the IS discipline as well as for the understanding of young children's behavior in general. In the following, we describe our research methodology to analyze the posed hypotheses.

3. Research methodology

We investigated our hypotheses with the help of a digital intervention in a field study to address the identified research gap pertaining to the impact of digital rewards on the motivation of children to learn health behavior. Comprehensive information concerning the design of the field experiment can be found in the trial protocol article ("author citation"). The study protocol was approved by the ethics committee at the authors institutions in Finland and Germany. The study was preregistered under clinicaltrials.gov with the ID NCT05395988.

3.1. Experimental procedure

A five-week cluster randomized controlled trial was conducted in three day care centers in Finland with children aged three to six years. The study hardware (smart faucets, soap dispensers, and gateways) was installed at the washbasins of all study groups. The day care centers were randomly assigned to one of three study groups (control, instruction, and reward group), and handwashing behavior was measured in the baseline, intervention, and post-phase (see Fig. 3).

Handwashing performance of children was measured in a baseline phase across all three study groups without the presence of any intervention. A short educational video was shown to the children in the classroom once in each day care center halfway through the baseline phase to first measure natural handwashing behavior and then provide all groups with equal knowledge before the intervention, preventing confounding effects of differing baseline knowledge across groups. Following the baseline phase, displays were installed above washbasins in all groups except for the control group to deliver the respective treatments. In the intervention phase, the instruction and reward group received animated handwashing instructions, with the reward group receiving a performance-contingent reward following the instructions. The instruction group received only instructions without any reward. The control group did not receive any visible intervention during the intervention phase. After the intervention phase, tablets were deinstalled, except for part B of the reward group, and measuring devices remained in all day care centers for the post-phase. During the post-phase, the control, the instruction, and part A of the reward group did not receive any further input from the tablets, while part B of the reward group continued to receive instructions without any reward.

This cluster randomized design, combined with simultaneous data collection across all groups during the same time period, ensures that external factors such as seasonal effects, weather conditions, or illness outbreaks affect all experimental groups equally and are controlled for through randomization and the parallel group structure.

3.2. Design of the digital system and the intervention

We developed a digital system to improve handwashing, an everyday health prevention behavior, among children in day care centers. The system was installed in the washing facilities of the day care centers and consists of a touchless faucet, touchless soap dispenser, and a feedback display (see Fig. 1). All devices sent and received information via Bluetooth to a gateway which relays the data to a cloud infrastructure, where data was processed and visualized.

The centerpiece of the system is the feedback display, which shows the intervention through a 30-s animated handwashing instruction sequence that activates when children begin handwashing (by extracting water or soap). The animation includes all relevant handwashing steps (European Centre for Disease Prevention and Control, 2020). When children continue to wash their hands throughout the whole handwashing instructions—using both soap and water while the animation plays—the system provides an immediate performance-contingent reward: animated dancing animals appear on screen (for selected animation screens see Fig. 2). The design of the instruction and reward screens is based on previous studies of health games for children (Ingadottir et al., 2022), and was confirmed through pre-tests with individual day care center children of different ages who provided feedback on the design. Furthermore, we pre-tested the digital system and the corresponding intervention to test if it is adequate to help us answer our research question. Results from the pre-study indicated that our intervention was successful in increasing handwashing quality.

3.3. Data collection and outcome measures

In the first quarter of 2022, we contacted three eligible day care centers and all of them agreed to participate in our field study. To prevent diffusion of the intervention, strict separation was enforced between the control and the two treatment groups by randomly assigning entire day care centers to one group or the other with a computer program. The split in the reward group into two subgroups in the post-phase was implemented on two different floors and building parts of the respective day care center. We installed our digital system at 35 washbasins across the three day care centers in Finland and collected data on handwashing observations, including the timing of the water and soap extraction, over at least 23 weekdays in each day care center in May and

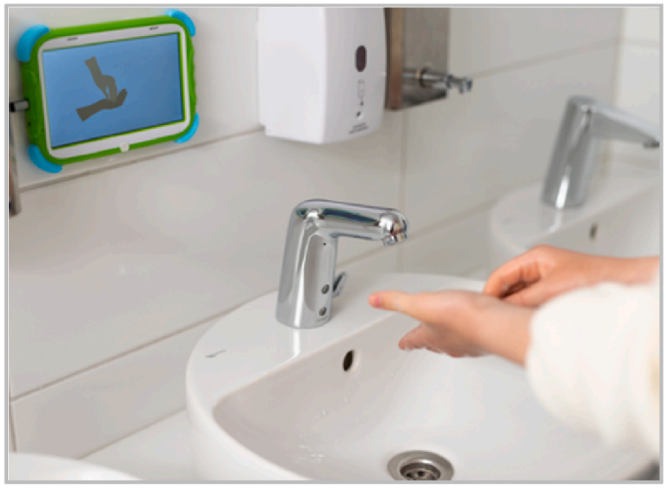


Fig. 1. Example of experimental setup at a washbasin.

Fig. 2. Selected screens of the intervention animation.

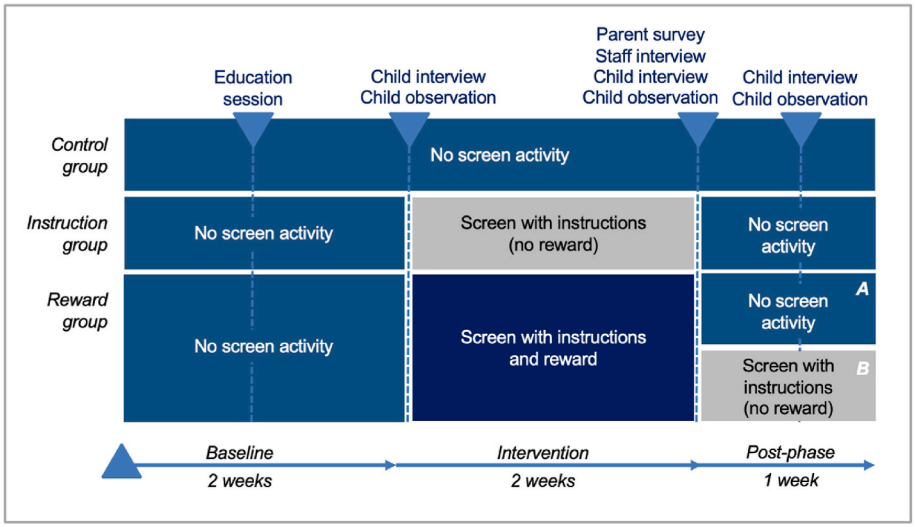


Fig. 3. Experimental design of the cluster randomized field study.

June 2022.

Our cluster randomized controlled study aimed at investigating the effect of motivation crowding on children's motivation to wash hands. As in existing literature, e.g., Lepper et al. (1973) and (Deci et al., 2001), we measure the time spent performing an activity as a proxy for motivation. Our study hardware provides objective and measurement data on time spent soaping the hands.

4. Research results

Our study involved 254 children in total, with our system recording handwashing activities of 177 children on average across all day care centers. Throughout the experiment's three phases, the equipment recorded 5709 handwashing procedures (water and accompanying soap extraction), which are processed in the result analysis. This number includes all recorded handwashing procedures except those, that were outside of the day care center opening hours (e.g., for cleaning purposes). For this study, handwashing processes are defined as soap extractions followed by water extractions. Furthermore, we observed 279 handwashing procedures of the children in the day care centers at 3 different points of time.

In Table 1, we present descriptive characteristics for the full sample as well as for each experimental group. The table provides the number of handwashes per cluster as well as cluster mean and standard deviation for the number of children in day care center per day across all experimental phases. Furthermore, the table reports the mean soaping time in the baseline phase. Across all clusters, the mean soaping time during the baseline phase was 5.99 s. Our result analysis adheres to the CONSORT guideline for randomized trials (Consort et al., 2010; Campbell et al., 2012), and thus, we do not provide further details on tests of baseline differences (Altman, 1985; De Boer et al., 2015; Moher et al., 2010; Senn, 2013).

Table 1
Descriptive statistics measurement data.

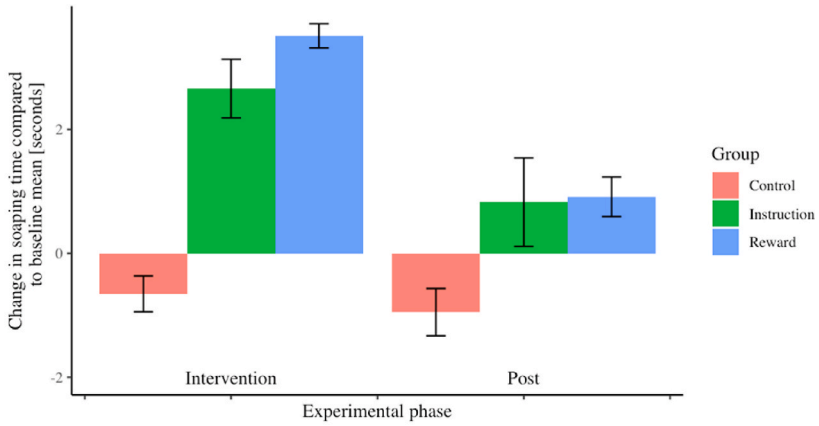
	Full sample	Control group	Instruction group	Reward group
Mean number of children in day care center per day (all experimental phases)	63 (18.24)	56 (6.53)	51 (7.55)	70 (21.37)
Number of handwashing processes (all experimental phases)	5709	1741	524	3444
Mean soaping time in baseline phase	5.99 (6.39)	6.59 (6.52)	5.38 (5.63)	5.61 (6.36)

Descriptive statistics for the full sample and the different clusters. Standard deviations are reported in parentheses.

4.1. Effect of the intervention on handwashing motivation

The effect of our intervention on the soaping time are visualized in Fig. 4, which visualizes changes in mean soaping time per experimental group. Soaping time for both the instruction and reward group rises during the intervention phase and remains slightly higher than the baseline level in the post-phase. The average increase in soaping time in the reward group is 62.54 % during the intervention phase and 18.99 % during the post-phase, both compared to the baseline phase. For the instruction group, the increase lies at 49.40 % and 0.01 %, respectively.

To formally estimate the effect sizes, we model the following relationship using ordinary least squares:



Note: Bars indicate the mean difference in soaping time per experimental group compared with the mean of the baseline phase. Error bars represent mean ± SEM.

Fig. 4. Change in mean soaping time across experimental phases
Note: Bars indicate the mean difference in soaping time per experimental group compared with the mean of the baseline phase. Error bars represent mean ± SEM.

$$y_{it} = a_i + IN_{it}^{intervention} \times \left(\beta_1 + \beta_2 T_i^{instruction} + \beta_3 T_i^{reward}\right) + IN_{it}^{post} \times \left(\beta_4 + \beta_5 T_i^{instruction} + \beta_6 T_i^{reward}\right) + \varepsilon_{it}$$

where the dependent variable y_{it} represents the soaping time in day care centre i on timestamp t. We include an individual fixed effects coefficient α_i for each day care centre to control for fixed differences in the washing places across the different day care centers. The variable $IN_{it}^{intervention}$ is 0 during the baseline and the post-phase, and 1 in the intervention phase. By contrast, the variable IN_{it}^{post} is 0 during the baseline and the intervention phase, and 1 in the post-phase. $T_i^{instruction}$ is a treatment group indicator that takes the value of 1 if a day care centre belongs to the instruction group and is else 0. Likewise, T_i^{reward} is a treatment group indicator that takes the value of 1 if a day care centre belongs to the reward group and is 0 otherwise. The standard errors are clustered on the day care centre level. The error term ε_{it} captures all effects that are not considered in our model.

The effect of the instruction and the reward on the handwashing behavior (measured by soaping time) across the three experimental phases is captured in Table 2 and further elaborated in the following. We see a small but statistically significant ($p = 0.034$) negative effect of the intervention phase on soaping time. In our field study, the hardware was installed well in advance of data collection, allowing the children to become accustomed to the new faucets. Nevertheless, we see a Hawthorne effect, as teachers and children may have been more aware of being part of a study in the beginning of the experiment. We see a positive effect of the instructions and the rewards on the soaping time in the intervention phase (both statistically significant at the 0.1 % level). The positive effect is larger for the reward group, where we also see a positive effect in the post-phase ($p = 0.020$). We also tested if subgroup A and B of the reward group differed in the post-phase by including an additional binary variable (1 for instructions in the post-phase, else 0). We find no statistically significant different outcome in the post-phase of the two subgroups. Furthermore, we evaluated possible changes in handwashing frequency. We do not see any statistically significant effects of our intervention on the handwashing frequency in the day care centers ($F = 0.560$, $p = 454$).

Our measurement results get backed up with data from visual observations. During observations in the day care center, the observing researchers rated the handwashing performance, defined as the sum of correctly completed handwashing steps divided by the total number of handwashing steps. In the baseline phase there was no statistically significant difference in handwashing performance of the children between the groups ($p = 0.063$). In the intervention phase however, the handwashing performance of children in the reward and the instruction group was statistically significantly better than in the control group ($p < 0.001$). With the observation, we were able to rule out certain pitfalls of our digital measurements: children with the digital intervention were performing the soaping movements while standing in front of the screen (rather than solely watching the animation instead of soaping hands).

Table 2
Main experimental outcomes.

		Handwashing behavior	
Phase effect	*Intervention phase*	−0.69* (p = 0.034)	(0.33)
	Post-phase	−0.94 (p = 0.147)	(0.65)
Instruction effect	*Intervention phase*	3.17*** (p < 0.001)	(0.80)
	Post-phase	1.65 (p = 0.112)	(1.04)
Reward effect	*Intervention phase*	4.12*** (p < 0.001)	(0.67)
	Post-phase	1.68* (p = 0.020)	(0.72)
Overall intercept		5.98	
Observations		5709	
R^2		0.03	

The table displays the effects on soaping time in seconds. Standard errors are reported in parentheses, adjusted for clustering at the day care center level. *, **, and *** indicate significance at the 5 %, 1 % and 0.1 % level, respectively.

5. Discussion

5.1. Implications for theory and practice

The aim of our study was to investigate if task performance for a specific activity decreases due to motivation crowding in children as a response to digital rewards. In a field study, we investigated task performance over the course of five weeks in a natural environment, as children continued their regular handwashing routine in their day care center.

Our findings have several implications (see Table 3). First, our study demonstrates the strong effects of digital rewards on performance while the rewards are in place. In line with our first hypothesis (H1), the provision of a digital reward resulted in a significant increase in task

Table 3
Hypotheses and results.

	Hypothesis	Result
H1	The presence of digital rewards has a positive impact on the task performance of children regarding the rewarded activity	Hypothesis confirmed
H2a	Withdrawing the digital reward sharply decreases task performance, even below the baseline level.	Opposite effect outlined
H2b	Withdrawing the digital reward task performance does not decrease task performance below baseline level.	Hypothesis confirmed
H3	A digital intervention without rewards (only instructions) will still have a positive impact on task performance, although this impact will be smaller compared to the intervention with rewards	Hypothesis confirmed
H4	Withdrawing the digital intervention without rewards will lead to a slight decrease in task performance, but this decrease will not fall below the baseline level.	Hypothesis confirmed

performance for handwashing, with the effect being present right from the onset of the intervention phase. The positive effect of the intervention can be attributed to the reward that serves as an additional performance feedback (Ryan et al., 1983), thereby potentially increasing the children's motivation. Second, the findings of the post-phase provide no empirical evidence for a change in task performance that could be attributed to motivation crowding effects of digital rewards on motivation of young children. During the post-phase, we observed that the removal of rewards in the reward group resulted in a decline in handwashing task performance (for subgroup A and B). However, the performance did not drop below the baseline level for either subgroup, soaping time stayed significantly longer than compared to the baseline phase (contrary to our hypothesis H2, in line with our hypothesis H2b). Thus, we do not find empirical evidence for motivation crowding effects. The two subgroups in the reward group allowed us to examine whether the adverse effects were specifically linked to children's expectations of receiving rewards. In subgroup A, tablets were removed before the post-phase and thus, children might have no longer expected any rewards. In subgroup B in contrast, tablets were still installed in the post-phase and showed instructions and thus, rewards were expected by the children. Since we found no statistically significant differences between the two groups, we provide empirical evidence to refute motivation crowding effects of digital rewards, whether expected or not.

The instructions alone (no reward), also had a positive impact on handwashing task performance (in line with hypothesis H3). The lower point estimate of the effect compared to the reward-based intervention suggests that the digital rewards might provide stronger feedback than mere display instructions. In the post-phase, the instructions group experienced a decline in performance but maintained a level of performance above the baseline level (in line with hypothesis H4), indicating that prior learning contributed to continued handwashing behavior. The performance level of the display-only group was lower than that of the reward-based interventions during both the intervention and post-phases, underlining the overall positive effect of the reward.

Overall, our findings enhance the understanding of motivation crowding theory in the context of young children and digital rewards provided by IT. By conducting measurements in the field (which is a novel approach, as existing studies are conducted in laboratories), we were able to demonstrate that digital rewards do not lead to decreased task performance, as soon as the rewards are withdrawn, a phenomenon that motivation crowding theory would predict. While there might have been a slight decrease in motivation due to the reward, this drop might be overtaking by learning effects. We provide empirical evidence that digital rewards positively contribute to task performance regarding health prevention behavior in children and thus, do not lead to motivation crowding effects. This finding challenges the potential negative impact of digital rewards on children's motivation and contributes to the advancement of understanding children's behavior and the design of digital learning interventions targeted towards children. While motivation crowding has been confirmed in various studies involving children (Deci et al., 2001; Festré & Garrouste, 2015), we do not observe motivation crowding in our specific context. This suggests that motivation crowding effects in children may be context-dependent: while well established for playful tasks and in laboratory settings (Deci et al., 2001), they may not emerge when children perform repeated everyday health behaviors over longer periods in natural settings. Another study on children's eating behavior similarly does not find motivation crowding and posits that this absence could be attributed to the overriding influence of habit formation (Loewenstein et al., 2016).

From a practical standpoint, our study holds implications for the design of IT applications aiming at improving children's everyday health behavior. Our field study demonstrates how IT can be used to encourage health prevention behavior and provides practical implications for the design and implementation of future digital interventions aimed at promoting children's health behavior. Specifically, practitioners can use digital rewards to improve children's health behaviors without concern that such rewards will undermine motivation once removed. Our findings suggest that real-time instructions combined with digital rewards are effective for establishing repeated everyday health behaviors, and that interventions should be sustained long enough to allow habit formation, as this appears critical for maintaining behavior change after interventions are removed. Our intervention showcases how educational institutions, such as day care centers and schools, can utilize IT to progress towards their vision of a digitally supported care offering. Our intervention provides a practical possibility for improving hand hygiene in day care centers, a pressing issue in practice. Despite handwashing being performed regularly by children, their behavior before our intervention still fell short of good hand hygiene standards, underlining the relevance of our system.

5.2. *Limitations and future research*

While our study provides valuable insights into motivation crowding theory, it is important to note several limitations and areas for future research. Despite using the longest timespan of continuous day care days without vacations, our field experiment still falls short of evaluating the formation of a new habit, for which a longer duration of data collection is needed. At the same time, habit formation might also be a reason that we have not detected motivation crowding out (Loewenstein et al., 2016). More precisely, many children in the day care center had already learned to wash their hands before the onset of the field experiment. For these children, handwashing might already have become a stable ritual so that rewards did not spoil the potentially joyful process of washing their hands. However, we cannot analyze such relationship, as the system was designed to protect children's personal privacy, meaning that we were not able to attribute handwashing data and potential insights from surveys to individual children. As a consequence, we also cannot rule out that specific subgroups of children, such those with a low intrinsic motivation, have dropped out of the experiment. In general, when doing behavioral experiments and designing digital interventions like ours, backdrops of technology, like data privacy risks should always be kept in mind (Sunyaev et al., 2015), especially since children are particularly vulnerable, protecting their privacy in digital health solutions is essential. Despite these limitations, our study underscores the potential of IT to promote positive behaviors and improve public health outcomes among children.

While in our setting, for the day care centers under study, we do not find evidence for motivation crowding, it still might show up in other settings and thus, should be subject of investigation of additional field studies. Future research should furthermore explore the effects of digital rewards on other behaviors besides handwashing, such as physical activity, healthy eating, or screen time. Given that handwashing shares behavioral characteristics with other everyday health behaviors such as tooth brushing (Bish & Michie, 2010; Kim & Lee, 2021), our findings may generalize to other frequently repeated health behaviors. While our

study focused on children aged three to six years, it remains unclear whether the effects of the feedback system would be similar for older children. Additionally, our study was conducted in Finnish daycare centers with a relatively homogeneous population, which limits generalizability to other socioeconomic and cultural contexts, as differences in cultural attitudes toward hygiene and IT systems may shape children's responses to the digital interventions. Replicating our study with a larger and diverse sample of children could offer a more comprehensive understanding of the generalizability of the effects of digital rewards across different populations.

6. Conclusion

The presented study introduced a feedback system designed for children to promote good hand hygiene. It was tested in the field to explore the effectiveness of digital rewards in enhancing the motivation of children in day care centers to engage in everyday health behavior. The results provide empirical evidence that digital rewards are highly successful in encouraging health behavior. In our field study, the task performance of the reward group increased by 62.45 % while the rewards were in place. The findings refute the notion of decreased task performance upon reward withdrawal, as predicted by motivation crowding theory. Instead, the task performance in the reward group remained 18.99 % above the baseline level even after the rewards were withdrawn. The effects of the rewards on task performance were evident immediately upon their introduction and removal. To conclude, the use of IT with rewards as incentives for positive behaviors holds great promise in improving public health outcomes in children. Nevertheless, the study also emphasizes the need for further research to investigate the long-term effects of digital rewards on motivation and habit formation in children across different age groups and settings. To conclude, this study highlights the effectiveness of digital feedback systems for promoting handwashing behavior in young children and underscores the significant potential of such interventions for promoting health behaviors.

CRediT authorship contribution statement

Joanna Graichen: Writing – original draft, Methodology, Investigation, Conceptualization. **Carlo Stingl:** Writing – review & editing, Methodology, Investigation, Formal analysis, Conceptualization. **Glenda Dangis:** Writing – review & editing. **Anni Pakarinen:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Riitta Rosio:** Writing – review & editing, Investigation. **Sanna Salanterä:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Kirsi Terho:** Writing – review & editing, Investigation. **Sebastian A. Günther:** Writing – review & editing, Investigation, Formal analysis. **Antti Siloaho:** Writing – review & editing, Investigation. **Thorsten Staake:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Thorsten Staake (T.S.) used to be a non-executive member of the Board of Directors and minority shareholder of Amphiro-AG, which provided parts of the equipment for measuring the water flow at the taps. Amphiro-AG made available the equipment free of charge. T.S. was neither involved in the implementation phase of the experiment nor in the analysis of the data. The other authors declare no competing interests.

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Data availability

Data will be made available on request.

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