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# Abandonment of personal quantification: A review and empirical study investigating reasons for wearable activity tracking attrition

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ABSTRACT

Wearable activity trackers hold great potential for facilitating self-regulated health behavior, thereby improving physical fitness and preventing cardiovascular diseases. Unfortunately, many users discontinue tracking after only a few months, mitigating large-scale health effects. To identify usage barriers and psychological mechanisms resulting in tracker abandonment decisions, it is essential to characterize former users regarding their abandonment reasons as well as former tracker usage patterns. Within the present research, we reviewed past literature on wearable activity tracking attrition and developed an online questionnaire for assessing abandonment reasons. Results from 159 former users revealed insights into the relative importance of abandonment reasons, former users' usage patterns, evaluation of personal quantification, and tracker acceptance. Correlational analyses showed that intensity of tracker usage and data interaction, current physical activity, and tracker acceptance were related to specific abandonment reasons. Moreover, abandonment due to perceived data inaccuracy/uselessness and loss of tracking motivation were linked to negative attitudes towards personal quantification. Furthermore, permanent abandonment decisions were particularly related to loss of tracking motivation. Based on the results, we derived six design guidelines for supporting continued tracker usage.

## 1. Introduction

Assessing physical activity data via wearable activity trackers (i.e., fitness trackers, smartwatches) constitutes a convenient approach to monitor personal fitness and health parameters (e.g., step count, calorie consumption, heart rate). Activity tracking may enhance motivation for physical activity (Coughlin & Stewart, 2016) and therefore increase fitness (Sullivan & Lachman, 2017), support weight loss (Pourzanjani, Quisel, & Foschini, 2016), and might help prevent cardiovascular diseases (Hickey & Freedson, 2016). Mechanisms suggested to motivate users include gamified elements (Cugelman, 2013; Deterding, Dixon, Khaled, & Nacke, 2011) such as quantified feedback, rewards, and peer competitions ((Attig & Franke, 2019; Rockmann & Gewald, 2018)) that facilitate self-regulation of healthy behavior. Despite considerable health benefits of using activity trackers, around a third of users abandon their tracker after a few months ((Gartner, n.d.; Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017; Lee & Lee, 2017)). However, continued use seems pivotal for successful habit formation ((Renfree et al., 2016)) as habits do not develop immediately (Lally, van Jaarsveld, Potts, & Wardle, 2010). Consequently, supporting users' continued tracking motivation is crucial for consistent tracker usage and achieving the desired positive health effects. However, to derive design guidelines for strengthening continued tracker usage, we first must know why some users discontinue wearable activity tracking to provide valuable insight into factors interfering with continued tracker usage (i.e., barriers to long-term adoption). This knowledge might ultimately increase health benefits by improving tracker design to enhance user satisfaction, engagement and consistent tracking motivation.

Despite the significance of this constraint to realizing the potential of wearable technology for achieving large-scale health effects, there is surprisingly little empirical research on the structural process of abandonment (i.e., antecedents of the decision to discontinue tracking). First research assessing reasons for tracking abandonment has shown a broad range of reasons why users discontinue activity tracking and fitness app use ((Ayobi, Cox, & Marshall, 2016; Gulotta, Forlizzi, Yang, & Newman, 2016; König, Sproesser, Schupp, & Renner, 2018)). However, the relative importance of these different reasons remains unclear and also there is a lack of robust findings detailing which reasons typically emerge together. More importantly, previous studies have not investigated usage differences across individuals that lead users to discontinue tracking. For instance, it is currently unknown why one

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user may feel perceived measurement inaccuracy is critical whereas another user disagrees.

To examine these key questions in self-regulated health-technology adoption, we conducted a comprehensive literature review and used this compiled knowledge to derive a questionnaire for analyzing former users' reasons for abandonment. Our two objectives were: First, to better understand the relative importance and co-occurrence of reasons for tracking attrition among former activity tracker users and second, to provide more knowledge regarding usage characteristics of former users, and thus, to shed first light on the psychological processes behind why users abandon their trackers.

## 2. Background

Since the 2006 market introduction of wearable activity trackers (Knoblauch, 2014), personal quantification research has suggested a plethora of reasons for activity tracker abandonment. To integrate and organize these reasons, we conducted a systematic literature review using Web of Science, PsycINFO and Medline with the search string: < ("fitness tracker" OR "activity tracker" OR smartwatch OR wearables OR "self tracking" OR "personal quantification" OR "quantified self" OR "personal informatics") AND (abandonment OR attrition OR adherence OR barriers OR "continued use" OR ex-user OR "former user") > . After deletion of duplicates, 509 hits remained. We also conducted a search in Google Scholar given its multidisciplinarity and extensive coverage (e.g., inclusion of grey literature such as master's theses; García-Pérez, 2010; Gehanno, Rollin, & Darmoni, 2013). Upon screening the 1380 hits in Google Scholar (last update of search: 31.05.2019), 41 additional references were identified as potentially includable. After title and abstract-screening of the 550 hits, 478 were excluded. The remaining 72 references were full text-screened. We only selected empirical studies which investigated why users actually abandon their activity tracker (i.e., literature reviews and meta-analyses were excluded; participants had to be former users). Finally, after backward and forward literature search, 20 studies were ultimately selected to be analyzed (see Table A.1 in the appendix for study characteristics). Two independent raters extracted, collected, and classified reasons for abandonment mentioned in the study results according to principles of qualitative content analysis (i.e., inductive category assignment; Mayring, 2014). Eleven categories were assigned (see Table 1), which are discussed in the following.

Although users rate activity tracker usability as rather positive ((Kupffer, Wutzler, Krems, & Jahn, 2018; Ridgers et al., 2018)), they often cite usability issues as a major factor contributing to abandonment. Core issues connected to abandonment include poor usability/ease of use and an overly complex tracker ((Fadhil, 2019; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015)) or connected smartphone app (Epstein et al., 2016a) technology causing disruptively high mental effort (Coorevits & Coenen, 2016; Lazar et al., 2015). Moreover, users named high temporal effort (Fausset et al., 2013; Lazar et al., 2015; Pour, 2019; Siscoe, 2019) and difficulties fitting the tracker into their daily routines (Lazar et al., 2015; Shih et al., 2015) as factors.

Measurement errors and perceived measurement inaccuracies are also linked to activity tracker abandonment ((Brandao, 2016; Coorevits & Coenen, 2016; Fausset et al., 2013; Garg, 2019; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Pour, 2019; Shih, Han, Poole, Rosson, & Carroll, 2015)). Tracker measurement accuracy is often not optimal, especially regarding calorie consumption, sleep (Evenson, Goto, & Furberg, 2015), and step count during low-intensity activities (Alinia et al., 2017). Besides higher chances of abandonment, perceived tracker measurement inaccuracies are also linked to lower user acceptance ((Trommler et al., 2018)) and usage intention (Rupp, Michaelis, McConnell, & Smither, 2018), suggesting a possible chain of causation between perceived measurement inaccuracy and abandonment.

Accurate tracking of the *right* data is crucial for long-term use. Participants from several studies ((Coorevits & Coenen, 2016; Fadhil, 2019; Fausset et al., 2013; Jeong, Kim, Kim, Lee, & Jeong, 2017; Kononova et al., 2019; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015)) mentioned that they had abandoned their devices because they perceived the data as useless (e.g., measured data did not provide insight, did not measure personally relevant data). Moreover, some former users remarked that data interpretation was impractical (e.g., presenting unprocessed data instead of calls to action/motivational affordances; Coorevits & Coenen, 2016) or that they could not use the data as desired (e.g., because the data could not be synchronized with other health apps; Brandao, 2016; Coorevits & Coenen, 2016; Lazar et al., 2015; Shih et al., 2015).

Whereas users can attach some trackers to their clothing, they typically wear them on their wrist. However, wristbands are easily visible and potentially disruptive during physical activity (Shih et al., 2015) or work ((Meyer et al., 2015)). Hence, users named constraints regarding design (i.e., poor tracker aesthetics; (Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015)) and comfort ((Brandao, 2016; Coorevits & Coenen, 2016; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015; Siscoe, 2019)) as reasons for abandoning wearable devices. Moreover, some former users abandoned tracking because the wristband caused an allergic reaction (i.e., skin irritation; Coorevits & Coenen, 2016) or because they evaluated the charging process as inconvenient ((Coorevits & Coenen, 2016; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Jeong, Kim, Kim, Lee, & Jeong, 2017; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017)). It might be plausible that users abandoned their tracker and switched to alternatives (i.e., abandoned *wearable* activity trackers but did not abandon activity tracking altogether; Coorevits & Coenen, 2016) because of the four reasons mentioned (i.e., usability issues, measurement inaccuracy, data uselessness, design/comfort issues) that directly relate to the wearable device.

Most users wear their tracker virtually 24/7 ((Attig & Franke, 2019; Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017)). If this consistent tracking routine is disrupted, abandonment might follow. Reasons for disruption in routine use included a dead or broken battery (Coorevits & Coenen, 2016; Hermsen et al., 2017; Maher et al., 2017), lost or broken tracker (Brandao, 2016; Hermsen et al., 2017; Kononova et al., 2019; Maher et al., 2017; Rieder et al., 2019), being on holiday (Hermsen et al., 2017; Lazar et al., 2015), and simply forgetting to wear the tracker (e.g., after showering; (Garg & Kim, 2018; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015; Siscoe, 2019)). Interestingly, abandonment because of a disrupted tracking routine was not reported to be necessarily an unconscious decision. Some users stated that they did not miss the tracker or even felt relief when their routinized use was disrupted and thus consciously decided to stop tracking (Lazar et al., 2015).

Two types of motivation are important in determining the difference between activity tracker usage and abandonment: Motivation for tracker usage and motivation for physical activity ((Attig and Franke, 2019)). Users stated to have abandoned tracking because of decreased motivation for tracker usage/tech curiosity ((Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Epstein et al., 2016; Fadhil, 2019, a, 2019, b; Garg & Kim, 2018; Rieder, Lehrer, & Jung, 2019); see also; Rapp & Cena, 2016) or for physical activity (Clawson et al., 2015). Repeatedly failing to meet activity goals might trigger decreased usage motivation ((Epstein et al., 2016; Garg, 2019; Garg & Kim, 2018)). Moreover, tracking can cause undesired affective or behavioral adaptations ((Attig & Franke, 2019; Garg, 2019; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Maher, Ryan, Ambrosi, & Edney, 2017)). For instance, some users mentioned that they tended to adapt the exercise type to the

**Table 1**
Reasons for activity tracker abandonment identified in systematic literature review.

| Category | Example | Reference |
|---|---|---|
| Usability issues | Low app usability | Epstein et al. (2016a) |
| | Low activity tracker usability | Shih, Han, Poole, Rosson, and Carroll (2015) |
| | Tracking takes too much mental effort/workload | (Coorevits & Coenen, 2016; Fadhil, 2019; Lazar, Koehler, Tanenbaum, & Nguyen, 2015) |
| | Tracking takes too much temporal effort (high maintenance frequency) | Lazar et al. (2015), Fausset et al. (2013), Pour (2019), Siscoe (2019), Garg (2019) |
| | Tracking does not fit into daily routine | Lazar et al. (2015), Shih et al. (2015) |
| | Technology is too complex | Clawson, Pater, Miller, Mynatt, and Mamykina (2015), Maher, Ryan, Ambrosi, and Edney (2017) |
| Measurement inaccuracy | Measurement errors and perceived inaccuracy | (Brandao, 2016; Chan, 2017; Coorevits & Coenen, 2016; Fausset et al., 2013; Garg, 2019; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Pour, 2019; Shih, Han, Poole, Rosson, & Carroll, 2015) |
| Data uselessness | Data interpretation is not comprehensible enough | (Coorevits & Coenen, 2016; Garg & Kim, 2018; Siscoe, 2019) |
| | Device does not track the personally relevant data/activities | Coorevits and Coenen (2016), Jeong, Kim, Kim, Lee, and Jeong (2017), Shih et al. (2015) |
| | Device tracks useless data/metrics | (Fadhil, 2019; Fausset et al., 2013; Kononova et al., 2019; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017) |
| | Data cannot be used as desired | Lazar et al. (2015), Shih et al. (2015) |
| | Synchronization with other apps impossible | Brandao (2016), Coorevits and Coenen (2016) |
| Design/comfort issues | Poor tracker aesthetics | (Fadhil, 2019; Garg, 2019; Garg & Kim, 2018; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015) |
| | Wearing the tracker is uncomfortable/"physical awareness of the tracker" | (Brandao, 2016; Coorevits & Coenen, 2016; Garg, 2019; Garg & Kim, 2018; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015; Siscoe, 2019) |
| | Wearing the tracker hampers physical activity | Shih et al. (2015) |
| | Allergic reaction to the wristband | Coorevits and Coenen (2016) |
| | Cumbersome battery charging/short battery life | (Coorevits & Coenen, 2016; Fadhil, 2019; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Jeong, Kim, Kim, Lee, & Jeong, 2017; Kononova et al., 2019; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Maher, Ryan, Ambrosi, & Edney, 2017; Pour, 2019) |
| Disruption of tracking routine | Disrupted tracking because battery was empty or needed replacement/charge cable missing or broke | Coorevits and Coenen (2016), Hermsen et al. (2017), Maher et al. (2017), Rieder, Lehrer, & Jung, 2019 |
| | Disrupted tracking during holidays | Hermsen et al. (2017), Lazar et al. (2015) |
| | User forgot to track ("out of sight, out of mind") | (Garg & Kim, 2018; Maher, Ryan, Ambrosi, & Edney, 2017; Shih, Han, Poole, Rosson, & Carroll, 2015; Siscoe, 2019) |
| | Tracker loss or breakage | Brandao (2016), Hermsen et al. (2017), Coorevits and Coenen (2016), Maher et al. (2017), Kononova et al. (2019) |
| Demotivation | Loss of tracking motivation | (Chan, 2017; Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Epstein et al., 2016; Fadhil, 2019, a, 2019, b; Garg & Kim, 2018; Rieder, Lehrer, & Jung, 2019) |
| | Loss of motivation for physical activity | Clawson et al. (2015); Maher et al. (2017) |
| | Psychological awareness (users become obsessed with the device) | Coorevits and Coenen (2016), Maher et al. (2017), Garg (2019) |
| | Feedback about failure is demotivating | (Epstein et al., 2016; Garg, 2019; Garg & Kim, 2018) |
| | Tracker usage led to undesired behavioral adaptation (choosing specific physical activities over others only because the device can track them) | (Harrison et al., 2015) |
| Change in priorities | Activity goals have changed (device not able/useful to track new activities) | (Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Fadhil, 2019; Shih, Han, Poole, Rosson, & Carroll, 2015) |
| | Personal circumstances have changed (e.g., pregnancy, new job) | Brandao (2016), Chan (2017), Clawson et al. (2015), Epstein et al. (2016a) |
| | Health status has changed (e.g., disease makes tracking impossible) | (Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Fadhil, 2019) |
| Social comparison | No or little comparability with users of other devices/apps | (Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015) |
| | Insufficient social interaction (e.g., challenges) | (Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015) |
| | Loss of desire for social comparison | Coorevits and Coenen (2016) |
| Privacy concerns | Concerns regarding personal data transfer | (Epstein et al., 2016; Garg, 2019; Garg & Kim, 2018; Kononova et al., 2019) |
| Usage of tracking alternatives | Using a more attractive tracking alternative (e.g., standalone smartphone app) | Coorevits and Coenen (2016), Garg (2019) |
| Successful habit formation | Goal achieved ("happy abandonment") | (Brandao, 2016; Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Epstein et al., 2016; Fadhil, 2019; Maher, Ryan, Ambrosi, & Edney, 2017) |

tracker's functionality (e.g., choosing running over Yoga as tracking was impossible with Yoga; (Harrison et al., 2015)). Some users even referred to these undesired adaptations as addictions (Duus, Cooray, & Page, 2018). Coorevits and Coenen (2016) described this as "psychological awareness" of the tracker: Some users stated they had become increasingly obsessed with the tracker and lost their intrinsic usage motivation (i.e., tracking was no longer fun).

Not all users seem to voluntarily stop tracking. Changing priorities due to external causes can make tracking unnecessary, possibly because of altered personal circumstances (e.g., pregnancy, new job situation; (Brandao, 2016; Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Epstein et al., 2016; Fadhil, 2019)) or changes in health status

**Table 2**
Research questions of the present study.

| No. | Research question | Examined variables |
|---|---|---|
| Q1 | What is the relative importance of specific reasons for abandonment (i.e., which reasons are mentioned more frequently than others)? | Reasons for tracker abandonment |
| Q2 | Which reasons co-occur? | |
| Q3a | How can former users be characterized in terms of usage patterns? | Past activity tracker usage, intensity of former activity tracker usage, current physical activity, permanence of abandonment |
| Q3b | How are usage patterns linked to abandonment reasons? | |
| Q4a | How do former users evaluate activity trackers and personal quantification retrospectively? | Evaluation of personal quantification, activity tracker acceptance |
| Q4b | How are evaluations of personal quantification and user acceptance linked to abandonment reasons? | |

((Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Fadhil, 2019)). Furthermore, as not all trackers can monitor every kind of physical activity (e.g., tracking swimming is only feasible with waterproof devices; (Fadhil, 2019; Shih, Han, Poole, Rosson, & Carroll, 2015)), the available tracker can become unusable with modified activity goals ((Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Fadhil, 2019)).

Activity trackers and companion apps offer social networking and comparison (e.g., challenges, leaderboards) opportunities, and thus potentially meet the needs for competence and relatedness (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Karapanos, Gouveia, Hassenzahl, & Forlizzi, 2016; Rockmann & Gewald, 2018; Rupp et al., 2018). Both insufficient social interconnectedness and comparison ((Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015)) as well as oversaturation of social comparison (Coorevits & Coenen, 2016) have been reported to cause abandonment. A recent systematic review (Tong & Laranjo, 2018) has also revealed this ambiguity of mobile health devices' social features.

Personal quantification is the automated collection, analysis, storage, and transfer of potentially sensitive data, such as regarding health (Banerjee, Hemphill, & Longstreet, 2018) or location (Chen, Mizera, & Pang, 2015). Thus, activity tracker usage poses user privacy and data safety risks (Fereidooni, Frassetto, Miettinen, Sadeghi, & Conti, 2017). Privacy concerns vary significantly among tracker users, although the majority have relatively few concerns ((Ostherr et al., 2017; Zimmer, Kumar, Vitak, Liao, & Chamberlain Kritikos, 2018)). As privacy concerns seem independent of tracker usage intentions (Rheingans, Cikit, & Ernst, 2016), concerns have rarely been mentioned as a reason for abandonment ((Epstein et al., 2016; Garg, 2019; Garg & Kim, 2018; Kononova et al., 2019)).

Finally, abandonment can also indicate successful habit formation: Users achieved their long-term goal (e.g., losing weight) or integrated their activity goals into their daily lives, making constant monitoring and external regulation unnecessary ((Brandao, 2016; Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Epstein et al., 2016; Fadhil, 2019; Maher, Ryan, Ambrosi, & Edney, 2017)). In fact, users improve their daily step count estimation with continued usage, indicating a learning process resulting in greater technology independence (Schneider, 2016). Hence, although most reasons for abandonment suggest the need for product design improvements or supporting intrinsic tracking motivation to increase user acceptance and long-term use ((Attig & Franke, 2019; Attig, Karp, & Franke, 2019; Trommler, Attig, & Franke, 2018)), not all abandonment instances are due to diminished user satisfaction.

## 3. Present research

Although there exists an extensive knowledge base regarding the different abandonment reasons, less research can be found on the relative importance of reasons for abandonment, usage characteristics of former users, and psychological mechanisms linked to abandonment. Hence, the objective of the present research was twofold: First, to advance understanding of the relative importance and co-occurrence of reasons for tracking attrition among former users, and second, to deepen knowledge regarding the usage characteristics of former users, which should shed light on the psychological processes into why users abandon their trackers.

However, examining abandonment is quite challenging given that abandonment rates (i.e., the sample size of interest) are uncertain in longitudinal technology adoption studies. Hence, obtaining a sufficient sample size of former users can be extremely resource intensive. Moreover, subject dropouts are common in studies particularly when subjects abandon their tracker. Consequently, there are relatively few longitudinal studies regarding tracker usage and abandonment has only been investigated marginally (Hermsen et al., 2017; Jeong et al., 2017). A more commonly used approach in past research is qualitative analysis of abandonment reasons (e.g., Coorevits & Coenen, 2016; Epstein et al., 2016a; Shih et al., 2015). While qualitative analysis allows for enhanced richness of participants' responses, assessing quantifiable data enables statistical analysis and thus allows for testing empirical relationships (Kaplan & Duchon, 1988). Hence, we decided to follow a quantitative, survey-based approach to investigate our research questions (similar to Maher et al., 2017). As we were particularly interested about abandonment decisions in field use, we surveyed actual former wearable fitness tracker users and exploratively analyzed four research questions (see Table 2). Fig. 1 depicts the examined variables and their relations to explicate how the research questions relate to each other. Please note that the research framework solely serves to visualize our exploratory research questions (i.e., at this point, we follow a strict exploratory approach without confirmatory analyses).

Q1 focuses on the relative importance of reasons for abandonment. To the best of our knowledge, nine previous studies have examined this

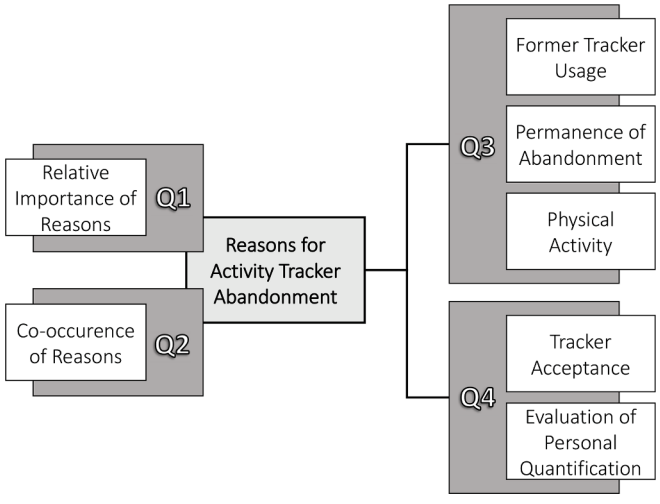


**Fig. 1.** Research framework depicting the four research questions.

question ((Chan, 2017; Clawson, Pater, Miller, Mynatt, & Mamykina, 2015; Coorevits & Coenen, 2016; Epstein et al., 2016; Garg, 2019; Garg & Kim, 2018; Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017; Maher, Ryan, Ambrosi, & Edney, 2017; Siscoe, 2019)). Two of these studies used qualitative research (Clawson et al., 2015; Coorevits & Coenen, 2016) based on written material (i.e., secondary sale advertisements; Clawson et al., 2015; discussion threads in an online community; Coorevits & Coenen, 2016). Three other studies employed a qualitative analysis of open-ended online survey questions ((Chan, 2017; Garg, 2019; Garg & Kim, 2018)). Hence, representativity and generalizability of findings remain restricted. Although the other four studies used quantitative research (Epstein et al., 2016a; Hermsen et al., 2017; Maher et al., 2017; Siscoe, 2019), the sample sizes of former users were rather small in three of them ($n$ = 64, Epstein et al., 2016a; $n$ = 37, Maher et al., 2017; $n$ = 60, Siscoe, 2019; see also Table A.1 in the appendix) and all three studies categorized reasons for abandonment rather broadly, impeding comparison of results. A clear cross-study pattern regarding relative importance of abandonment reasons was unidentifiable. In sum, knowledge about the relevance of particular reasons is rather sparse and inconsistent. Furthermore, none of these nine studies provided information regarding co-occurrence of reasons (e.g., correlations or factor analysis results regarding the connection between abandonment reasons; Q2).

Identifying which abandonment reasons are more influential and the possible relationships between them are only the first steps to fully understand discontinued use of wearable fitness trackers. Our goal was to go one step further: Deriving guidelines for sustained use and increasing large-scale health benefits requires a deeper understanding of abandonment decisions. Therefore, our core aims were to describe former users based upon relevant usage characteristics (Q3a, Q4a) as well as to reveal connections between these variables and abandonment reasons (Q3b, Q4b).

With Q3a, we aim to characterize usage patterns of former users. Assessing the duration and intensity of past usage from former users is presently understudied (e.g., because of small samples; Brandao, 2016; Maher et al., 2017; or a methodology which prevents assessing past usage; Coorevits & Coenen, 2016; Clawson et al., 2015). In addition, by comparing former users' evaluations of their current physical activity level to their evaluations during the tracker usage phase, we aim to clarify how activity tracker usage and abandonment affects physical activity. Although prior research suggests that activity tracker usage increases physical activity (Coughlin & Stewart, 2016), successful habit formation seems dependent on continued tracker usage ((Renfree et al., 2016)) and tracker absence might cause activity reduction ((Attig & Franke, 2019; Austin & Kwapisz, 2017)). Hence, the amount of physical activity might decrease after tracker usage, probably aside from those users who stopped tracking because of successful habit formation. With Q3b, we examine relationships between past tracker usage, physical activity and abandonment reasons. Furthermore, assessing the permanence of tracker abandonment (i.e., temporary vs. permanent) enables identification of reasons that might be more influential to users (i.e., more likely linked to permanent attrition).

How do former users view previously incorporating personal quantification technologies? An emerging criticism of tracking physical parameters for body and health optimization is that fitness tracking might cause undesirable consequences (Rockmann & Gewald, 2018; Toner, 2018). For instance, activity tracking may diminish exercise enjoyment ((Attig & Franke, 2019; Etkin, 2016; Toner, 2018)) and trigger obsessive tracking behaviors ((Attig & Franke, 2019; Coorevits & Coenen, 2016; Maher, Ryan, Ambrosi, & Edney, 2017)). Experiencing such negative consequences may engender more negative attitudes towards personal quantification in general. Moreover, users may become dissatisfied with the last tracker they used. Hence, with Q4a, we aim to assess users' general attitude towards tracker usage regarding personal quantification and general acceptance of their last used tracker. Moreover, we propose that the retrospective tracker evaluation and the phenomenon of personal quantification depend on the reason for abandonment. For example, if a user discontinues tracking because they perceived numerical feedback as demotivating, then they might appraise tracking critically in general. However, acceptance of the last used tracker may not be reduced. Consequently, with Q4b, the relationship between retrospective attitude towards personal quantification, user acceptance, and abandonment reasons is examined.

## 4. Method

### 4.1. Participants

To sample German-speaking former users of wearable activity trackers, we recruited individuals from German-language interest groups on social media websites (Instagram, Facebook, Twitter) regarding activity tracker usage, fitness, and weight loss. Moreover, a press release was published to recruit additional participants (Technische Universität Chemnitz, 2018). The questionnaire study employed the LimeSurvey platform (LimeSurvey GmbH, 2018) where the participants also gave their informed consent. Data acquisition occurred from September to November 2018. In sum, 167 participants (who were not compensated) completed the questionnaire. Four participants were excluded from the analyses because they still used their activity tracker, while four additional participants were excluded due to poor data quality (i.e., repeated implausible answers). Thus, the analysis included data from 159 participants. The sample had a mean age of $M$ = 32.4 ($SD$ = 11.2, $Min$ = 18, $Max$ = 80) and the majority were female (74%).

### 4.2. Scales and measures

Cronbach's alpha was interpreted according to common practice (see e.g., Cripps, 2017) as poor ($0.5 \leq \alpha < 0.6$), questionable ($0.6 \leq \alpha < 0.7$), acceptable ($0.7 \leq \alpha < 0.8$), good ($0.8 \leq \alpha < 0.9$), or excellent ($\geq 0.9$). Participants provided their answers (if not stated otherwise) on 6-point Likert scales ranging from 1 (*completely disagree*) to 6 (*completely agree*).

#### 4.2.1. Reasons for activity tracker abandonment

To assess reasons for activity tracker abandonment, we developed a questionnaire based on prior literature (see Background section). Our scale development procedure was as follows: (1) The identified reasons from the literature (see Table 1) were complemented by additional reasons based on past research ((Attig and Franke, 2019); i.e., reasons directly linked to the dependency effect were added). (2) An initial 147-item pool was generated. (3) The initial item pool was condensed and items were reformulated according to three criteria: (a) coverage (item phrasing should cover all aspects of individual identified reasons), (b) reliability (categories should be assessed by at least two items to avoid single-item clusters), and (c) economy (assessment with as few items as possible). Consequently, rephrasing consolidated single behaviors into higher-order abandonment motives according to the 11 categories identified in the literature. For instance, the item "I stopped using the activity tracker because my tracker was defective, or the battery wouldn't charge anymore" assessed abandonment due to a disrupted tracking routine caused by technical issues with the device itself (i.e., unnecessary to distinguish prototypic battery problems from other technical defects). The final scale consisted of 31 items (see Table A.2 of the appendix). Internal consistencies were computed after factor analysis and reported in Section 5.4.

In addition to this quantitative assessment, we also incorporated an open, qualitative item ("Are there other reasons that significantly contributed to your activity tracker abandonment in addition to what we have already asked? If yes, which reasons?").

#### 4.2.2. Past activity tracker usage

By applying a broad range of items, we aimed to comprehensively characterize participants' past activity tracker usage. Items focusing on participants' last-owned activity tracker assessed the tracker type (i.e., worn on the wrist, worn on clothing, non-wearable activity tracking via smartphone app), brand and model, usage duration (months, hours in a typical day, and days in a typical week), usage frequency in a typical day (i.e., tracking only specific physical activities vs. entire everyday physical activity), and assessed data types.

Items centering on participants' general activity tracker usage (i.e., since their first device) examined the number of different trackers used, usage duration in months, usage disruptions, and alternative methods for tracking physical data.

#### 4.2.3. Intensity of activity tracker usage and permanence of abandonment

Four self-generated items measured former tracker usage intensity. Two focused on general estimated tracker usage intensity ("I think I used the tracker very intensively.", "Compared to other users, I probably have not used the tracker as intensively.") and two on intensity of tracker/data interaction ("In a typical day, I looked at the tracker or the corresponding app often.", "I encountered my gathered data frequently."). Internal consistency was acceptable for both subscales (general: $\alpha = .72$; interaction: $\alpha = .70$).

Three self-generated items assessed permanence of tracker abandonment ("I imagine that I will resume tracking eventually.", "I have ruled out ever resuming tracking.", "Ultimately, I have permanently stopped tracking."). Internal consistency was excellent ($\alpha = .91$).

#### 4.2.4. Current physical activity

Four self-generated items measured participants' self-reported current level of physical activity. First, two numerical items assessed the amount of physical activity (i.e., exercise duration in hours/week, everyday physical activity in hours/day) and one Likert-scale item stated: "Generally, I try being physically active during my everyday activities.". Second, the item "How often are you currently physically active compared to when you used your activity tracker?" assessed physical activity change on a 7-point bipolar scale (from *much less physical activity* to *much more physical activity*).

#### 4.2.5. Activity tracker acceptance and evaluation of personal quantification

For assessing activity tracker acceptance, the nine items of the 5-point bipolar Van der Laan scale were used (Van der Laan, Heino, & De Waard, 1997). This scale measures acceptance on usefulness and satisfaction subscales. Internal consistency was good (usefulness: $\alpha = .82$), resp. acceptable (satisfaction: $\alpha = .76$).

Lastly, three self-generated items evaluated personal quantification ("I would recommend using an activity tracker to my best friend.", "I am convinced that assessing physical activities with an activity tracker is a good idea.", "Retrospectively, I am rather critical of tracking/personal quantification.", reverse coded). Internal consistency was good ($\alpha = .83$).

## 5. Results

### 5.1. Relative importance of reasons for abandonment (Q1)

To investigate Q1, we dichotomized participants' responses on abandonment reasons into either agree (strongly, widely, and rather agree) or disagree (strongly, widely, and rather disagree). Fig. 2 depicts the percentage of agreement with the individual reasons (i.e., items) sorted by size.

The most agreed upon reason for abandonment was decreasing intrinsic tracking motivation. After this came disrupted tracking routines and changes in priorities or life circumstances, indicating that context factors which interrupt or deprioritize activity tracking are notably contributing to abandonment. Reasons directly linked to the characteristics of the wearable device (i.e., perceived measurement inaccuracy, design/comfort, usability) scored consecutively less. Around a third of participants stated that obsessive tracking (i.e., tracking for satisfying feedback instead of for health/activity itself) and one aspect of "happy abandonment" (i.e., habitualized activity) contributed to tracking attrition, reflecting the coexisting potentials and risks of fitness tracking.

The open-ended question responses regarding additional abandonment reasons were compared to the questionnaire item responses. Most answers constituted more detailed depictions of already existing items in the questionnaire. However, several participants named additional reasons: 5% of participants stated they felt stressed by the tracker or reported having a guilty conscience when failing to reach their daily goals. Another 4% stated they felt the tracker overly affected their daily lives or that the tracker's controlling influence impeded their feeling of personal freedom. Another 3% mentioned they preferred wearing analogue watches. Finally, 1% reported they developed an eating disorder and felt that activity tracking might have exacerbated their symptoms, and another 1% blamed failing battery life for abandonment. All other additional reasons were only mentioned once (tracker malfunctions, annoying notifications, wristband getting dirty, incompatibility of app and smartphone, insufficient incentives from health insurance).

### 5.2. Co-occurrence of reasons for abandonment (Q2)

To gain insight into co-occurrence of abandonment reasons and to reduce data complexity for correlation analyses, we conducted a principal axis factor analysis with oblique rotation (Promax) regarding the individual abandonment reasons. The Kaiser-Mayer-Olkin measure (KMO = 0.72) was acceptable according to Kaiser (1974) and the Bartlett's test of sphericity was significant ($p < .001$), indicating that the data was suitable for factor analysis. An initial analysis was conducted to compute eigenvalues for each factor. Nine factors were obtained with eigenvalues exceeding Kaiser's criterion of 1. However, the scree plot suggested a six-factor solution. We repeated the analysis with a predefined number of six factors to be extracted. The final solution was reasonably interpretable and explained 54% of the variance. Table 3 depicts factor loadings after rotation.

Results suggested that perceived measurement inaccuracy and perceived data uselessness often go together (Factor 1). Privacy concerns and usage of a tracking alternative (e.g., smartphone) loaded together on Factor 2. Discomfort regarding handling/charging/wearing the tracker and simply forgetting to wear the tracker loaded together on Factor 3. Factor 4 comprised demotivating effects, oversaturation of social comparison, high temporal effort, and abandonment due to a broken tracker (albeit negatively loaded). Factor 5 represented reasons connected to perceived loss of tracking feasibility or necessity (i.e., disrupted routine, changes in health, priorities or activity goals, loss of motivation for exercising, mismatch regarding daily routines). Finally, Factor 6 represents "happy abandonment". Two reasons (Items 10 and 11) loaded poorly on all factors and could not be classified.

### 5.3. Former users' usage patterns (Q3a)

Table 4 depicts participants' usage characteristics. Regarding usage duration, 27% of participants used their last-owned tracker more than one year and 49% used activity trackers in general more than one year. Regarding typical daily usage of their last-owned tracker, 56% stated they wore the tracker more than 23 h in a typical day. Most participants (77%) mentioned they typically wore their last-owned tracker 7 days a week. Only 3% stated they used the tracker to exclusively monitor their sporting activities, while the rest (97%) noted that they fully used the tracker or primarily used it to monitor their entire everyday activities.

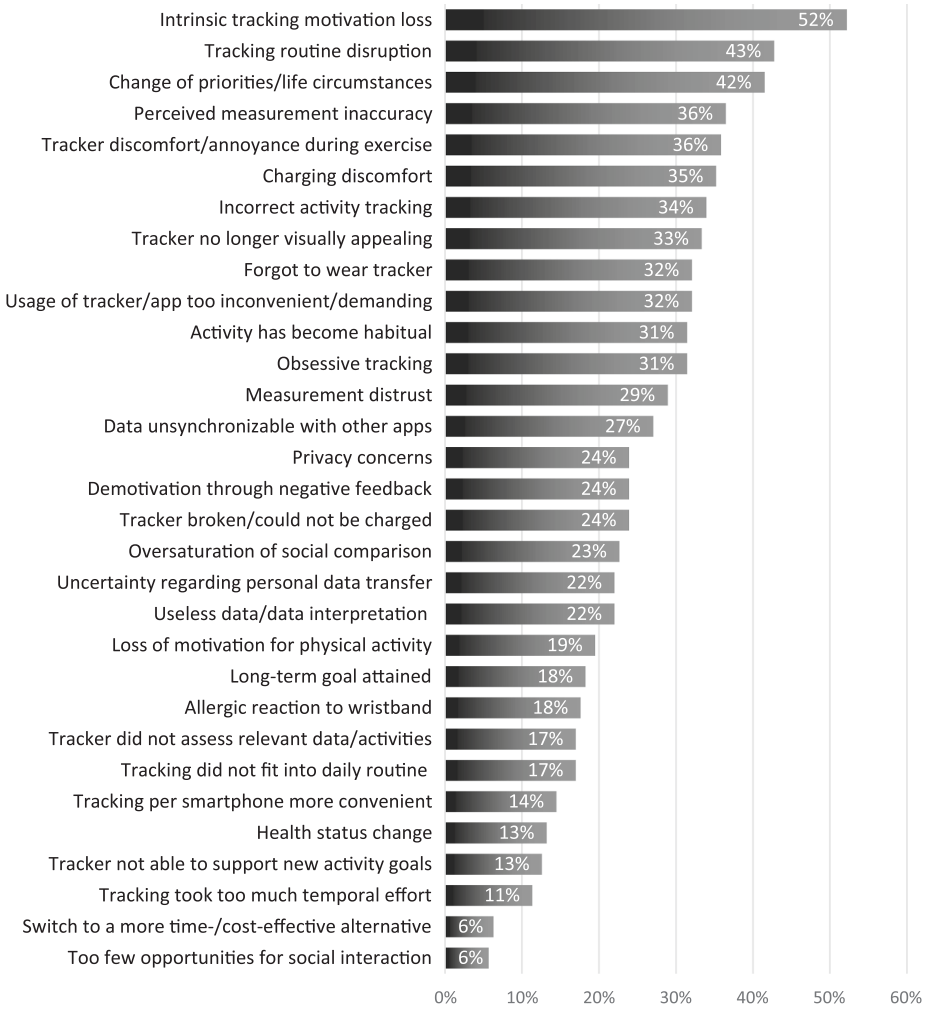


**Fig. 2.** Percentage of participants confirming relevance of the 31 individual abandonment reasons.

Regarding usage disruptions, 45% stated using the tracker continuously, 30% experienced brief usage disruptions, whereas 25% experienced usage disruptions longer than one month. After using their wearable activity tracker, 26% incorporated tracking alternatives, and of these participants, 78% continue to do so.

The large majority (96%) noted wearing their last-owned activity tracker on the wrist while the rest (3%) attached their trackers to their clothes (e.g., belt, bra) or used a standalone app (1%). The most highly represented brand was Fitbit (44%), followed by Polar (12%), Garmin (9%), Xiaomi (7%), Jawbone (5%), Samsung (5%), and Apple (2%). Participants stated that their last-owned tracker could gather the following type of data: step count (99%), calorie consumption (90%), heart rate (77%), sleep activity (22%), distance (8%), and stairs (7%).

Participants used the tracker rather intensively. Mean scores for both general usage ($M = 4.47$, $t(158) = 11.32$, $p < .001$, $d = 0.90$) and data/device interaction ($M = 4.50$, $t(158) = 11.36$, $p < .001$, $d = 0.90$) were significantly above the scale midpoint (3.5). In contrast, abandonment duration was significantly below the scale midpoint ($M = 2.63$, $t(158) = -7.83$, $p < .001$, $d = -0.62$), indicating that many participants might resume tracking in the future. Dichotomizing the responses revealed that 74% of former users' abandonment decisions might not be permanent.

Regarding current physical activity, participants noted sports engagement for an average of 3.78 h/week and everyday physical activity engagement for 5.18 h/day. The majority (84%) stated they generally try being physically active during everyday activities. Compared to their fitness tracker usage phase, 38% mentioned they were currently less physically active whereas 13% mentioned they were more physically active. The rest (49%) stated that their current physical activity level did not change.

### 5.4. Relationships between usage patterns and abandonment reasons (Q3b)

To calculate two-tailed Pearson correlations between usage pattern variables and abandonment reasons, we computed mean scores for each of the six factors emerging from the factor analysis (see Table 3). However, three problems impeded a straightforward approach: First, Items 10 and 11 did not load substantially (i.e., factor loading > 0.30) on any factor and were therefore excluded from further analyses (according to Furr, 2011). Second, some items also loaded substantially high on a second factor, although in all cases, the primary factor loading was considerably higher. Third, Item 22 had a notable, but negative loading on the "motivation loss" factor. To ensure interpretability of this factor, we deleted this item from further analyses. Internal consistency (calculated via Cronbach's alpha) was acceptable for most of the six scores: habit formed (Items 30, 31): $\alpha = .65$; loss of tracking feasibility/necessity (Items 24–29): $\alpha = .68$; design/discomfort (Items 12–17): $\alpha = .70$; motivation loss (Items 18–21, 23): $\alpha = .70$; privacy concerns/switch to alternative (Items 6–9): $\alpha = .72$; data inaccuracy/uselessness (Items 1–5): $\alpha = .88$.

A principal axis factor analysis and scree test condensed the general tracker usage frequency items (i.e., usage duration in hours in a typical day, usage duration in days in a typical week, usage intensity in a typical day, general estimated tracker usage intensity) into a clear one-

**Table 3**
Results of principal component analysis for the higher order abandonment reasons.

| Abandonment reason | | Rotated factor loadings | | | | | |
|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 | F6 |
| 1 | Perceived measurement inaccuracy | **.95** | -.22 | .01 | .03 | -.01 | .01 |
| 2 | Measurement distrust | **.95** | -.05 | -.04 | .08 | -.06 | .01 |
| 3 | Incorrect activity tracking | **.85** | .04 | .03 | .04 | -.11 | -.00 |
| 4 | Useless data/data interpretation | **.61** | .09 | -.02 | .07 | .03 | .00 |
| 5 | Tracker did not assess relevant data/activities | **.46** | .18 | .03 | -.15 | .16 | -.02 |
| 6 | Uncertainty regarding personal data transfer | .01 | **.95** | -.20 | .13 | -.07 | -.09 |
| 7 | Privacy concerns | .02 | **.87** | -.19 | .05 | -.12 | .04 |
| 8 | Switch to a more time- or cost-effective alternative | -.02 | **.52** | .04 | .13 | .02 | .17 |
| 9 | Tracking per smartphone more convenient | -.27 | **.40** | .15 | -.04 | -.00 | .13 |
| 10 | Too few opportunities for social interaction | .09 | .29 | .12 | -.12 | .26 | -.14 |
| 11 | Data unsynchronizable with other apps | .15 | .21 | .17 | -.18 | .16 | -.05 |
| 12 | Tracker discomfort/annoyance during exercise | -.01 | -.11 | **.69** | .12 | -.11 | .02 |
| 13 | Tracker no longer aesthetically appealing | -.01 | -.21 | **.65** | .07 | .04 | .01 |
| 14 | Charging discomfort | .01 | .10 | **.61** | -.16 | -.01 | .01 |
| 15 | Forgot to wear tracker | -.12 | .06 | **.44** | -.07 | **.30** | .02 |
| 16 | Allergic reaction to wristband | .04 | -.09 | **.44** | .16 | -.13 | .00 |
| 17 | Usage of tracker/app too inconvenient/demanding | .22 | .19 | **.32** | -.00 | .05 | .06 |
| 18 | Obsessive tracking | .23 | .00 | -.15 | **.59** | .13 | -.05 |
| 19 | Oversaturation of social comparison | -.13 | **.30** | .18 | **.58** | -.20 | -.03 |
| 20 | Demotivation through negative feedback | .09 | .03 | .01 | **.48** | .25 | -.21 |
| 21 | Intrinsic tracking motivation loss (i.e., loss of interest/fun) | .07 | -.02 | .19 | **.44** | .06 | .20 |
| 22 | Tracker broken/could not be charged | .25 | .16 | .05 | **-.43** | -.01 | -.11 |
| 23 | Tracking took too much temporal effort | .18 | .13 | .20 | **.39** | .04 | .17 |
| 24 | Tracking routine disruption | -.04 | -.11 | .14 | .02 | **.63** | -.14 |
| 25 | Health status change | .01 | -.07 | -.29 | -.05 | **.60** | .24 |
| 26 | Loss of motivation for physical activity | -.12 | .00 | .03 | .29 | **.53** | **-.37** |
| 27 | Tracker unable to support new activity goals | .12 | .11 | -.04 | -.05 | **.46** | **.33** |
| 28 | Change of priorities/life circumstances | -.10 | -.07 | -.12 | .25 | **.45** | .25 |
| 29 | Tracking did not fit into daily routine | -.01 | .06 | .23 | .09 | **.38** | .10 |
| 30 | Activity has become habitual | .05 | .02 | .15 | .04 | -.10 | **.68** |
| 31 | Long-term goal attained | -.07 | .06 | -.09 | -.01 | .18 | **.64** |
| | Eigenvalues | 5.28 | 2.54 | 1.89 | 1.60 | 1.22 | 1.07 |
| | Percentage of variance | 17.05 | 8.20 | 6.11 | 5.16 | 3.93 | 3.44 |

*Note*. Factor loadings over 0.30 are boldfaced, $N = 159$. F1 = data inaccuracy/uselessness, F2= privacy concerns/switch to alternative, F3 = design/discomfort, F4 = motivation loss, F5 = loss of tracking feasibility/necessity, F6 = habit formed.

factor solution. Similarly, physical activity items were condensed into one factor. However, everyday physical activity in hours/day was excluded because of insignificant low correlations with the other three items (all $r < .08$). Effect sizes were interpreted according to Cohen (1992).

Results (see Table 5) indicated that less intensive general tracker usage was moderately linked to higher abandonment probability due to design/discomfort and slightly connected to abandonment due to privacy concerns/switch to alternatives, loss of tracking feasibility/necessity, and data inaccuracy/uselessness. Less intensive tracker/data interaction was slightly linked negatively to higher abandonment probability due to design/discomfort and privacy concerns/switch to alternatives. In contrast, motivation loss was slightly, but insignificantly related positively to intensity of tracker/data interaction. Current amount of physical activity was moderately related positively to habit formed and moderately to loss of tracking feasibility/necessity in the negative direction. Hence, abandonment due to successful habit formation was associated with a higher physical activity intensity after tracker use. On the contrary, users who abandoned their tracker because of a loss of tracking feasibility/necessity were less physically active after tracker usage. Permanence of abandonment was slightly related positively to motivation loss. Moreover, weak but insignificant correlations existed between habit formed and data inaccuracy/uselessness (positive) as well as with loss of tracking feasibility/necessity (negative). Thus, happy abandonment, perceived data inaccuracy, and particularly demotivation were associated with firm abandonment decisions, whereas former users who stopped tracking because of decreasing tracking feasibility/necessity more likely resumed tracking in the future.

**Table 4**
Usage characteristics of the participant sample.

| | *M* | *SD* | Range | 25th percentile | 75th percentile |
|---|---|---|---|---|---|
| Usage duration of last-owned tracker (in months) | 10.77 | 0.63 | 0.70–36.00 | 4.00 | 14.00 |
| Usage duration of last-owned tracker in a typical day (in hours) | 19.94 | 5.79 | 1.00–24.00 | 16.00 | 24.00 |
| Usage duration of last-owned tracker in a typical week (in days) | 6.64 | 0.06 | 2.00–7.00 | 7.00 | 7.00 |
| Usage duration of activity trackers in general (in months) | 17.11 | 23.62 | 0.00–260.00 | 5.98 | 21.96 |
| Number of activity trackers used | 1.52 | 0.74 | 1.00–5.00 | 1.00 | 2.00 |
| Current exercise duration (in hours/week) | 3.78 | 3.49 | 0.00–25.00 | 2.00 | 5.00 |
| Current everyday physical activity (in hours/day) | 5.18 | 3.81 | 0.00–16.00 | 2.00 | 8.00 |
| Tendency to be physically active during everyday activities | 4.34 | 1.14 | 1.00–6.00 | 4.00 | 5.00 |
| Physical activity change during/post tracker usage | 3.60 | 1.24 | 1.00–7.00 | 3.00 | 4.00 |

**Table 5**
Correlations between abandonment reasons and tracker usage patterns, tracker acceptance, and evaluation of personal quantification.

| Research Question | Variable | *r* (*p*) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Data inaccuracy/ uselessness | Privacy concerns/ switch to alternative | Design/ discomfort | Motivation loss | Loss of tracking feasibility/necessity | Habit formed |
| Q3b | General tracker usage intensity | **-.16 (.048)** | **-.25 (.001)** | **-.35 (< .001)** | -.14 (.085) | **-.22 (.005)** | .04 (.616) |
| | Intensity of tracker/data interaction | .03 (.751) | **-.18 (.025)** | **-.21 (.007)** | .13 (.108) | .02 (.838) | .04 (.578) |
| | Current physical activity | .11 (.160) | -.01 (.858) | -.04 (.629) | -.08 (.758) | **-.30 (< .001)** | **.30 (< .001)** |
| | Permanence of abandonment | .14 (.078) | -.02 (.782) | -.11 (.181) | **.26 (< .001)** | -.15 (.057) | .15 (.061) |
| Q4b | Acceptance – Usefulness | **-.34 (< .001)** | -.14 (.084) | -.10 (.223) | **-.22 (.006)** | .07 (.389) | .10 (.191) |
| | Acceptance – Satisfaction | **-.36 (< .001)** | -.06(.449) | **-.16 (.047)** | **-.24 (.002)** | .04 (.578) | .04 (.664) |
| | Evaluation of personal quantification | **-.21 (.009)** | -.06 (.447) | .04 (.582) | **-.33 (< .001)** | .09 (.268) | -.05 (.499) |

*Note.* Significant correlations ($\alpha = .05$) are boldfaced, $N = 159$.

### 5.5. Former users' evaluation of activity tracking and personal quantification (Q4a)

Across all participants, activity tracker acceptance was quite positive. Mean scores for the usefulness and satisfaction subscales differed significantly from the scale midpoint of 3 ($M_{usefulness} = 3.61$; $t(158) = 9.99$, $p < .001$, $d = 0.79$; $M_{satisfaction} = 3.35$, $t(158) = 5.82$, $p < .001$, $d = 0.46$). The subscales were strongly positively correlated ($r = .68$, $p < .001$). Both usefulness ($r = -.50$, $p < .001$) and satisfaction ($r = -.48$, $p < .001$) strongly correlated negatively with permanence of abandonment. Hence, the lower activity tracker acceptance of former users, the more permanent their abandonment decision. Regarding usage intensity, usefulness slightly correlated positively with general estimated tracker usage intensity ($r = .25$, $p = .001$) and intensity of tracker/data interaction ($r = .17$, $p = .029$). In contrast, satisfaction slightly correlated positively with general usage intensity ($r = .17$; $p = .029$), but not with interaction intensity ($r = .00$, $p = .985$).

The mean score for evaluation of personal quantification was also rather positive across all participants, differing significantly from the scale midpoint of 3.5 ($M = 3.85$, $t(158) = 3.93$, $p < .001$, $d = 0.32$) and strongly correlated with both acceptance subscales (usefulness: $r = .58$, $p < .001$; satisfaction: $r = .56$, $p < .001$). Moreover, it was strongly related negatively to permanence of abandonment ($r = -.67$, $p < .001$). Hence, the more negatively former users evaluated personal quantification, the more permanent their abandonment decision. Furthermore, evaluation of personal quantification seemed unrelated to usage intensity, both generally ($r = .10$, $p = .192$) and regarding interaction ($r = .05$, $p = .541$).

### 5.6. Relationships between evaluation of activity tracking, personal quantification, and abandonment reasons (Q4b)

Table 5 depicts the results for Q4b. Regarding activity tracker acceptance, the usefulness subscale was moderately linked negatively to abandonment due to data inaccuracy/uselessness and slightly negatively to motivation loss. The satisfaction subscale was moderately correlated negatively to data inaccuracy/uselessness and slightly negatively to motivation loss and design/discomfort. Hence, the more participants evaluated the tracker as useless or ineffective, the more likely they abandoned their tracker because of data accuracy/usefulness issues or demotivation. In addition, the more participants evaluated the tracker as unsatisfying or undesirable, the more likely they abandoned it because of data accuracy/usefulness issues, demotivation, or design/comfort issues.

Evaluation of personal quantification was slightly related negatively to data inaccuracy/uselessness and moderately negatively to motivation loss. Thus, data accuracy or usefulness issues and demotivating effects might lower attitudes concerning personal quantification overall.

## 6. Discussion

### 6.1. Summary of results

The present research exploratively investigated four research questions to comprehensively characterize former activity tracker users and the reasons why they stopped tracking. Results revealed that most former users experienced decreased intrinsic tracking motivation, followed by tracking routine disruption and changes in priorities or life circumstances (Q1). A factor analysis showed that the abandonment reasons could be condensed into six broader factors: data inaccuracy/uselessness, privacy concerns/switch to alternative, design/discomfort, motivation loss, loss of tracking feasibility/necessity, and habit formed (Q2). Former users in our sample were intensively using their tracker and the majority stated that they may return to using their tracker after abandonment. Moreover, almost half stated that their physical activity levels remained consistent after abandonment, whereas most of the other half reported an activity level reduction (Q3a). Examining relationships between usage patterns and abandonment reasons showed that less intensive usage was related to abandonment because of design/discomfort, loss of tracking feasibility/necessity, and privacy concerns/switch to alternatives. Moreover, motivation loss and habit formed were associated with more permanent abandonment decisions, whereas users who stopped tracking because of decreasing tracking feasibility/necessity were more likely to say they would resume tracking in the future. Higher physical activity levels after tracking were linked to abandonment because of successful habit formation and lower activity levels were connected to abandonment because of tracking feasibility/necessity (Q3b). Former users in our sample evaluated acceptance of their last-owned tracker and personal quantification rather positively as a whole (Q4a). The less useful participants rated their last used tracker, the more likely they discontinued tracker usage because of data inaccuracy/uselessness and privacy concerns/switch to alternative. The less satisfied with their tracker, the more likely they stopped tracking because of data inaccuracy/uselessness or demotivation. The same pattern existed for evaluation of personal quantification, however with a stronger link to motivation loss (Q4b).

### 6.2. Implications

In the following, we discuss theoretical and practical implications of the present findings. Moreover, we derived six design guidelines [DG] to enhance sustained use of wearable fitness trackers (see Table 6 for a concise summary).

Regarding which factors might have led to tracking attrition, our research showed that the most important reasons were demotivation and contextual factors interrupting or deprioritizing activity tracking. The finding that motivation loss was associated with lower user acceptance, a more negative evaluation of personal quantification, and

**Table 6**
Design guidelines based on core results and related research.

| Result | Design Guideline | Related Research |
|---|---|---|
| Motivation loss linked to lower user acceptance, more negative evaluation of personal quantification, and more permanent abandonment decisions | [DG1] Implement meaningful reminders for continued usage<br>• remind users of the activity's health benefits<br>• strengthen users' autonomous motivation<br>[DG2] Give personalized feedback:<br>• support reflection and update of self-knowledge<br>• provide tailored interpretations rather than mere numerical feedback<br>• take user group, behavioral stage, and goals into account | Coorevits & Coenen, 2016; Clawson et al., 2015; Epstein, Kang, Pina, Fogarty, & Munson, 2016b<br>(Baretta, Perski, & Steca, 2019; Canhoto & Arp, 2016; Li, Dey, & Forlizzi, 2010, 2011; Niess & Woźniak, 2018; Purpura, Schwanda, Williams, Stubler, & Sengers, 2011; Rapp & Tirabeni, 2018; Rapp & Tirassa, 2017) |
| Perceived measurement issues linked to lower tracker acceptance and more negative attitudes towards personal quantification | [DG3] Advance users' trust in activity tracker measurement<br>• optimize sensor technologies and algorithms<br>• enhance measurement transparency | (Niess & Woźniak, 2018; Trommler, Attig, & Franke, 2018; Xie et al., 2018) |
| Design/discomfort are considerable reasons for abandonment | [DG4] Support user identification with the tracker<br>• provide customizable tracker designs | (Kang, Binda, Agarwal, Saconi, & Choe, 2017; Pateman, Harrison, Marshall, & Cecchinato, 2018) |
| A third of participants stated that obsessive tracking contributed to their abandonment decision | [DG5] Enhance understanding of problematic tracker usage<br>• identify usage patterns automatically<br>• make users aware of deviation from beneficial tracker usage patterns | (Attig & Franke, 2019; Fritz, Huang, Murphy, & Zimmermann, 2014; Gouveia, Karapanos, & Hassenzahl, 2015) |
| A quarter of participants stated that privacy concerns contributed to their abandonment decision | [DG6] Enhance data authority<br>• provide transparency regarding data sharing with companion and third-party applications<br>• give freedom to prohibit data transfer | (Lydinia, Schomakers, & Ziefle, 2018; Maltseva & Lutz, 2018; Zimmer, Kumar, Vitak, Liao, & Chamberlain Kritikos, 2018) |

more permanent abandonment decisions highlights the particularly harmful effect of demotivation on long-term tracker usage. Consequently, as a first design guideline [DG1], implementations to prevent lapses and remind users to keep wearing the tracker (Coorevits & Coenen, 2016) and why tracking is beneficial (i.e., remind users of the activity's value, i.e., the various health benefits) might encourage long-term use even after longer usage interruptions (Clawson et al., 2015; Epstein et al., 2016b). In terms of self-determination theory, this would mean strengthening users' autonomous motivation, that is, integrating the activity's value into users' sense of self (Deci & Ryan, 2008). Hence, tracker feedback should focus on supporting self-knowledge, self-determination, and self-efficacy rather than mere behavioral change (Rapp & Tirassa, 2017). From a phenomenological and constructivist perspective, the sense of self is dynamically constructed on the basis of self-knowledge, which itself is dynamically constructed through interactions with the world, other individuals, and itself (Rapp & Tirassa, 2017). Thus, to make quantified feedback truly meaningful to the individual user, it should support updating self-knowledge by taking the individual user's perspective (e.g., needs, expectations, goals, context) into account [DG2]. Providing tailored interpretations and guidance rather than mere numerical feedback (Baretta et al., 2019; Rapp & Tirassa, 2017) while leaving room for reflection and mindfulness ((Niess & Woźniak, 2018; Purpura, Schwanda, Williams, Stubler, & Sengers, 2011)) would likely strengthen self-understanding, autonomy, the individual significance of personal quantification as a whole, and thus, continued use. For instance, individual differences in tracker usage (exploratory vs. focused use) reflecting variances in tracking motivation between amateur and elite athletes ((Rapp and Tirabeni, 2018)) should be considered to make data interaction more meaningful for these different user groups. Moreover, stage-based models of personal quantification suggest that user perception of meaningfulness differs with the behavioral stage they are in ((Li, Dey, & Forlizzi, 2010, 2011)): What users consider helpful to boost motivation for physical activity in early usage stages (i.e., discovery phase) might be perceived as meaningless or even annoying in later stages (i.e., maintenance phase). Furthermore, users' initial goal type (e.g., fitness vs. weight goal) should be considered when creating tailored feedback (Canhoto & Arp, 2016). In sum, tracker feedback should be flexible and tailored to different user groups as well as to different usage stages and goals.

Abandonment reasons linked to the tracking device (e.g., measurement inaccuracy, usability issues, discomfort) were also identified as substantial, corroborating previous studies ((Brandao, 2016; Coorevits & Coenen, 2016; Fausset et al., 2013; Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015; Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017; Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015)). This finding mirrors the positive relations between perceived ease of use/usefulness with tracker usage (Lunney, Cunningham, & Eastin, 2016). In addition, our correlational analyses suggested that lower tracker acceptance and more negative attitudes towards personal quantification reflect perceived measurement issues. Consequently, enhancing users' trust in activity tracker measurement [DG3], either through optimized sensor technologies and algorithms (Xie et al., 2018) or enhanced measurement transparency ((Niess & Woźniak, 2018; Trommler, Attig, & Franke, 2018)), is a key design goal for boosting user acceptance and satisfaction. Enhancing user identification with the tracker through cosmetic modifications in design (i.e., customizable physical appearance of the tracker [DG4]; (Kang, Binda, Agarwal, Saconi, & Choe, 2017; Pateman, Harrison, Marshall, & Cecchinato, 2018)); can also encourage user engagement.

A third of participants stating that obsessive tracking contributed to their abandonment decision underlines the risk of some users developing undesirable, excessive tracking behaviors that impede user satisfaction, sustained tracker use, and well-being ((Attig and Franke, 2019)). Past research has shown that glances (i.e., brief interactions to check current activity status; Gouveia et al., 2015) dominates activity tracker usage. Here, intensive device/data interaction was slightly related positively, albeit insignificantly, to abandonment due to demotivation. Consequently, excessive, short interactions might indicate problematic tracker usage and are worthy of further investigation. However, past research also suggests that a strong tracker attachment and obsessive tracking behavior automatically weaken in some users, leading to more moderate and less emotion-laden use (Fritz et al., 2014). Thus, *continuously* engaging in highly frequent micro-interactions with the device might signal problematic tracker usage. Automated detection of such usage patterns could foster reasoned and beneficial tracking [DG5], for instance, through enhancing self-understanding (i.e., making users aware of deviation from beneficial tracker usage patterns).

Around a quarter of participants mentioned privacy concerns as contributing to their decision to stop tracking. This is a considerable figure compared to most past research on the relative importance of reasons. Generally, privacy concerns are barely mentioned as contributing to tracker attrition (Chan, 2017; Garg & Kim, 2018; Clawson

et al., 2015; Coorevits & Coenen, 2016; Fadhil, 2019, a, 2019, b; Garg & Kim, 2018; Hermsen et al., 2017; Kononova et al., 2019; Maher et al., 2017; Pour, 2019; Rieder et al., 2019; Siscoe, 2019). Exceptions include research conducted by Epstein et al. (2016a) and Garg (2019) who both reported that more than 35% of participants stopped tracking because of data sharing concerns. Apparently, tracker users' level of privacy concerns vary substantially, from pronounced distrust (Maltseva & Lutz, 2018) to being unaware of the relative sensitivity regarding gathered health and location data ((Lydinia, Brauner, & Ziefle, 2018; Ostherr et al., 2017; Zimmer, Kumar, Vitak, Liao, & Chamberlain Kritikos, 2018)). It seems that strong concerns might prevent potential users from tracker adoption, possibly resulting in lower mean privacy concerns in tracker user versus non-user samples ((Lydinia et al., 2018b)). Data sharing enables personalized feedback and social interactions, serving basic psychological needs of competence and relatedness (Lomborg & Frandsen, 2016). Although sharing and transfer of most personal activity data serves a reasonable purpose (e.g., comparing step count data with other users), other data might not be perceived as essential for benefiting personal quantification (e.g., GPS data; (Zimmer et al., 2018)). Consequently, tracker users should receive transparency regarding data sharing with companion as well as third-party applications and should be free to prohibit data transfer [DG6].

Previous research has identified "happy abandonment" as a key factor for stopping tracker use (Brandao, 2016; Clawson et al., 2015; Coorevits & Coenen, 2016; Epstein et al., 2016a; Maher et al., 2017). In our research, around a third of users stated they ceased tracking because they became habitually active, indicating they no longer needed to rely on the tracker's external control. Additionally, successful habit formation was linked to higher amounts of current physical activity. Thus, participants' self-reported data suggests that sustaining physical activity after tracker usage is feasible, which supports activity trackers' potential for positive health effects (Stiglbauer, Weber, & Batinic, 2019).

The aforementioned findings (e.g., data on the relative importance of reasons, see Fig. 2), emphasize the enormous diversity of former users. As many different reasons contribute to abandonment decisions, no one-size-fits-all solution exists to support long-term usage of activity trackers (Shin et al., 2019). Although the current research focused on individually differing usage characteristics, personality differences may also affect tracker abandonment decisions. For instance, prior research has shown that affinity for technology interaction (Franke, Attig, & Wessel, 2019) or trust in activity tracker measurement ((Rupp, Michaelis, McConnell, & Smither, 2016, 2018; Trommler, Attig, & Franke, 2018)) are associated with tracker usage variables ((Attig and Franke, 2019)). Hence, further research should investigate user diversity variables in more detail to examine abandonment decisions and, thus, barriers to long-term adoption more comprehensively.

### 6.3. Limitations and future research

As obtaining a sufficient sample of former users is challenging, especially for longitudinal observational studies, we investigated the research questions using an online questionnaire. Even though we recruited a considerably large sample, our methodological approach is only a first and limited step to assess the chain of causation between activity tracker usage and abandonment. The next step for making the results more robust is to build on the present findings and use a stringent, hypothesis-driven explanatory approach (e.g., structural equation modeling).

Moreover, because our questionnaire assessing abandonment reasons created some unsystematic factor loadings and some rather low reliability scores, it should be revised and extended for future use (e.g., by incorporating additional items and rephrasing). In addition, we used four self-constructed items to economically assess participants' current physical activity and one self-constructed item to specifically measure physical activity pre and post-tracker usage. Future studies should employ validated scales for physical activity assessment (e.g., World Health Organization Global Physical Activity Questionnaire; Armstrong & Bull, 2006) at least in addition to more context-specific self-constructed items to examine and ensure assessment validity.

Based on the correlational design, we cannot draw causal inferences. However, relationships between variables corresponding to different usage stages (e.g., tracker usage patterns, reasons for abandonment) are valuable hints to test precise chains of causation when utilizing longitudinal designs.

The current sample's gender distribution (biased towards female users, 74%) differs from the relatively even gender distribution of health and fitness tracker users in Germany (GfK, 2016). Therefore, the relative importance of design issues for abandonment might be overestimated as female users have been reported to place higher importance on tracker design than male users (Shih et al., 2015). Furthermore, based on our research design, we could not assess how participants corresponded to certain types of tracker users as identified in past research (Jarrahi, Gafinowitz, & Shin, 2018). We can only assume that specific user types were likely underrepresented (e.g., quantified selfers, elite athletes). Future research should focus on combining abandonment reasons and specific user type characterizations.

### 6.4. Conclusion

To exploit the full potential of wearable activity trackers for maximizing health benefits, examining why former users discontinued tracking and thereby identifying key usage barriers are crucial research goals. Furthermore, insight into usage characteristics of former users can reveal the psychological mechanisms involved in tracker abandonment decisions. The objectives of the present research were thus to highlight the reasons for wearable activity tracking attrition, to advance understanding regarding the relative importance of reasons, and to gain insight into the psychological processes that might underlie abandonment decisions by clarifying usage characteristics of former users.

The present research has comprehensively examined and integrated past findings regarding tracker abandonment reasons. These reasons were ranked by relative importance, indicating the core long-term adoption barriers of wearable fitness trackers. Specific abandonment reasons were linked to usage variables, suggesting that these factors varying across individuals play an important role regarding wearable activity tracking attrition. Given the methodological limitations of questionnaire-based research, our study can only indicate, not identify chains of causation leading to abandonment. Despite this constraint, our findings can serve as the foundation for future research regarding abandonment and usage barriers of wearable activity trackers and digital health applications in general.

## Conflicts of Interests

None.

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## Appendix

Table A.1
Characteristics of the studies included in the systematic literature review.

| Reference | Focus of study | Methodology | Sample size |
|---|---|---|---|
| Brandao (2016) | Factors linked to long-term adoption of wearable activity trackers | Online-survey and follow-up interviews (quantitative and qualitative analysis) | Survey: $N = 335$ ($n = 17$ ex-users); interviews: $N = 10$ ($n = 4$ ex-users) |
| Chan (2017) | Motivational impact of wearable fitness devices | Qualitative online-survey | $N = 68$ ($n = 8$ ex-users) |
| Clawson et al. (2015) | Abandonment of health tracking devices | Qualitative analysis of secondary sales posts on Craigslist | $N = 462$ Craigslist postings |
| Coorevits and Coenen (2016) | Abandonment of health tracking devices | Qualitative analysis of Reddit posts about fitness tracker abandonment (netnography) | $N = 93$ |
| Epstein et al. (2016a) | Abandonment of quantified self-technologies | Survey and interviews (quantitative and qualitative analysis) | Survey: $N = 175$ ($n = 64$ former activity tracker users); i nterviews: $N = 12$ |
| (Fadhil, 2019a) | Abandonment of wearable health and fitness trackers | Qualitative analysis of secondary sales posts on Kijiji and Gumtree | $N = 484$ Kijiji postings, $N = 624$ Gumtree postings |
| (Fadhil, 2019b) | Stages of wearable health tracking adoption and abandonment | Qualitative analysis of secondary sales posts on Kijiji (see (Fadhil, 2019a)) and additional user survey | $N = 26$ (current and ex-users) |
| Fausset et al. (2013) | Older adults' use of and attitudes toward activity tracking devices | Interview with older adults (qualitative analysis) | $N = 8$ |
| (Garg and Kim, 2018) | Reasons for (non-)use of Internet of Things | Qualitative online-survey | $N = 489$ ($n = 193$ ex-users of health wearables/personal informatics systems) |
| Garg (2019) | Reasons for (non-)use of Internet of Things | Qualitative online-survey | $N = 834$ ($n = 113$ ex-users of heath wearables) |
| (Harrison et al., 2015) | Adoption barriers and reasons for activity tracker abandonment | Online-survey and interviews (qualitative analysis) | $N = 24$ ($n = 8$ ex-users) |
| Hermsen et al. (2017) | Determinants for sustained use of an activity tracker | Observational study with 3 online-surveys (quantitative analysis) | $N = 711$ (after 90 days of usage $n = 40$ stopped tracking; after 232 days of usage $n = 187$ stopped tracking) |
| Jeong et al. (2017) | Smartwatch usage patterns | Longitudinal study (quantitative and qualitative analysis) | $N = 50$ ($n = 4$ ex-users) |
| Kononova et al. (2019) | Usage of wearable activity trackers in older adults | Focus groups | $N = 11$ ex-users |
| Lazar et al. (2015) | Usage and abandonment of smart devices | Interview after 2 months of usage (qualitative analysis) | $N = 17$ (36 of 49 smart devices were abandoned) |
| Maher et al. (2017) | Users' experiences of wearable activity trackers | Online-survey (quantitative analysis) | $N = 237$ ($n = 37$ ex-users) |
| Pour (2019) | Factors influencing adoption and attrition of fitness trackers | Qualitative analysis of customer reviews on Amazon | $N = 60$ reviews |
| Rieder et al. (2019) | Habitual usage of wearable activity trackers | Qualitative analysis of narrative interviews | $N = 10$ (current and ex-users) |
| Shih et al. (2015) | Adoption challenges of wearable activity trackers | Observational study with 2 surveys (quantitative and qualitative analysis) | $N = 26$ ($n = 17$ stopped usage after two weeks) |
| Siscoe (2019) | Effects of fitness tracker usage on motivation | Qualitative and quantitative online survey | $N = 420$ ($n = 60$ ex-users) |

Table A.2
Questionnaire items for the assessment of activity tracker abandonment reasons and short descriptions as used in Fig. 2 and Table 3.

| Item No. | Item Text | Short Description |
|---|---|---|
| I stopped using the activity tracker because … | | |
| 1 | …I felt that the tracker wasn't measuring accurately. | Perceived measurement inaccuracy |
| 2 | …I didn't trust the results of the measurements. | Measurement distrust |
| 3 | …I experienced that the tracker wasn't correctly registering my activities. | Incorrect activity tracking |
| 4 | …I had no use for the data, or the data was ambiguous. | Useless data/data interpretation |
| 5 | …the tracker didn't register activities which were relevant to me. | Tracker did not assess relevant data/activities |
| 6 | … I didn't know what would happen to my data. | Uncertainty regarding personal data transfer |
| 7 | … I had concerns regarding the circulation of my personal data. | Privacy concerns |
| 8 | … I found an alternative which used less time or cost less. | Switch to a more time- or cost-effective alternative |
| 9 | … tracking with my smartphone is more convenient, because I have it with me anyway. | Tracking per smartphone more convenient |
| 10 | … the tracker and/or the companion app did not offer enough possibilities to interact with others (e.g., challenges). | Too few opportunities for social interaction |
| 11 | …the tracker didn't synchronize my gathered data with other apps. | Data unsynchronizable with other apps |
| 12 | …the tracker was uncomfortable or bothered me during my activities. | Tracker discomfort/annoyance during exercise |
| 13 | …I didn't like the visual appearance of the tracker (anymore). | Tracker no longer aesthetically appealing |
| 14 | …charging the battery was inconvenient. | Charging discomfort |

(*continued on next page*)

Table A.2 (*continued*)

| Item No. | Item Text | Short Description |
|---|---|---|
| 15 | …I forgot to wear my tracker. | Forgot to wear tracker |
| 16 | …my skin under the wristband became irritated or had an allergic reaction. | Allergic reaction to wristband |
| 17 | …I found the use of the tracker and/or the companion app complicated, wearisome or cumbersome. | Usage of tracker/app too inconvenient/demanding |
| 18 | …I had the feeling that I was no longer doing activities for myself, but rather for a satisfying result on my tracker. | Obsessive tracking |
| 19 | … I was no longer interested in comparing myself to other users. | Oversaturation of social comparison |
| 20 | …I was demotivated by seeing my failures. | Demotivation through negative feedback |
| 21 | …I didn't have any further interest in tracking my data and/or I no longer had fun tracking. | Intrinsic tracking motivation loss (i.e., loss of interest/ fun) |
| 22 | …my tracker was defective, or the battery wouldn't charge anymore. | Tracker broken/could not be charged |
| 23 | …tracking meant investing more time than I wanted to. | Tracking took too much temporal effort |
| 24 | …I paused my tracking routine (e.g., because of vacations or sickness) and didn't start again thereafter. | Tracking routine disruption |
| 25 | … my state of health had changed, and tracking was no longer meaningful and/or possible. | Health status change |
| 26 | …I lost interest in physical activity. | Loss of motivation for physical activity |
| 27 | … my activity goals had changed, and my tracker could no longer support me in achieving these. | Tracker unable to support new activity goals |
| 28 | … my priorities/life situation had changed, and tracking my activities was no longer important. | Change of priorities/life circumstances |
| 29 | …I couldn't integrate tracking into my day-to-day. | Tracking did not fit into daily routine |
| 30 | … my activities were now a habit and I no longer had to control them. | Activity has become habitual |
| 31 | … I reached the long-term goal that I had wanted to achieve with the use of the tracker. | Long-term goal attained |

*Note*. Items were answered on a 6-point Likert scale from 1 (*completely disagree*) to 6 (*completely agree*). Original German wording can be obtained from the corresponding author.

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