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Exploring the Impacts of Elaborateness and Indirectness in a Behavior Change Support System

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ABSTRACT Numerous technologies exist for promoting a healthier lifestyle. These technologies collectively referred to as ''Behavior Change Support Systems''. However, the majority of existing apps use quantitative data representation. Since it is difficult to understand the meaning behind quantitative data, this approach has been suggested to lower users' motivation and fail to promote behavior change. Therefore, an interpretation of quantitative data needs to be provided as a supplement. However, different descriptions of the same data may lead to different outcomes. In this paper, we explore the impact of different communication styles for interpretations of quantitative data on behavior change by developing and evaluating Walkeeper – a web-based app that provides interpretations of the users' daily step counts using different levels of elaborateness and indirectness with the aim of promoting walking. Through the quantitative analysis and results of a user study, we contribute new knowledge on designing such interpretations for quantitative data.

INDEX TERMS Behavior change, communication styles, physical activity.

I. INTRODUCTION

Nowadays, lifestyle diseases have become a global social problem [1]–[3]. As the term implies, lifestyle diseases, such as diabetes and obesity, are usually caused by individuals' poor daily habits. To treat lifestyle diseases, it is necessary to review individuals' daily life patterns and promote better lifestyles; this is referred to as ''behavior change'' in the medical field. The classical way of inducing behavior change is by holding consultations to inform people of future risks and ask them to monitor themselves (e.g., sugar intake, weight, blood pressure) manually. However, this approach places a large burden on people, which makes it difficult to continue over the long term. Therefore, alternative approaches are needed. With the rapid progress of technology in recent years, numerous systems for inducing behavior change have been developed using information technology. Positive results have been reported in some areas, such as in the management of smoking cessation, hazardous drinking, obesity, diabetes, asthma, tinnitus, stress, depression, and insomnia [4]. For instance, Saksono *et al.* [5] designed a mobile app for promoting family physical activity. Wang *et al.* [6] developed an app that visualizes users' degree of stress estimated based on heart rate to promote stress self-regulation. These types of systems are also collectively referred to as ''behavior change support systems (BCSSs)'', which are defined as sociotechnical information systems with psychological and behavioral outcomes designed to form, alter, or reinforce attitudes, behaviors, or acts of compliance without using coercion or deception [7]. Some studies attempting to enhance the effectiveness of existing systems by exploring the effects of different timings and frequencies of interactions on behavior change have been reported [8], [9].

To induce behavior change effectively, it is necessary to select the appropriate contents, timing, and ways of representation. However, while the majority of existing apps

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use a quantitative approach involving charts, graphs, and statistical reports as the ways of representation, some evidence showing that the quantitative approach can be difficult for users to understand has been presented [10], [11]. This could reduce the motivation of users and result in a failure to improve health [12]. To offset the shortcomings of the quantitative approach, interpretations of quantitative data need to be provided as a supplement. Providing interpretations would allow users to understand their own situation more clearly, thereby increasing the possibility of inducing a behavior change. Meanwhile, different descriptions of the same data may lead to different outcomes. According to Pragst *et al.* [13], the elaborateness and indirectness of content can influence users' perceptions of the information provided. Miehle *et al.* [14], [15] demonstrated that the elaborateness and indirectness of content influence user satisfaction in a spoken dialogue system. Therefore, to enhance the effectiveness of behavior change, the effects of different communication styles for interpretations on behavior change need to be investigated.

To this end, we developed Walkeeper, a Web-based app that provides interpretations of users' daily step counts based on different communication styles. In this paper, we overview the design of Walkeeper and explore the receptivity of users toward such a system. In doing so, we attempt to answer research questions surrounding how individuals react to different interpretations of their daily step counts and how the interpretation style affects their activity levels, attitudes, and engagement. Our specific contributions are as follows: (1) a novel approach that helps people understand the meaning behind quantitative data by adding interpretations in different communication styles, (2) an investigation of how the interpretation style affects the behavior of users, and (3) a discussion of how the interpretation of quantitative data should be designed. The results could be expected to provide useful information for future research exploring the influence of other factors such as the gender or cultural background of users.

The remainder of this paper is organized as follows: Section II reviews the relevant related work. Section III presents our Web-based app, Walkeeper, which was developed within the scope of this work. A field study using Walkeeper is described in Section IV, and the experimental results are given in Section V. Section VI discusses the findings. Finally, Section VII concludes and provides some future directions.

II. RELATED WORK

In this section, we describe the existing work related to our study. We first explain technology-based behavior change, followed by the adaptive communication style.

A. TECHNOLOGY-BASED BEHAVIOR CHANGE PROMOTION

An increasing amount of research is being conducted on technology-based tools that utilize gamification design elements, social support, and self-monitoring to promote behavior change. Systems such as WhoIsZuki [16] and UbiFit Garden [17] encourage users to walk more by connecting their physical activity with game elements in the app. WhoIsZuki [16] contains a multi-chapter quest and ties the main character's progress to the user's physical activity. In UbiFit Garden [17], the user's physical activity leads to a more beautiful and growing virtual garden. Other work has explored novel types of social support for inducing behavior change. For example, Jaques *et al.* [18] developed a Web-based pairing service in which two people pair their needs to help each other achieve their own goals, such as drinking more water or engaging in more exercise. By pairing and encouraging paired individuals to support each other, the service successfully induces behavior change. Luhanga *et al.* [19] conducted a study to induce behavior change through group competition and support from group members to promote the success of the user's diet. Meanwhile, as a continuation of the classic method of inducing behavior change by asking users to monitor themselves, self-monitoring has been the most applied approach in BCSSs [20]. For instance, Escoffery *et al.* [21] proposed a system that allows users to review their smoking habits through the sending of e-mails that include personalized assessments, whereas An *et al.* [22] described a system that sends weekly e-mail invitations to users encouraging them to visit the study website to report their health and lifestyle habits for the prior week. Wang *et al.* [6] developed an app that visualizes the user's stress degree, which is estimated based on heart rate, to promote the self-regulation of stress. Some studies have attempted to promote behavior change by using devices deployed in the environment instead of mobile phones. For instance, Zhang *et al.* [23] developed an interactive signage system that actively talks to passing users and promotes behavior change by presenting user-related information through voice and text messages. These types of systems are also collectively referred to as ‘‘behavior change support systems (BCSSs)’’, which are defined as sociotechnical information systems with psychological and behavioral outcomes designed to form, alter, or reinforce attitudes, behaviors, or acts of compliance without using coercion or deception [7].

To induce behavior change effectively, it is necessary to select the appropriate contents, timing, and ways of representation. Although the studies mentioned above help to inform the design of BCSSs, the majority of existing systems still use quantitative approaches involving charts, graphs, and statistical reports as ways of representation, and these can difficult for users to understand [10], [11]. According to Crum *et al.* [12], a heavily quantitative approach may reduce the motivation of users and result in a failure to improve health. To offset the shortcomings of the quantitative approach, interpretations of quantitative data need to be provided as a supplement. Providing interpretations would allow users to understand their own situation more clearly, thereby increasing the possibility of inducing a behavior change.

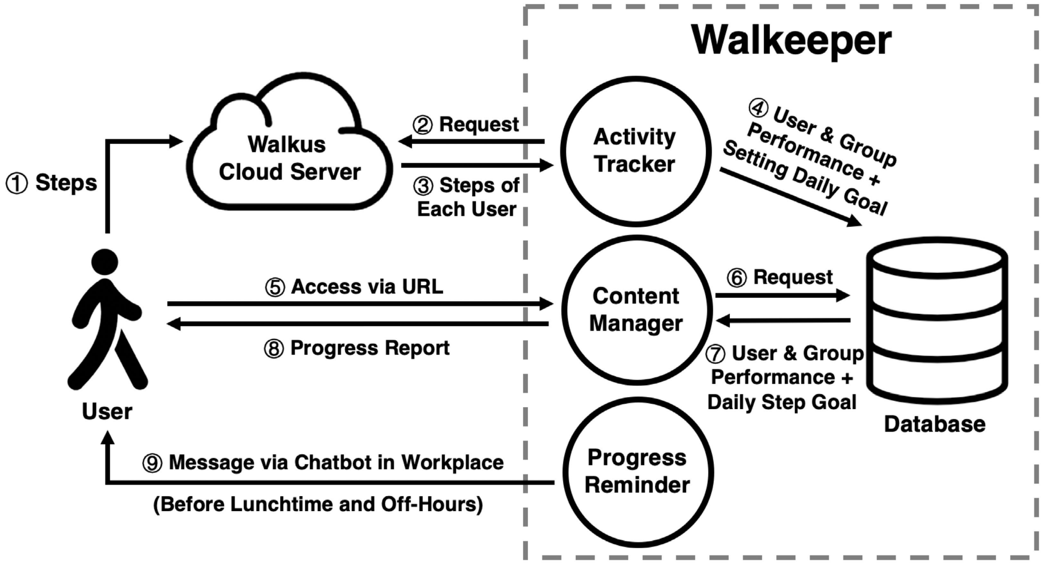

FIGURE 1. Our Web-based application, called Walkeeper, consists of three parts: an activity tracker, a content manager, and a progress reminder.

Meanwhile, different descriptions of the same data may lead to different outcomes. For example, Pragst *et al.* [13] demonstrated that different levels of elaborateness and indirectness can influence users' perceptions of the information provided. Therefore, it is necessary to take consider the effects of different communication styles for the interpretations when designing a BCSS.

B. ADAPTIVE COMMUNICATION STYLES

It has been shown that people adapt their interaction style to each other when they communicate [24]–[28]. Therefore, many researchers suggest adapting systems to users in a similar way [29]–[32]. By adapting the system's behavior to the user, the system may appear more familiar and trustworthy, and the interaction may be more effective. One adaption approach is keeping the propositional content of a system action the same and changing only the way it is presented, i.e., the communication style. Pragst *et al.* [13] investigated the applicability of elaborateness and indirectness as possibilities for adaptation in human–computer interaction. They found that these dimensions influence the user's perception of dialogue and are therefore valuable candidates for adaptive dialogue management. The level of elaborateness describes how much additional information is provided to the user. In response to a question concerning the current day's weather forecast, a low level of elaborateness resulted in providing only the requested information, whereas a high level of elaborateness resulted in providing information that included the weather forecast for the next few days. The level of indirectness describes how concretely the information is addressed by the system. For instance, a direct answer to the question about the current weather would be an accurate description of the weather, such as "It is raining", whereas an indirect response would be advice to take an umbrella. Although the indirect response does not mention the weather directly, it can be inferred from the given information. Miehle *et al.* [15] investigated the issue of how various communication styles of a spoken user interface are perceived by users. They found that the system's level of elaborateness and indirectness influenced the user's satisfaction and perception of the dialogue, and that there was no general preference for the system's communication style.

Although those studies have demonstrated that different communication styles can affect the users' perceptions of interactions in a spoken dialogue system, the effects of communication style on inducing behavior change remain unclear. Therefore, further investigation is needed to enhance the effectiveness of behavior change.

III. WALKEEPER PROTOTYPE DESIGN

We developed Walkeeper, a Web-based application that provides interpretations of users' daily step counts based on different levels of elaborateness and indirectness, to examine how the interpretation style affects the user's walking performance. As can be seen in Figure 1, Walkeeper consists of three parts: an activity tracker, a content manager, and a progress reminder. The activity tracker tracks the users' activity and sets the daily step goal for each user. Based on the data collected by the activity tracker, the contents manager selects the content to be provided to the user, including the contents of the interpretation, the facial expression of the emoji, the graph of historical records, and the group ranking table. The progress reminder sends messages to the users before lunchtime and off-hours every weekday in an attempt to promote the users to walk more by reminding them of their walking progress. In the design of Walkeeper, we applied

TABLE 1. Software Features in Walkeeper.

Feature	Way to Apply
Self-monitoring	Providing information on the user's walking progress
Praise	Congratulating the user when the daily goal has been reached
Suggestion	Promoting the user to walk more when the user has not reached the daily goal
Reminder	Sending messages to the user before lunchtime and off-hours
Comparison	Showing the average number of steps of the whole group in a historical records graph
Competition	Showing the rank of other users in a ranking table

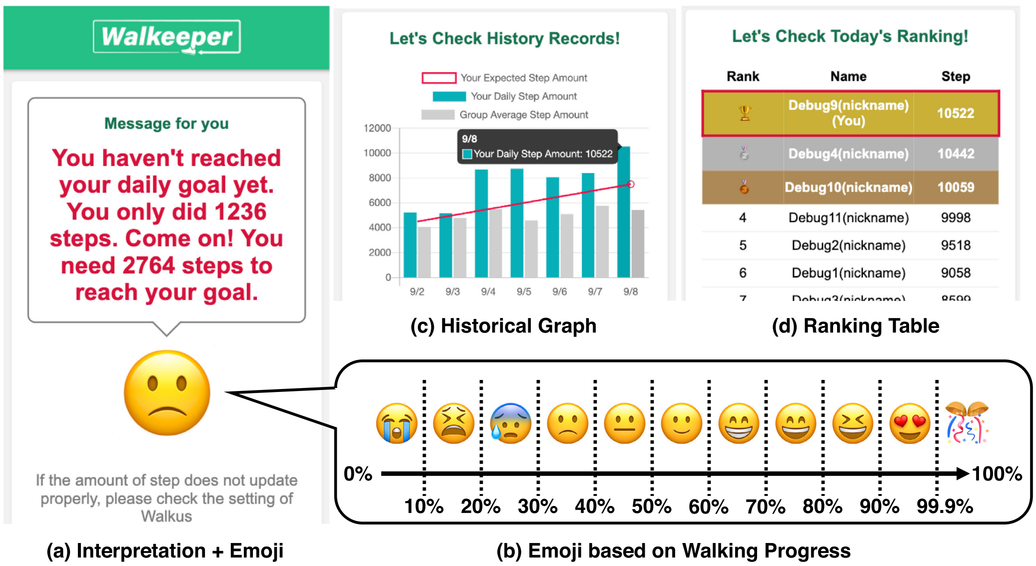

FIGURE 2. The Walkeeper interface.

BCSS theory by importing self-monitoring, praise, suggestions, reminders, comparisons, and competition from a list of BCSS software features [7] (Table 1). These features have also been widely applied in other existing BCSSs and got positive results.

In the following, we describe the main features of Walkeeper, including how the system tracks the activity, sets the daily step goal, selects the contents of the interpretation to be provided, and reminds the user of his/her walking progress.

A. ACTIVITY TRACKING AND GOAL SETTING

To track the number of steps of each user, we used Walkus,[1] a mobile app that can track the activity of users and upload the data to a cloud server. In the cloud server for Walkeeper, we developed a function called an activity tracker to update the users' step counts. The activity tracker accesses the application programming interface of Walkus every 5 minutes to obtain data at that time via the users' Walkus IDs and store these data in the Walkeeper database. Afterwards, the activity tracker calculates the average number of steps of the whole group and stores it in the database as the group performance at that time. At the end of each day, the activity tracker checks whether each user has reached his or her daily step goal. If the user has reached his/her goal, the activity tracker increases the daily step goal for the next day by 500. Otherwise, the activity tracker keeps the current step goal for the next day.

[1] https://apps.apple.com/us/app/walkus/id1273735006

B. PROGRESS REPORTING

Walkeeper provides a unique URL for each user so that he or she can check his or her walking progress at any time. After accessing the URL, each user can see the Walkeeper interface containing an interpretation of the current step count, an facial expression emoji, a historical records graph, and a ranking table, as shown in Figure 2.

We developed a content manager to deal with the decision of the contents to be provided to the user when accessing Walkeeper. Every time a user accesses the URL, the content manager decides on the contents according to the following

TABLE 2. Different communication styles for the interpretations, where <X> is the user's number of steps at that time and <Y> is the number of steps remaining to reach the goal.

Status	Communication Style	Content
User has reached goal	Direct & Elaborate (DE)	You have reached your daily goal. You already did <X> steps today. Well done! You improve your health with physical activity.
	Direct & Concise (DC)	You have reached your daily goal. Well done!
	Indirect & Elaborate (IE)	You did it. <X> steps are fantastic! Your health is benefiting from physical activity.
	Indirect & Concise (IC)	You did it. Fantastic!
User has not reached goal	Direct & Elaborate (DE)	You haven't reached your daily goal yet. You only did <X> steps. Come on! You need <Y> steps to reach your goal.
	Direct & Concise (DC)	You haven't reached your daily goal yet. Come on!
	Indirect & Elaborate (IE)	You still need to do some steps today. <X> steps are a good start. Get going! <Y> are all that is needed.
	Indirect & Concise (IC)	You still need to do some steps today. Get going!

steps: (1) identify the user based on the URL, (2) calculate the walking progress of the user, (3) check the communication style setting for the user, (4) formulate an interpretation based on the communication style and walking progress, and (5) select the facial expression emoji, historical records graph, and ranking table based on the walking progress of the user and the group performance. Walkeeper provides four different communication styles for the situation in which the user has and has not reached his or her goal, as shown in Table 2. Templates were created based on the definitions provided in Section II-B. Hence, the concise interpretations contain only the most important information, while the elaborate interpretations contain some additional information, such as the exact number of steps taken or the number needed to reach the goal. The direct interpretations state concretely whether the daily goal has been reached, while the indirect interpretations provide positive or negative feedback only based on the walking progress.

The interpretation is displayed as a speech bubble next to an emoji, as shown in Figure 2(a). Eleven different emoji facial expressions are used to represent the user's walking progress rate, as can be seen in Figure 2(b). To maintain the user's motivation, Walkeeper also provides a graph showing the daily step records, daily step goal, average number of daily steps of the whole group for the past week (see Figure 2(c)), and an overall ranking table containing the user's rank, nickname, and current step count (see Figure 2(d)). For Japanese-speaking users, all contents are provided in Japanese. The translations were conducted by a native Japanese speaker with a high TOEIC score (915/990) to ensure that the contents were translated accurately.

C. PROGRESS REMINDER

We developed a function called progress reminder that sends messages to users twice a day through a chat bot developed in Workplace Chat.[2] The message sent by the progress reminder contains a text ("Please access the URL and check your performance") and a unique URL for each user. For Japanese-speaking participants, the reminder is provided in Japanese. The first message is sent at 11:30 and the second at 16:30. Hence, users receive their walking progress before lunchtime and before leaving the office. In this way, they can decide whether to have an active lunch break (e.g., use the stairs instead of the elevator when going to the canteen, take a walk after having lunch) or plan to walk more in the evening (e.g., walk to the train station instead of taking the bus, exercise after arriving home).

[2] https://www.workplace.com/

IV. FIELD STUDY

We evaluated Walkeeper during a 6-week user study to explore the following research questions: (1) How do people react to Walkeeper?; (2) How do different communication styles affect the attitudes and behavior of users?; and (3) How does the browsing duration affect the behavior of users?

A. PARTICIPANTS AND PROCEDURES

A user study was conducted from June to July 2020. In total, 24 members of the Ubiquitous Computing Systems Laboratory at the Nara Institute of Science and Technology participated in the evaluation (21 men, 3 women; mean age, 29 years; age range, 22–52 years). Eighteen of the 24 participants were Japanese speakers; the remaining six were English speakers. After informed consent was obtained from the participants, they were introduced into the experiment without receiving an explanation of the experimental details (e.g., communication styles, contents). All participants were given assistance with the installation and setup of Walkus, Workplace, and Walkeeper.

During the first 2 weeks, steps were taken to ensure that the participants' steps were tracked continuously. Moreover, the overall activity levels of the participants were investigated to set an appropriate daily goal for each participant and obtain a comparative value for the evaluation. During this

TABLE 3. All participants were randomly assigned to one of four teams.

Team	Number of Participants	Week 1	Week 2	Week 3	Week 4
1	7	DE	IC	IE	DC
2	6	DC	IE	IC	DE
3	4	IE	DC	DE	IC
4	7	IC	DE	DC	IE

experimental stage, Walkeeper collected step data only; it did not send any messages or provide URLs to the participants that would enable them to check their progress. Using these data, the average amount of steps was calculated and set as the initial daily step goal for each participant.

Afterwards, a 4-week study was conducted to assess the participants' reactions to Walkeeper in their daily life, the ways it affected both their attitudes and behaviors toward physical activity, and the overall experience of the different communication styles. To ensure the same conditions for the data collection during the course of the study, Walkeeper interacted with the participants only on workdays (from Monday to Friday). Moreover, the daily step goal of each participant was reset to the initial daily step goal at the beginning of each week so that the starting point was identical each week. At the end of each week, the participants completed a 3–4-minute survey on their opinions about that week's interface and interpretations. All participants were sent a text message containing a link to the weekly survey, which was hosted on Google Forms, each Friday evening. In addition, we collected analytic data about the Walkeeper access time and the duration of browsing the Walkeeper website. At the end of the 4-week study, we asked the participants to complete a final questionnaire on their overall experience with the Walkeeper app. After answering the final questionnaire, the participants received a gift card worth 2000 JPY (around 19 USD) as a reward for participating in the study. Based on the collected data and survey responses, we conducted a statistical analysis to investigate the participants' experiences with the system.

B. STUDY GROUPS

To investigate the effects of different communication styles in Walkeeper, the participants were randomly assigned to one of four teams, whereby each team experienced a different communication style each week, as can be seen in Table 3. We collected data every day for each communication style to ensure that the weather would have no impact on the results. At the beginning of the study, six participants were assigned to Team 3, two of whom failed to participate fully because of personal reasons; therefore, their data were excluded from the subsequent analysis. In the first week, we assigned one of four communication styles to each team. In the second week, the communication styles were reversed (direct ↔ indirect, elaborate ↔ concise) to strengthen the differences. In the third week, Walkeeper maintained the same level of indirectness but changed the level of elaborateness (elaborate ↔ concise). In the final week, Walkeeper reversed the communication styles used in the third week.

V. FINDINGS

In this section, we first introduce the method we used to evaluate the impact of different communication styles. Then, we describe the effect of Walkeeper on promoting people to walk, the impact of different communication styles on behavior change, and the participants' overall impressions about the design of Walkeeper's interface through insights from the user study.

A. DATA FILTERING AND CALCULATION OF THE STEP INCREASE RATE

A statistical analysis was conducted to examine the correlation between the step counts and communication styles. To ensure the reliability of the data, incorrect data owing to technical issues were filtered out according to the following conditions:

1) The daily step count had to be at least 500.
2) For each participant, at least three data records had to be available for the first experimental phase (i.e., the average number of steps for this phase had to be reliable).

Any data that did not meet these conditions were excluded from the subsequent analysis. After data filtering, 89 data records were obtained for the first experimental phase and 400 for the second (DE: 96, DC: 99, IE: 103, IC: 102). To compare the step counts, using each participant's average number of steps during the first experimental phase M, the step increase rate (SIR) for each day of the second experimental phase was calculated as follows:

$$SIR(\%) = \frac{\#DailySteps - M}{M} \times 100 \tag{1}$$

The result represents the change in the participant's daily step count compared with the average number of steps before receiving a reminder from the Walkeeper system. On days with a positive SIR, the user walked more than the average number of steps during the first experimental phase; when the increase rate was negative, the participant walked less than the average number of steps during the first experimental phase.

B. IMPACT OF COMMUNICATION STYLES ON THE PARTICIPANTS' BEHAVIOR

The average SIR for each communication style (DE: Direct & Elaborate, DC: Direct & Concise, IE: Indirect & Elaborate, IC: Indirect & Concise) is shown in Table 4. A positive SIR was obtained for each communication style, showing that overall, the participants reacted positively to the Walkeeper system and walked more during the second than during the first experimental phase, when only the steps were tracked and Walkeeper did not send any messages or URLs to the participants so that they could check their progress. The highest average SIR of 32.79% was obtained for IE, whereas

TABLE 4. Results of a one-way ANOVA showing significant differences between communication styles.

	Sample Size	Average Step Increase Rate (SIR)	p-value (ANOVA)
DE	96	4.82%	0.017*
DC	99	5.07%	
IE	103	32.79%	
IC	102	13.38%	

TABLE 5. Results of Tukeyś all-pairs comparison test showing significant differences between DC and IE and between DE and IE.

	DE	DC	IE	IC
DE	-	1.000	0.030*	0.833
DC	1.000	-	0.030*	0.842
IE	0.030*	0.030*	-	0.209
IC	0.833	0.842	0.209	-

TABLE 6. Results of the two-way non-repeated measures ANOVA.

	p-value
Indirectness	0.012*
Elaborateness	0.168
Indirectness:Elaborateness	0.168

the lowest average SIRs of 4.82% and 5.07% were obtained for DE and DC, respectively.

We conducted a one-way analysis of variance (ANOVA) to assess the effects of the different communication styles. The results of the statistical analysis revealed statistically significant differences between communication styles ($p = 0.017$). Tukey's post-hoc analysis revealed a significant difference DC and IE ($p = 0.030$) and between DE and IE ($p = 0.030$), as shown in Table 5.

To explore further the impact of the different communication styles on the participants' behavior, the two dimensions of elaborateness and indirectness were considered independently. A t-test demonstrated that the participants had a significantly higher SIR with an indirect compared with a direct communication style ($p = 0.011$), but no significant difference was found between the elaborate and concise communication styles ($p = 0.164$). This result was confirmed in a two-way non-repeated measures ANOVA. The results are shown in Table 6. Figure 3 visualizes the correlation between the average SIR and different levels of elaborateness and indirectness. Additionally, the two-way ANOVA showed no interaction between elaborateness and indirectness that influenced the participants' average SIR ($p = 0.168$).

C. IMPACT OF BROWSING TIME ON THE PARTICIPANTS' BEHAVIOR

We conducted a statistical analysis to examine whether there was a correlation between the SIR and the time participants spent browsing the Walkeeper website. To achieve this, we extracted the access records for the Walkeeper website and calculated the total browsing time for each day. Next, we filtered out the data records with a total browsing time

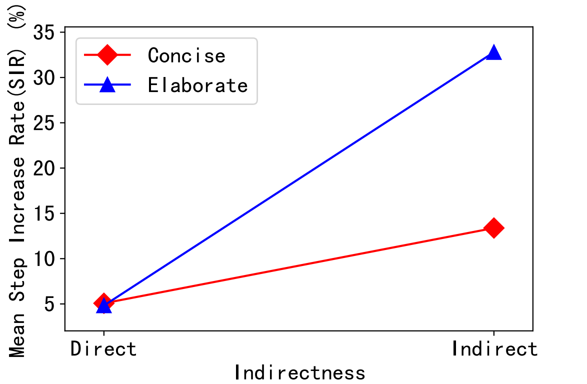

FIGURE 3. Correlation between the SIR of the participants and different levels of indirectness and elaborateness.

of zero (meaning that the participant did not access the Walkeeper website that day) or longer than 90 seconds (assuming that the participants did not actively check the information for more than 90 seconds), leaving 288 data records for the analysis. To examine the correlation between the SIR and browsing time, we calculated the Spearman rank-order correlation coefficient. The results revealed no significant correlation ($p = 0.54$).

D. IMPRESSIONS OF THE INTERFACE DESIGN OF WALKEEPER

Using the weekly survey and final questionnaire of the second experimental phase, we obtained the participants' (N=24) impressions about the interface design of Walkeeper, including the interpretations, emoji facial expressions, graph of historical records, and ranking table.

1) IMPRESSIONS ABOUT THE OVERALL SYSTEM

Using the weekly questionnaire, we obtained the participants' opinions about the overall Walkeeper system according to each communication style. The questionnaire contained statements that had to be rated on a five-point Likert scale (1=fully disagree, 5=fully agree). Table 7 shows the results of all weekly questionnaires. Despite the fact that the communication style of the interpretation had changed, most of the participants considered the system to be friendly and to provide the appropriate amount of precise information that was easy to understand. Meanwhile, most of the participants disagreed with the statement that the system provided more information than needed when using the indirect and elaborate style.

The final questionnaire included one open-ended question that asked the participants whether the Walkeeper system helped them with their exercise. In total, 19 participants reported that the Walkeeper system was useful for their exercise, nine of whom answered that it was because the Walkeeper system could track their steps in real time and show the distance to the daily goal directly, six appreciated that the Walkeeper system sent messages to them regularly so that they could remain aware of their exercise progress, and seven reported that competition (e.g., group performance, ranking

TABLE 7. Results of all weekly questionnaires.

Statement	Metric	DE	DC	IE	IC
1. The system seemed polite.	Median	4	4	4	4
	Average	3.81	3.73	3.65	3.69
	SD	0.85	0.86	1.06	0.74
2. The system seemed unfriendly.	Median	2	2	2	2
	Average	2.23	2.15	2.04	2.00
	SD	0.99	1.05	1.08	0.75
3. The system seemed professional.	Median	3	3	3	3
	Average	3.00	3.15	3.00	3.00
	SD	0.80	0.83	1.10	0.94
4. The system provided more information than I needed.	Median	3	3	2	3
	Average	2.85	2.62	2.42	2.69
	SD	0.83	1.02	0.99	1.09
5. The system provided the right amount of information.	Median	4	4	4	4
	Average	3.54	3.50	3.50	3.46
	SD	0.99	0.96	1.10	1.03
6. I would have preferred to get more details.	Median	3.5	3	3.5	3.5
	Average	3.58	3.27	3.46	3.38
	SD	0.95	1.12	1.24	1.17
7. I got the information I wanted.	Median	3	4	4	3
	Average	3.38	3.54	3.38	3.19
	SD	0.94	0.99	0.85	1.06
8. I always knew what the system wanted to tell me.	Median	4	4	4	4
	Average	4.19	4.23	4.12	4.04
	SD	0.75	0.82	0.99	0.82
9. The system provided imprecise information.	Median	2	1	2	2
	Average	2.12	1.96	2.42	2.00
	SD	0.86	1.09	1.30	1.02

table) encouraged them to walk more (some overlap was seen because some participants mentioned two or three aspects). By contrast, five participants reported that the Walkeeper system was not useful for their exercise. The main reason mentioned for this was that the Walkeeper system could only track and show the step count, not other types of exercise information.

2) IMPRESSIONS ABOUT THE INTERPRETATIONS

The final questionnaire contained three questions about the participants' impressions of the interpretations. The first question was whether they noticed any changes in the interpretations. Eighteen participants reported ''Yes'' and six reported ''No''. The second question was an open-ended question about how the participants described the differences. Among the 18 participants who noticed changes in the interpretations, nine reported that they noticed changes regarding whether exact numbers were shown, five reported that they noticed changes in the tone of the interpretations, and four reported noticing both. The third question was an open-ended question on the aspects of the interpretations that the participants found most important. The most frequently mentioned aspects were: (1) showing the exact number of steps, (2) using a soft tone for the interpretations, (3) providing sufficient information, including the benefits of walking more, and (4) using an appropriate sentence length.

3) IMPRESSIONS ABOUT THE EMOJI FACIAL EXPRESSIONS

In the final questionnaire, we asked the participants to rate five statements (based on a five-point Likert scale) regarding their opinions of the emoji facial expressions. The details and results are shown in Table 8. Most of the participants could understand their progress from the emoji; they felt happy when the emoji had a happy face and sad when the emoji had a sad face. However, neither the happy nor sad face encouraged the participants to walk more.

4) IMPRESSIONS ABOUT THE GRAPH OF HISTORICAL RECORDS

The participants were also asked to answer six questions about their impressions of the graph of historical records (Table 8). Most of the participants reported that they were glad to see their daily step count, daily step goal, and group average. However, while the participants felt encouraged to walk more when seeing their daily step count and goal, the group average did not have the same effect.

5) IMPRESSIONS ABOUT THE RANKING TABLE

Finally, we asked the participants four questions about their impressions of the ranking table (Table 8). Most of the participants reported that they were glad to see their and the other users' rankings, but did not feel encouraged to walk more by these elements.

VI. DISCUSSION

In this paper, we explored how the communication style of a supplemental interpretation in a quantitative approach-based BCSS can affect users' behaviors and attitudes toward walking. The following section discusses the findings of our user study, including how Walkeeper helps people with their

TABLE 8. Results of the final questionnaires regarding the emoji facial expressions, graph of historical records, and ranking table.

Element	Statement	Average	SD	Median
Emoji	1. I knew my progress clearly from the face expression.	3.67	1.40	4
	2. I felt happy when I saw a happy face.	4.17	0.87	4
	3. A happy face encouraged me to walk.	3.33	0.87	3
	4. I felt upset when I saw a sad face.	3.50	1.02	4
	5. A sad face encouraged me to walk.	3.00	1.06	3
Graph of History Records	1. I was glad to see my daily amount of steps.	4.67	0.56	5
	2. Checking my daily amount of steps encouraged me to walk.	3.92	0.88	4
	3. I was glad to see the expected amount of steps.	4.25	1.03	5
	4. I felt like to walk more since I wanted to reach the expected amount of steps.	3.67	0.87	4
	5. I was glad to see the group average amount of steps.	4.46	0.98	5
	6. I felt like to walk more since I wanted to walk more than the group average amount of steps.	3.42	1.02	3
Ranking Table	1. I was glad to know my rank.	4.33	0.76	4.5
	2. I was glad to know the others' rank.	4.17	0.76	4
	3. I felt like to walk more since the others can see my rank.	3.46	1.06	3
	4. I felt like to walk more since I wanted to get a higher rank.	3.63	0.97	3

daily exercise and how the communication style affects their behavior, thereby contributing new knowledge for the design of quantitative approach-based BCSSs.

A. EFFECT OF WALKEEPER ON INDUCING BEHAVIOR CHANGE

Despite the adverse weather during the rainy season in the study region, we obtained a positive SIR for each communication style, indicating that overall, the participants reacted positively to the Walkeeper system and walked more. One reason for this might be that Walkeeper regularly sends messages to users to remind them of their walking progress. The majority of apps currently available on the market tend to adopt a negative approach that rarely interacts with the user and only reports the user's status upon opening the app.

For example, the well-known fitness app Google Fit[3] sends notifications to users to inform them that they have achieved a certain exercise level. However, if the user constantly lacks exercise, Google Fit does not send any notifications to promote the user to exercise more, even though the user should care more about his/her health. In addition, numerous applications (e.g., Walkus) only report the user's status at the end of the day, which is too late for the user to engage in exercise, even if he or she thinks that their exercise amount was insufficient. By contrast, Walkeeper actively sends messages to users before lunchtime and off-hours to remind them of their status. Hence, the users can understand their progress more clearly and have enough time to change their plans, thereby increasing the possibility of walking more.

The results of the final questionnaire support our conclusion. In total, 19 participants reported that the Walkeeper system was useful for their exercise. The reasons given were that the Walkeeper system can track the users' steps in real time and show the distance to the daily goal directly, and that it reminds them of their exercise progress regularly, which increases their awareness.

[3]https://www.google.com/intl/en_us/fit/

B. IMPACT OF COMMUNICATION STYLES ON BEHAVIOR CHANGE

The result of the statistical analysis regarding the correlation between the amount of steps and the communication style led us to the conclusion that the communication style of the interpretations in the Walkeeper system influences the behavior of the user. Among the four communication styles, the indirect and elaborate style had the highest SIR. This reflects two issues that were also emphasized by the users in the questionnaire. First, compared with the concise style, the elaborate style includes more details, such as the exact number of steps that has already been achieved at the current time and information about the benefits of being more active and playing more sports; this helps the users understand their progress more clearly and motivates them to achieve their goal. Second, the indirect style is usually perceived as being more friendly than the direct style because it uses a softer tone and does not concretely address (negative) information. If the Walkeeper system has to address an issue such as the user not being active enough, it is easier for the user to accept it if the system does not mention it directly. Considering these aspects when designing interpretations of quantitative data for BCSSs could influence behavior change among users and encourage them to be more active. These results also confirm that different levels of elaborateness and indirectness can influence users' perceptions of the information provided [13] in inducing behavior change.

VII. CONCLUSION AND FUTURE WORK

In this paper, we described Walkeeper, a Web-based app that provides interpretations of users' daily step counts using different levels of elaborateness and indirectness. We conducted a 6-week user study with 24 participants to evaluate Walkeeper. The results indicated that Walkeeper had a positive effect on increasing the users' daily step count. The results also revealed that the communication style of the interpretations of the quantitative data affects the users' walking performance. The indirect and elaborate communication style led to the highest SIR, while the direct and elaborate and direct and concise communication styles led to the lowest SIRs. This might be explained by the fact that the elaborate style includes more details, which makes it easier for users to get a clear picture of their progress accompanied by an increased sense of achievement and motivation. The indirect style has a softer tone than the direct style and does not concretely address (negative) information, thereby making it easier to accept. Therefore, BCSSs that apply a quantitative approach should consider different communication styles when explaining quantitative data to users; this could lead to enhanced behavior change among users. Based on these results, we will continue to explore the influence of other factors such as gender and cultural background on users in future work.

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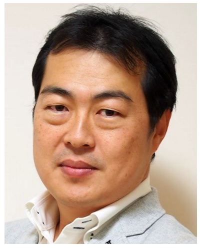

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