Master thesis

Alleviating negative emotions associated with goal failure with the use of musical data representation.

Study program

Interaction technology

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Abstract

This study investigates the role of emotions in goal achievement within the context of physical activity (PA). Previous research has shown that emotions can serve as indicators of performance in education and sports, but there has been little focus on how emotions impact goal achievement in PA. To address this gap, the study is conducted in two parts. In the first part, a survey was conducted to explore which emotions are most commonly experienced when individuals fail to reach their goals. The results showed that disappointment, frustration, regret, and guilt were the four most commonly reported emotions. Based on these findings, a solution was proposed through iterative ideation for alleviating negative affective states. In the second part of the study, an experimental study was conducted to examine the use of music in representing PA. Music was found to be an effective tool for representing PA and helping individuals cope with the negative emotions associated with goal failure. The findings indicate that emotions play a significant role in goal achievement and music can help alleviate negative emotions when encountering goal failure.

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1. Introduction

In recent years, there has been a rise in apps aimed at promoting positive behaviour change [1]. This group of apps are called behaviour change applications. They aim to foster, assist in and maintain the desired behaviour change [2]. According to a survey, over 325,000 health apps were available for smartphones worldwide in 2017 [3]. The most popular apps promote exercise, diet, and weight management. Approximately 500 million users are actively using these services [4]. These applications are collectively referred to as "Mobile Health" or "mHealth" [5]. mHealth applications encompass a range of contexts, including the use of mobile phones to enhance point-of-service data collection, care delivery, patient communication, utilisation of alternative wireless devices for real-time medication monitoring, and adherence support [6]. Behaviour change applications employ a variety of strategies to assist users in achieving their desired change. Among these strategies, goal-setting is one of the most effective [7]. The notion of goal-setting falls within the realm of cognitive psychology. The theory was initially developed for academic and organisational domains [7]. It has since been applied to other domains and has become one of the most practical and validated theories for work motivation. The theory was developed as a framework for predicting, explaining, and influencing an individual's motivation in the workplace [8]. "The goal-setting theory posits that specific and challenging goals are associated with a higher level of task performance than vague or easy goals [9]. Accomplishing a challenging goal yields more satisfaction than easier goals, as they require more effort to achieve. Variables in goal-setting such as performance feedback, knowledge of results, and rewards can support the established goal and inspire participants to strive for more challenging goals [10], [11].

1.1 | Challenges and scope

The goal-setting theory promotes setting challenging goals. However, there will always be a fraction of the population who do not reach their goal [12], [13]. Current mHealth applications and studies utilising goal setting promote using positive reinforcement theory to motivate individuals to perform physical activity(PA) in case of goal failure [14]–[16]. The theory focuses on positive outcomes achieved by individuals and rewarding individuals for accomplishment [15]. The implementation of the theory has resulted in the current PA-related application avoiding failed outcomes. The focus is maintained on positive outcomes and goal achievement [17], [18]. An example of this practice can be seen within, the Fitbit application [19] facilitates this by showing a short animation of fireworks on the wrist device when the individual reaches their goal. In the case of failure of a goal, there is a lack of attention given to the efforts made by individuals. The failure in reaching a goal should not be celebrated, but ignoring the efforts taken can lead to negative effects on individuals' self-efficacy [20], [21].

Bringing attention to the failure to achieve a goal can lead to a positive effect on goal pursuit if information regarding the goal shows insufficient progress made but does not undermine the effort taken by the individual [21]. Showing progress towards the goal in the current PA application is heavily dependent on the graphs and numbers [22]. Although graphs and numbers are an efficient way of representing the goal, it fails to provide contextual information about the presented data. Without contextual information related to data, individuals could struggle to create actionable changes in their behaviour change journey. An alternative way to represent PA and the progress towards goals has been explored in the form of abstract representation but it has been rarely implemented into applications outside of research studies and experiments [22].

When pursuing a goal there is a possibility that one might fail to achieve their goal. Reasons for failure vary between people and scenarios [21]. Although the reason for goal failure can be different, the common affective states felt in case of failure to achieve the goal are in the domain of negative valence [14]. Affective states (Emotions) are complex psychological constructs composed of many underlying dimensions, valence is the positive or negative evaluation of the subjectively experienced situation [23], [24]. The case of goal failure can be analysed with the emotional goal system proposed by Bagozzi [25]. The model suggests the possibility of achieving or not achieving is reacted with positive and negative anticipatory emotions. The anticipatory emotions then contribute to volitions in the form of intentions, plans, and the decision to expend energy in the service of goal-striving. The model showcases the importance of emotions within the goal-related activity.

A theoretical framework like the Emotion goal system has been utilised within the domain of academics, professional sports and work-related environments with positive results. Theories similar to the emotion goal system suggest emotions can be good predictors of physical activity, but there has been very little research done on PA-related applications [26]. This expands into even fewer studies researching the effects of specific negative emotions on the motivation and self-efficacy of an individual performing PA.

1.2 | Research question

The study aims to understand how an alternative way of representing PA can help in the reduction of negative affective states associated with goal failure. This Study focuses on filling the gap in understanding the role emotions play in the case of goal failure in the context of PA. A research question is posed with its supporting sub-questions to address the research gap outlined.

Research question:

How can the use of alternative ways to represent physical activity can help in alleviating negative emotions associated with goal failure?

Sub questions:

1. Which emotions are prominent when goal failure occurs related to physical activity?
2. How do emotions associated with goal failure affect goal progress?
3. How can physical activity be represented to help alleviate negative emotions associated with goal failure?

The subquestion presented offers the opportunity to examine the emotions within PA-related applications. SQ1 and SQ2 are posed to gain insight and fill in the research gap for lack of investigation performed within goal-related emotions in the case of PA applications. SQ3 is posed to help with ideation and designing an experience that can help in supporting individuals with alleviating the negative affective states when encountering goal failure.

1.3 | Approach and Outline

The thesis follows the Double Diamond Model of the British Council (4D) [27]. The model represents the divergent and convergent nature of the design process. The model is presented with 4 steps, Discover, Define, Develop, and Deliver. The model proposes to use the first step to discover the problem and explore the information available. Step 2 helps in narrowing the focus of research and defining a problem to be solved with additional insights from the discovery phase. Step 3 helps in developing the idea, where the scope of research is broadened again to explore different solutions possible for the problem defined. From the ideas generated the focus becomes narrow again within step 4 to evaluate and release the solution.

The outline of the thesis is presented in the form of a double diamond. The representation is sketched in Figure 1. Chapter 2 presents a discussion of previous research within the domain of goal setting and personal informatics and goal-related emotions. Additionally, sub-questions 1 and 2 (SQ1 and SQ2) will be partially explored. Lastly, a discussion related to the current state of PA representation is outlined. Chapter 2 represents the first divergent discovery phase in the double diamond model. Chapter 3 outlines a study design aimed at answering SQ1 and SQ2. Chapter 3 is shown as a converging point for the double diamond. Chapter 3 provides a narrowed focus on the emotions that should be considered for future research and design.
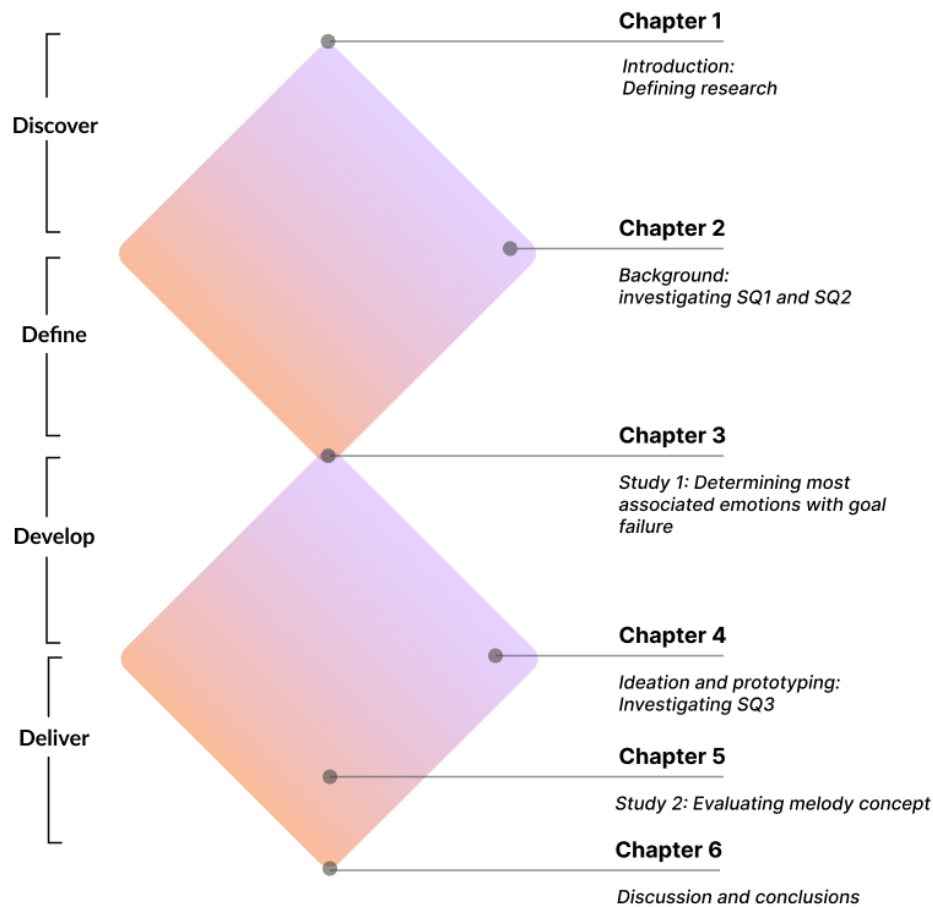
Figure 1. Outline of the thesis presented with the double diamond model.

The representation depicts a divergent point again for Chapter 4. Chapter 4 includes a discussion of the ideation and conceptual phase for designing with goal failure in mind. A final concept 'Melody' for a PA representation is sketched with prototyping details explained within the same chapter. Chapter 4 explores several ideas and design implementations for alleviating the negative emotions explored within the previous chapter.

Chapter 5 and 6 represents the second convergent point for the double diamond. Chapter 5 focuses on the evaluation of the prototype, with Study 2 addressing sub-question 3 (SQ3). Chapter 6 includes a general discussion related to the research question posed in Chapter 1.2. Study. Chapter 7 includes the conclusion regarding both studies and the discussion related to limitations and future work.

2. Background

Many mobile phones now have the ability to passively collect a variety of health data including physical activity, social interaction, sleep, and mobility patterns to make inferences about mental and physical health [28], [29]. Mobile fitness apps and fitness trackers utilise personal informatics, which supports users to reflect on data collected and track progress towards the goal. One of the most extensively studied strategies to help users on their way to making the desired behaviour change is goal setting [30]. Goal-setting is a widely used strategy for promoting physical activity. The goal-setting theory proposed by Locke and Latham is the primary theoretical framework for setting goals in psychology and plays a prominent role in physical activity promotion [9]. According to goal-setting theory, setting a challenging goal compared to an easy goal leads to a higher level of performance and satisfaction from reaching the goal. However, a portion of the population is likely to not reach their goal. [12], [13]. This raises the question of how to communicate goal failure to the user without demotivating them from pursuing their goal. This chapter will include discussions of previous work done on emotions related to goals, goal failure, and PA representation.

2.1 | The Role of Emotions in Goal Achievement

There are some common understandings of emotions related to goal achievement states, goal achievement is associated with positive emotions while goal failure with negative emotions [31]. This chapter will explore emotions related to goal achievement beyond the common understanding of goal-related emotions.

Emotions are ubiquitous in achievement settings and are recognized as critical to individual performance and productivity [31], [32]. An earlier system proposed by Bagozzi [25] can help understand the role of emotions in goal-directed behaviours. The model outlines appraisals of the consequences of achieving or not achieving a goal that is hypothesised to elicit anticipatory emotions. The anticipatory emotions are expected, in turn, to contribute to volition in the service of goal pursuit. Anticipatory emotions can influence intentions, plans and decisions to expand energy towards goal progression. The model was tested with 406 participants in a longitudinal study in the Netherlands. The context of the study was the regulation of one's body weight via exercising and dieting.
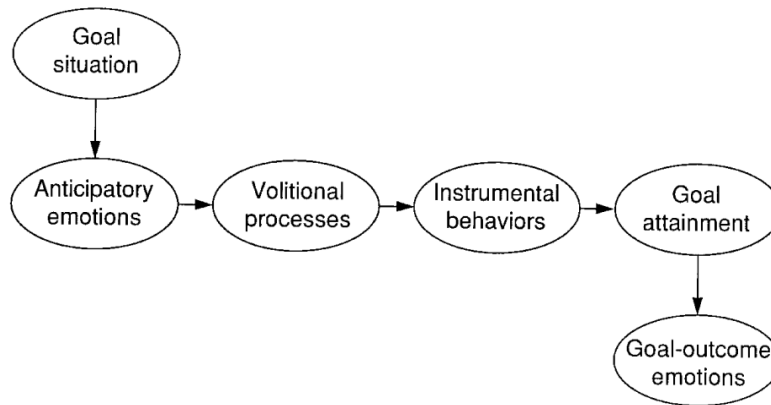
Figure 2. Emotion goal model [23]

The model presented in Figure 2, depicts the involvement of emotions within goal achievement setting. The model draws on previous work in the field of cognitive determinants of emotions and assumes that appraisals of goal situations give rise to different emotional experiences, and anticipatory emotions are evoked by the prospects of goal success or failure. The proposed conceptualisation is similar to the notion of success and fear of failure. The intensity of anticipatory emotions is a crucial aspect that gives them motivational potential. Different variables determine the intensity of these emotions. Some of these variables are the level of expectation for a goal, which influences how an individual feels about pursuing it. Individuals who have higher expectations of their goal will feel more intensely about failure related to the goal compared to individuals who had low expectations of their goal. A similar observation can be made on positive emotions. To understand this concept consider this example, an athlete participating in a competition they have trained for years to win first place. The athlete will experience more intense emotions depending on their achievement of the goal compared to an athlete who had a lower aspiration of the competition. Thus the model puts anticipatory emotions as the focus from which volitional and instrumental behaviour gets determined before reaching goal attainment.

After the goal outcome is received, individuals' reaction towards the goal is mostly dependent on subjective appraisals of goal achievement. Compared to anticipatory emotions, goal-outcome emotions are felt in a more disjointed way. Individuals might have positive or negative reactions to goal achievement, but the felt degree of achievement should vary considerably. Some people will achieve at a low level and therefore experience stronger negative than positive reactions. Others will achieve at a higher level and feel the opposite. The intensity of emotions experienced depends on the individual's perception of the outcome. If an individual achieves a goal but perceives the outcome to be less valuable, they may experience intense negative emotions. If an individual perceives the outcome to be valuable to them they might experience intense positive emotions with the achievement of that goal. These concepts were further expanded with help of achievement emotions [30] and control-valence theories [31].

Achievement emotions theory further helped in understanding the role of emotions in goal-related situations. The theory is based upon the control-value theory of achievement emotions developed by Pekrun [31]. The theory focuses on providing a framework for assessing achievement emotions and expanding the role of emotions in goal pursuit. The theory utilises previous work done within the domain of psychology and goal-directed emotions [25] to expand the understanding of emotions concerning achievement settings.

The theory proposes a three-dimensional taxonomy of achievement emotions consisting of object focus, valence, and activation. The focus of the emotions could be directed towards the activity or outcome. Within valence, emotions are classified as positive or negative, such as pleasant enjoyment versus unpleasant anxiety. In terms of activation, physiologically activating emotions are distinguished from deactivating emotions such as activating excitement versus deactivating relaxation. By using the dimensions valence and activation, the taxonomy is consistent with circumplex models that arrange affective states (emotions) in a two-dimensional (valence × activation) space. The taxonomy classifying emotions can be seen in Figure 3.

Object Focus	Positive[a]		Negative[b]	
	Activating	Deactivating	Activating	Deactivating
Activity	Enjoyment	Relaxation	Anger Frustration	Boredom
Outcome/ Prospective	Hope Joy[c]	Relief[c]	Anxiety	Hopelessness
Outcome/ Retrospective	Joy Pride Gratitude	Contentment Relief	Shame Anger	Sadness Disappointment

[a]Positive = pleasant emotion.
[b]Negative = unpleasant emotion.
[c]Anticipatory joy/relief.

Figure 3. Three-dimensional taxonomy of achievement emotions. [31]

In the control-value theory of achievement emotions, the theory posits that achievement emotions are induced when the individual feels in control or out of control for activities and outcomes that are subjectively important [31]. Implying that appraisals of control and value have a direct correlation between control and value and these emotions. Control appraisals pertain to the perceived controllability of achievement-related outcomes whereas value appraisals relate to the subjective importance of these activities and outcomes. Importantly, the control-value theory does not imply that achievement emotions are always mediated by

conscious appraisals. Rather, it is expected that recurrent appraisal-based induction of emotions can become automatic and non-reflective over time. When the achievement activities are repeated over and over again, appraisals and the induction of emotions can become routine to the extent that there is no longer a conscious mediation of emotions or no longer any cognitive mediation at all [33].

The achievement emotions theory utilising the control-valence principles provides evidence that emotions are an integral part of goal-related achievement settings. The theories show the importance of the subjective nature of evaluation related to activity/outcome and goal, being influential in determining the emotional impact experienced. These theories had been influential in the educational domain to help with performance and health, and the well-being of individuals [32]. However, Outside the context of the educational and professional sports domain, there has been very little research done to explore the role of emotions in applications focusing on PA. Using Emotions as predictors of PA had remained dormant for a long time, Darko et. al. [26] investigated 20 experimental studies from 2002 to 2017, which shows a research gap using the theoretical frameworks available to use in cases when encountering goal failure to create experiences that support users in their emotional experiences and provide motivation to achieve the set goal.

The papers discussed in this chapter show that emotions related to goal achievement and goal failure can impact an individual's behaviour and motivation in pursuing their goals. According to the emotion goal model, anticipatory emotions experienced before the outcome of a goal is received can influence volitional and instrumental behaviours towards goal pursuit. The intensity of these emotions can vary based on the individual's expectations and the perceived value of the goal. The control-value theory of achievement emotions states that the intensity of achievement emotions is influenced by the individual's perceived control over the outcome and the value or importance of the goal to the individual. Positive emotions, such as pride and joy, are typically experienced when an individual achieves a valued, controlled goal. On the other hand, negative emotions, such as shame and disappointment, are typically experienced when an individual fails to achieve a valued, controlled goal. The emotions experienced can vary among individuals and be influenced by factors such as personality traits, cultural norms, and subjective appraisals. Understanding the role of emotions in goal pursuit can help individuals improve their motivation and performance.

2.2 | Negative Affective States and Goal Failure

The current literature shows goal failure is closely associated with negative affective states[34], Within negative affective states there can be different emotions experienced and each emotion can be experienced with different intensity according to the factors discussed in the previous Chapter 2.1. Within this chapter discussion related to the emotions and their relation with the goal is explored.

While creating a goal, goal-setting theory encourages individuals to set challenging goals. Some individuals could create unrealistic expectations for their goals which could lead to negative goal commitment [35]. Regret and disappointment are the two emotions that are closely linked to decision-making [36] these two emotions can be understood as emotions manifesting due to the expectation of a goal and the perception of self-efficacy that an individual has. The behaviour of creating or setting expectations around the goal can be explored further with fantasy realisation theory [37]. The theory suggests creating favourable expectations will help in goal commitment towards a goal. if a goal is set without considering present obstacles and the individual's ability, this could result in an unrealistic expectation. These unrealistic expectations will create a discrepancy between reality and expectations big enough that can discourage the individual from the goal [38].

Further research expands upon this theory to include methods to help link the concrete goals to the important higher-order goal [39]. In the study, simple 'if-then' plans were created with goals and observed the goal commitment changes among the participants. 'If-then' plans help link the instrumental goal-directed behaviour (then component) with the anticipated situational cues (if component) to help automate the goal-striving process thus facilitating getting started on one's goals and shielding them from disruptions. After conducting two studies, they concluded that implementation intention formation can be used to promote the realisation of desired outcomes not only by facilitating getting started with goal striving but also by preventing goal striving from straying off course. This method helps to create an understanding for the user of obstacles present in their reality and make plans for that situation. This behaviour will help with goal commitment and remove the uncertainty in some expectations which could result in less negative emotions when encountering a goal failure [25].

One of the emotions that can be influenced by the discrepancy in expectation of a goal is Disappointment [36], Disappointment is experienced when one finds out that something one had hoped for has not happened [40]. Disappointment is assumed to depend on the perceived match between expectations and the actual outcome; Disappointment is aroused when anticipated success does not occur [32]. As disappointment is tied to the success or failure of an event it is classified as an outcome-related emotion within the control-value theory [31]. Furthermore, the control-value theory proposes that these outcome-related emotions also

depend on the subjective importance of achievement outcomes, implying that they are joint functions of perceived control and value. If an individual perceives the value of an outcome to be higher and perceives their ability to perform the task to be lower (Low-controllability). It will create a scenario where if the individual fails to reach the desired outcome they will experience outcome-related emotions more intensely than in a case where the individual's perceived controllability is higher and the perceived value of the outcome is lower. Similar to disappointment, regret relates to the feeling when one thinks that something one did not want to happen could have been prevented if one had acted differently [40].

Regret in most cases relates to one's ability and decision-making ability. The perception of the ability of the self to perform a task is called self-efficacy [41]. Guilt as an emotion shares some similarities with regret, where both emotions are experienced as reactions to the bad consequences of something due to actions performed (or not) by the individual [40]. Regret is associated with individuals' self-efficacy whereas guilt is most often associated with moral considerations that are not present in regret [42]. In the experience of guilt, an individual thinks more about the harm that they have done to others or themself (the consequence), whereas regret focuses more on the decision or action that leads to the bad outcome.

Frustration can be experienced when one wants to achieve something but finds one's action blocked. Nevertheless, one keeps trying [40]. Frustration can be associated with this feeling of trying and not achieving the desired outcome. According to the control-value theory, frustration is classified as an activity emotion, where frustration is aroused when the intrinsic value of the activity is considered negative whereas boredom is experienced in case of activity lacking any intrinsic value.

Within positive emotions, an interesting study observation shows hope can be associated with PA and help in building the self-efficacy of participants. Hope is defined as anticipatory emotion where the intensity of the emotion experienced depends on the ability of the self to achieve the desired outcome [43].

Exploration of goal-related emotions shows their emotions should be studied and considered while designing experiences related to goals. The concept of self-efficacy shows an important link between affective states and emotions experienced when encountering goal failure.

2.3 | Lack of focus on goal failure

The discussion within this chapter highlights the lack of research performed on emotions related to PA outside of the professional sports and education context. The subject is rarely explored within the current implementation of PA applications. The chapter will provide evidence of how emotions can be an important factor in the design of the goal-related application.

A study performed to understand the rumination effects of different representation methods recommended not bringing attention to the failed states and focusing on goal achievement [17]. Similar reasoning has been provided within other PA-related applications to utilise the positive reinforcement theory [44]. The theory suggests focusing on positive achievement and rewarding individuals for the achievement of the goal. The focus on positive emotions has been further supported by other studies exploring the effect of feedback related to the non-achievement of goals. Negative feedback related to goals can potentially undermine people's confidence in their ability to pursue their goals and their expectation of success [45]. Aarts et al [46] found that humans may cease their goal pursuit when their goals are regularly followed by the cues or events evoking negative affect, such as highlighting the failure in achieving their goal [47]. How individuals respond to negative as well as positive feedback can be different depending upon the context of the goal and how it's been communicated to them.

Positive feedback on successful actions can encourage the pursuit of goal-congruent actions when it signals an increase in commitment to the goal but a decrease in motivation when it signals sufficient progress was made [21]. Negative feedback on unsuccessful actions can encourage the pursuit of goal-congruent actions if it signals insufficient progress has been made but decrease motivation when it signals a decrease in commitment to the goal. Building on these findings Ayelet et al [21] propose that people often start by evaluating commitment and then shift to monitoring progress as they gain experience or expertise in a goal domain. Individuals make this shift because novices feel uncertain about their level of commitment, whereas experts are already committed and wish to monitor efforts in response to negative feedback on their lack of success. Feedback provided regarding the goal progress can contribute towards the self-efficacy of an individual.

The self-efficacy of an individual can be defined as an individual's perception of their ability to perform a certain task[48]. A person's self-efficacy is a strong determinant of their effort, persistence, and strategizing, affective states, as well as their subsequent training and performance. Besides being highly predictive, self-efficacy can also be developed to harness its performance-enhancing benefits [48]. The current implementation of PA representation refrains from showing the failure of an individual to avoid negative affective states [17], [18]. There is a lack of studies investigating the effects of negative emotions and how they can be utilised in supporting individuals in their goal progression. According to the achievement emotions [32], Activating negative emotions like frustration can lead to positive effects as seen in a study performed to analyse the use of negative affective states in re-evaluating goals [49]. A study was performed in an educational domain, and results from the study showed that participants felt negative activating emotions like anger and frustration after failing to reach a goal. These emotions motivated participants to perform better for the next goal and in some cases re-evaluate goals to make them manageable. The study suggests negative affective

emotions can help participants to self-evaluate the goal and create a better action plan to achieve the goal in the next attempt. Other studies performed within PA, also provide evidence that some participants would like to see their failure represented even if they experience some negative affective states [17], [18]. Participants mentioned seeing the failure represented in some cases motivated them to perform PA. Exploration of emotions related to goal failure within the PA domain should help individuals with the motivation to reach goals. Instead of avoiding negative affective states, embracing them into the design process will lead to experiences beneficial towards individuals' goal progress.

2.4 | Exploration of PA representation.

The domain of PA, representing physical activity has been dominated by two forms of representation methods, Numbers and graphs [13]. Showing feedback related to PA activity and goal progress in the form of numbers and graphs is a very efficient method, which can relay the information directly to the individual. The limitations of quantitative data visualisations such as numbers and graphs are that they lack contextual information about physical activity. The contextual information about their progress or hints towards points of improvement can help individuals build self-efficacy to better support their goal pursuit. Jones et al. [14] conducted a study in which they explored possible reflection and rumination triggered by five different visualisation methods on unmet fitness tracker goals. Four visualisations include 2 bar charts (mono and multi-colour) and 2 radial bar charts (mono and multi-colour) with one textual representation(numbers). Their findings suggest multi-colour visualisation resulted in more association with negative affective states and rumination compared to mono-colour representation. Qualitative data analysed within the study mentioned some of the participants preferred the multi-coloured representation even if it induced negative affective states. The study suggests current fitness trackers should present alternative goal visualisation options to individuals so that they can choose an interface attuning to their goal orientation. Researchers concluded the study by urging future studies to experiment with a different form of visualisation to represent PA.

One alternative method for representing physical activity has been explored in several previous studies. Niess et al. [50] conducted a study, where they explored the effect of different communication styles and construal levels on persuasive feedback used in fitness applications. The level of abstraction of data can be measured by construal levels [50]. The construal level describes how concretely or abstractly something is represented in a person's mind. e.g. walking 1000 steps each day (concrete) versus becoming a fitter person (abstract). The study focused on textual feedback that was altered to show feedback at low and high construal levels. They tested these levels with goal attainment and goal failure conditions also. The results from the study suggest that presenting the feedback in the abstract form leads to a significant positive change towards goal commitment regardless of goal attainment condition. Researchers suggest that abstract representation helped participants in making connections

between higher and lower-level goals. Higher-level goals refer to the primary motivation behind setting any goal, in this case taking 10,000 steps each day is considered a lower-level goal as it just describes the activity whereas losing weight is a higher-level goal that can be a motivation for setting the lower-level goal. The researchers recommended using high construal representation in the case of goal failure as it helped participants with goal commitment even though it might induce some negative affective states.

Expanding further with research done within abstract visualisation for PA included attempts at creating engaging experiences with the help of visual representations and storytelling. One example of abstract representation is 'WhoisZuki' developed by Murnane et.al [18] demonstrating the use of narrative-based interfaces to help in reflection and motivate physical activity. In the study, a story was developed and divided into several chapters. Participants' physical activity was tracked and represented with abstract elements relevant to the chapter within the story. In one of the chapters, each activity performed was represented as flags on the top of the screen as seen in Figure 4. Flag sizes were determined by the duration of the activity. The weekly goal progression of participants will reveal more of the story, every 20% progression towards the weekly goal reveals the next bit of the story until the participant reaches their weekly goal and finishes the chapter. Upon completion of the goal, participants were rewarded with an animation of confetti or balloons being shown on the screen.

If the participants failed to reach the weekly goal, the chapter was reset and they had to reach the goal again to progress in the story. The results from the 3-week-long study showed interesting observations, The use of a storyline created an engaging experience for the participants. Participants mentioned making connections with visualisations to help motivate them for PA.

20% - Zuki has barely made it a couple feet up the mountain before Gryff angrily makes his way to the base.

40% - Zuki climbs faster. The sounds of his pursuer follow.

60% - Zuki starts to get tired, but he doesn't dare stop climbing.

80% - Zuki can see the top of the mountain – he's almost there.

100% - Finally Zuki makes it to the top of the mountain, still hearing Gryff's shouts behind him. "Onwards," he decides.

Figure 4. A weekly storyline, illustrating the incremental progress of the main character, Zuki, towards his goal for that chapter (here, climbing to escape his antagonist), which parallels the user's progress. The glanceable display uses visual elements to give feedback about tracked activities (e.g. birds – top of the screen) and progress towards weekly goals (e.g. carabiners – bottom right), accentuated with celebratory overlay (e.g., balloons) at 100%.[18].

Another direction explored within abstract representation for personal informatics is the use of tangible objects to represent physical activity. Two studies done within this domain provided interesting insights. In a study designed by Shalawadi et. al. [51], The study used pneumatic inflatable membranes to produce haptics and visual effects for users to experience their PA mapped on an inflatable balloon. Results from the study show participants could interpret their activity level with the inflation level of the object. These objects brought the aspect of sharing personal informatics with others where participants eagerly wanted to share their objects and compare the activity. Another study conducted by Khot et.al. [52] utilised 3D printers to create tangible objects representing participants' physical activity. These objects were designed in a manner that they can be displayed and shared with others as a representation of their personal informatics in an abstract format. Karya et.al [53] further expanded upon this study to explore the behaviour of gifting the objects created from personal informatics with others. The study demonstrated that the objects (gifts) metaphorically represent the personal data of the receiver where an effort is made to match the gift with the person.

The discussion within this chapter presents some of the innovative ways to represent PA to help self-reflection and motive to perform PA. Abstract representation helps to reduce the reliance on numbers and graphs in personal informatics while creating an engaging experience which could provide more contextual information about the PA.

2.5 | Conclusion

The discussion within the chapter highlights a gap in research investigating the role of emotions. in PA-related applications. Theories like Achievement emotions and goal-directed emotions show the importance of emotions within the goal-related setting. The SQ1 and SQ2 are partially explored within Chapters 2.1 to 2.3, highlighting the effects of negative emotions for PA and outlining some of the emotions that could be experienced in the case of goal failure. The current implementation of PA-related applications avoids representing goal failure. This presents an opportunity to explore negative emotions through the theories discussed in Chapter 2.1 and to design a representation of PA that can alleviate negative emotions associated with goal failure.

Based on the discussion within this chapter a set of guidelines were proposed. The guidelines show how the representation of PA in cases of goal failure be designed. The guidelines are presented in Table 1, The table displays three major categories: Emotions, Acknowledgement of Efforts, and Representation. The three categories highlight factors to consider when designing the representation for PA in case of goal failure. The guidelines provided prioritisation based on the literature discussed in this chapter. The prioritisation is coded using

the Moscow method of prioritisation [54]. Must represent the highest priority for consideration in the design, where Should represents that the addition of the guideline can bring value to the representation, but it is not crucial for the design.

Table 1. Guidelines for designing physical activity representation in case of goal failure.

ID	Guidelines		Priority
1	**Affective states**	Alleviate negative deactivating emotions.	Must
2		Help inspire positive activating emotions.	Should
3		Use of negative activating emotions as motivating factors.	
4	**Acknowledgement of efforts**	Provides recognition for the efforts taken on the goal journey	Must
5		Indicate the lack of progress made towards the goal	
6	**Representation**	Utilisation of alternate data representation of PA activity.	Must
7		PA data easily interpreted to understand the activity performed	
8		Provide contextual information about the data represented	Should

The guidelines related to affective states were inspired by previous research discussed in Chapters 2.2 and 2.3. The guidelines show the focus on reducing negative deactivating emotions. Helping in alleviating those emotions can lead to a better perception of self-ability and motivation to perform PA for an individual. Some positive emotions like hope can be inspired in case of goal failure to help in supporting individuals on their goal journey [43]. A lower priority is given to inspiring positive emotions, as the focus should be on alleviating negative emotions. Some negative activating emotions can be used to motivate individuals [49], But the emotions being classified as negative were offered less priority.

Discussion from Chapter 2.3 highlights the need to acknowledge the efforts performed by an individual towards a goal. If the efforts are not acknowledged in case of goal failure, the individual may experience a loss of motivation towards PA which may result in negative affective states [21]. The discussion from Chapter 2.3 provides two guidelines (4 and 5) which focus on recognising the efforts taken towards the goal and indicating the lack of progress made towards the goal. Both guidelines should be considered a high priority as they convey to individuals the need for improvement to reach the goal.

The representation category presents three guidelines. Guidelines 6 and 7 are considered must from the discussion in Chapter 2.4. The background review shows the need to move away from the conventional number and graph methods for the representation of PA and promote the use of alternate methods of representation. The use of alternative methods has shown to be more effective in motivating individuals while providing contextual information related to PA performance. Guideline 8 is a lower priority as there could be ways to provide contextual information outside of the representation method and should not be limited to it.

The presented guidelines were used in future chapters and expanded to design requirements for designing a representation method helping in alleviating negative emotions in case of goal failure in PA.

3. Study 1: Understanding Goal Failure Emotions

The discussion within Chapter 2 provides an indication of the emotions that may be experienced in the event of goal failure. No studies have investigated which emotions are prominent in the case of goal failure related to PA. The achievement emotions theory provides valuable insight into emotions related to goals, but it has rarely been applied outside of the domains of education and sports-related research. The lack of research done within non-sports-related PA gives space to bridge the research gap. To investigate SQ1 and SQ2, as proposed in Chapter 1.2, a survey-based study was designed to collect data on emotions and goal failure. SQ1 was used as a research question for this study.

Which emotions are prominent when goal failure occurs related to physical activity?

To understand which emotions are dominant when a goal failure occurs, 14 emotions were selected to investigate. The emotions selected were taken from achievement emotions theory [55] and goal-directed emotions [25]. The theory of achievement emotions mentions several negative affective states, including disappointment, frustration, anger, sadness, anxiety, shame, and boredom. In addition, the theory of goal-directed emotions lists affective states that can be associated with goal failure, such as regret, guilt, and worry. Combining the findings from both studies 10 negative affective states were selected represented in Table 2. A smaller selection of positive emotions was selected for investigation within the study. Including positive emotions in the study can help establish a foundation for understanding their relationship with negative emotions. There can be some cases where positive emotions like hope can be experienced in case of goal failure. The selected positive emotions including Hope, Pride, Regret, and Relaxation were present in achievement emotions.

To investigate which of these emotions are prominent in the case of goal failure related to PA, a study was designed. The study consisted of an online survey inquiring participants to associate their emotions with their past PA-related goal failure experience. An online survey provided an opportunity to reach a broader audience worldwide. The study design and results from the study are discussed in the following chapters.

Table 2. Affective states selected for study 1.

The valence of emotions		Emotions
Negative affective states	Deactivating	Disappointment
		Regret
		Guilt
		Sadness
		Worry
		Boredom
	Activating	Anger
		Anxiety
		Shame
		Frustration
Positive affective states	Deactivating	Relaxation
		Relief
	Activating	Hope
		Pride

3.1 | Study design

3.1.a | Participant Selection

Inclusion criteria
- Participants were required to be at least 18 years old.
- The participants who had used a PA tracking application (ex. Fitbit Samsung fit)

Exclusion criteria
- Participants who can not read or write in the English language.
- Participants who failed to achieve a PA-related goal in the last 30 days.

Participants who hadn't experienced a goal failure in a significant amount of time could have different perceptions of those events which could lead to false reporting of emotions and events. Due to this reason a limit of 30 days was chosen as inclusion criteria. To remove the possibility of participants who had not experienced any event of non-achievement of goals related to PA, a filtering question was used. The question asked participants if they had failed a PA-related goal in the last 30 days.

Participants

A total of 67 participants' responses were recorded within the study. The participants were recruited through online forums and chat groups. Within online forums, communities related to fitness trackers were targeted. The 67 participants were filtered through the inclusion and exclusion criteria mentioned above. After filtering the participants with the criteria 27 responses were collected and analysed further within the study.

3.1.b | Study procedure

The survey was designed and distributed to participants on an online platform. The survey was structured in three steps. In the first step, the survey provided all the necessary details related to the study and included a consent form to take part in the study. Participants were directed towards step 2 only if they agreed to the terms presented in the consent form.
Step 2 included the filtering question mentioned in the inclusion and exclusion criteria. If a participant failed to satisfy the criteria, they were directed to the end of the survey.
Step 3 was presented to the participants who satisfied the criteria mentioned in step 2. In this step, participants were required to complete a questionnaire, which comprised a Likert scale for 14 emotions and two open-ended questions. The first open-ended question asked participants to fill in any other they had experienced besides the 14 mentioned in the Likert scale. An additional open-ended text field was provided where participants were asked to give the reason for their failure to reach the goal. These questions could help in giving context to the emotions experienced when goal failure occurred. The full survey can be found in appendix (A). The study procedure was verified by the ethics committee present at the University of Twente with reference number: 2022-132.

Participants were given the flexibility to complete the survey at their convenience and the survey was distributed through an online forum link. The survey was kept online for 2 weeks after 14 days survey entries were closed and collected data were used to analyse further.

3.1.c | Data collection

The online survey consisted of a Likert scale representing all 14 emotions as shown in Table 2. participants were asked to associate their emotions with their recent experience of failing to achieve PA-related goals. Collected responses were rated on a scale of 1-5 where 1 represented strongly disagree and 5 represented strongly agree. The two open-ended text fields were collected within simple text form.

3.2 | Data analysis

The data collected from the Likert scale was analysed with mean and standard deviation regarding an emotion. The mean and standard deviation for all the recorded emotions is shown in Table 3. The data represented in Table 3 is sorted showing the highest mean value at the top and the lowest mean value at the bottom for the emotions.

Table 3. Mean and SD association with goal failure. Emotion entries are sorted with the mean values

The valence of emotions	Emotions	Mean	SD
Negative affective states	Disappointment	3.65	1.13
	Frustration	3.46	1.07
	Regret	3.42	1.03
	Guilt	3.35	1.02
	Sadness	3.08	1.06
	Worry	3.08	1.38
	Boredom	3.04	0.96
	Anger	2.69	1.05
	Anxiety	2.69	1.23
	Shame	2.58	1.27
Positive affective states	Hope	2.54	1.07
	Relief	2.15	1.12
	Relaxation	2.12	1.03
	Pride	2.00	0.98

*(Emotion entries are sorted with the mean values and Mean value range from 1-5 where
1 represents least association and 5 represent high association with emotion.)*

The participant's reasons for not achieving the goal were also recorded, records were analysed and converted into themes related to barriers for categorization purposes. The barriers used for categorization were taken from a previous study analysing the barriers present for PA [56]. The reasons for failure were categorised into 5 barriers including health/medical-related issues (H) and procrastination(P), lack of time (LT), lack of motivation (LM), and lack of interest (LI). The barrier lack of time (LT) was further subdivided into LT1 and LT2. LT1 represented reasons where the failure of the goal is due to lack of time but no further action was taken. LT2 was assigned for the reasons that mention an intent or action performed to make up for the failure of the goal. The categorised results are shown in Table 4. For example, the reason provided by Participant 31 (P31) mentions that they had been busy which was categorised as LT1. P73's reason is categorised as LT2 since they mention they do more PA on their active day to cover for the failed goal on the non-active day. Each response was analysed to extract keywords manually to categorise it with barriers, Some responses were associated with more than one barrier. A list of reasons and barriers categorised is presented in Table 4.

Further analysis was performed with the responses to the goal failure. The direction of reasoning provided is analysed where If the recorded reasons were directed toward an external entity (work, weather) for failure then it was categorised as external. The internal directed reason is where the participant directs the reason to an internal entity (motivation, procrastination). The analysis can hint towards the perception of a self and how an individual processes the goal failure. Previous research indicates when encountering goal failure individuals tend to point toward external reasons more often than internal reasons [21]. An example of an internally directed reason for goal failure is Participant 18's response *"Working remotely, too many video calls."* where the reason for failure was associated with the working environment and other external factors that prevented them from performing PA. On the other hand, the P37 response was categorised as *"Failing to check my watch often. Most of the time I'm very quick. Not achieving the goal of the training"* internal directed reason for not achieving the goal. P13 mentioned they set a PA goal related to keeping a constant running pace but they failed to achieve it because they failed to check their watch and keep track of the pace to achieve the goal. The internal and external reasons for goal failure were analysed with a mean and *SD* method against all the emotions, This analysis can be seen in .

Table 4. Categorization of the responses into barriers and direction of reasoning (DOR)

ID	Reason	Barrier	DOR
11	Leg injury	H	External
13	Lacklustre and other priorities came in the way.	LT1, LM	External
14	I was just working (sitting on a chair) all day, so the steps the device gathered are the ones I'm actually moving to get a cup of coffee or go to the kitchen. And for the past few days, this has been my schedule, so I couldn't really get time to exercise.	LT1	External
16	It's a goal I've set, but I don't actively chase this goal. I just go about my business and some days I'm busy and can easily achieve this goal. I can't always carry my phone around to record my steps so for most days I don't know how much I've walked (I probably do hit the 10K goal though on those days). On the weekends I tend to stay at home, so I don't hit my goal because I sit or lay down most of the day.	LI	External
17	Sitting for study for a long time	LT1	External
18	Working remotely, too many video calls.	LT1	External
19	It was very rigid and after initial recommendations, there were not a lot of variabilities to account for off days, busy days, etc. I also have a hard time sticking to these types of apps with a lack of personalised recommendations and limited relevant engagement. The recommendations feel every size fits all.	LT2	External
20	I'm in university and often get busy with projects & my capstone	LT1	External
21	I was feeling ill, so managed to only work out 4 days that week	H	External
30	It was a predefined goal that I did not care about much. I found the stats entertaining	LI	External
31	I'm too busy	LT1	External
32	Vacation and sports injury.	LT1, H	External
34	I work a desk job and simply don't have time to walk as much as needed to hit this goal. Even on days when I go walking for exercise I only hit around 136k steps in total. I can only walk as an exercise for about 131.1 miles before my knees start to hurt so simply making my exercise longer won't work.	LT1, H	External
36	Too busy with work	LT1	External
37	Failing to check my watch often. Most of the time I'm too quick. Not achieving the goal of the training	LI	Internal
38	I have no motivation	LM	Internal
41	Didn't particularly notice it/mind it. These are goals set by the fitness application, not by myself. I Just find Joy in the moments where I do meet goals and am made aware of them	LT2, LI	Internal
42	It was due to procrastination, and lack of self-motivation.	P, LM	Internal
61	Inconsistent diets and exercise. Too many snacks	LM	Internal
62	Decided to drink alcohol instead	P	Internal
64	Lack of motivation and awareness. I don't even know what the challenges are most of the time.they failed to follow through bc of ADHD.	LM	Internal
67	I was procrastinating the whole time	P	Internal
70	I exercised in the mornings, and was too hungry to do it.	LM	Internal
73	I get enough exercise on other days of the week and my goals (for calories burnt and exercising minutes) are higher than what I would burn on a non-exercising day. So on days when I'm resting, I ignore the push to achieve these goals since I know it's not important to reach them	LT2	Internal
74	Did not leave the house a lot, so ended up walking less	Undefined	Undefined
76	not working out on a couple of days, not walking/biking enough	undefined	Undefined

(lack of time (LT), lack of motivation(LM), lack of interest(LI). health/medical-related issues (H) and procrastination(P))

3.3 | Results

From the mean and standard deviation analysis represented in Table 3, The four most associated emotions were Disappointment, Frustration, Regret, and Guilt. The four least associated emotions were Hope, Relief, Relaxation, and Pride. Disappointment showed the highest mean value among all emotions with higher variation when compared with Frustration and Regret.

The most common reason for the failure of data collected is Lack of time. This barrier was present in 12 entries recorded in the survey. Other barriers to the achievement of the goal were recorded in fewer numbers where lack of motivation was the reason for 4 entries and a similar result for the health/medical-related barriers. Lack of interest and motivation was related to 3 entries present in the study. From the reason for failure given, another sub-categorization was made. Participants' reasons for failure were directed to internal or external entities. The subcategorization is done in an attempt to provide more information about where the direction of reasoning provided by participants, as a previous study performed by Fischbach [21] shows individuals can show a tendency to attribute the mood related to the failure of goal towards external entities more than internal.

Table 5. Mean and SD analysis was performed with internal and external directed reasons

Emotion/ Barrier	External (14)		Internal (10)	
	Mean	SD	Mean	SD
Anger	2.86	1.18	2.50	1.03
Anxiety	2.64	1.48	2.80	1.15
Disappointment	3.71	0.97	3.50	1.33
Frustration	3.43	1.35	3.40	0.94
Guilt	3.21	0.97	3.50	1.12
Regret	3.29	1.17	3.60	0.99
Sadness	3.00	0.99	3.10	1.18
Shame	2.43	1.45	2.90	1.16
Worry	3.07	1.62	3.20	1.33
Boredom	3.07	0.94	3.00	1.07
Hope	2.36	1.07	2.60	1.08
Pride	2.14	0.97	1.60	0.95
Relaxation	2.29	0.88	1.90	1.14
Relief	2.36	0.88	1.90	1.28

(scale of 1-5 where 1 represent low association with emotion and 5 represents high association with emotions)

The responses collected in Table 4 were categorised into 14 reasons classified as external and 10 reasons classified as internal. Two entries were recorded with an ambiguous reason for categorization so they were omitted from this analysis. The mean and standard deviation analysis performed is presented in Table 5. When the reason for the goal failure is directed towards an external entity there is a higher association with disappointment when compared with internally directed reasons. Guilt and sadness show more agreeable data for less association towards the emotion in the case of externally directed than internally directed reasons. Regret shows higher mean values when reasons can be classified as internally directed with $M = 3.60$ and $SD = 0.99$ for agreeability, compared to externally directed showing a mean of $M = 3.29$ and $SD = 1.17$. Pride showed lower association when the reason was internally directed. From the positive emotions, hope does show more association when the reason for goal failure is directed internally. The positive emotions show less association when goal failure occurs. An observation can be made for positive emotions where besides hope the remaining emotions show a weaker association with positive emotions when reason is internally directed.

Analysis of all responses from Table 4, showed lack of time as a prominent barrier to physical activity. This result is seen in previous studies also where individuals who are not suffering from any health-related condition and fail to achieve the goal are attributed to a lack of time [57]. Although it is the most common barrier to physical activity, there were instances of responses mentioned that due to lack of time some days they fail to achieve the goal but they would make an attempt to perform more PA during their free days to compensate for the previous failure. As P73 elaborated *"I get enough exercise on other days of the week and my goals (for calories burnt and exercising minutes) are higher than what I would burn on a non-exercising day. So on days when I'm resting, I ignore the push to achieve these goals since I know it's not important to reach them".* There were 4 instances of an event like this observed.

3.4 | Discussion

The results remain consistent with some previous studies conducted in this domain where goal failure is related to negative affective states [15]. The results show that Disappointment, Frustration, Guilt, and Regret are the most common emotions felt in case of goal failure. Further discussion focuses on analysing the four most associated emotions (Disappointment, Frustration, Regret and Guilt) from this study.

Disappointment arises from the discrepancies present between the perception of anticipated success and the failure of the goal. This emotion has been associated with goal failure when the reason for failure is classified more toward external entities. Considering disappointment as the most associated emotion from the survey conducted within this study points towards creating an experience for goal setting that will help individuals manage their expectations to

set meaningful goals. In the current implementation of the PA application, very little focus is given to creating a link between concrete and higher-level goals [58], which could help promote better practices for expectations related to goals. One of the notable contributions made in this direction is the goal evolution model [13] which proposes hedonic & eudaemonic needs of individuals should be translated into qualitative goals.The model presents some potential ways to incorporate theories present in the study in the interventions for goal-setting.

Frustration was the second-most associated emotion within the survey, Frustration is experienced when the perceived intrinsic value of an activity is negative for an individual [32]. The analysis from the direction of the reason for failure showed that there is a higher mean for frustration present for reasons directed inwardly. Although being classified as a negative emotion it is also categorised as an activating emotion. These emotions are poised to influence the following mechanism underlying performance; (i) the availability of cognitive resources enabling individuals to focus attention on achievement tasks; (ii) interest and motivation to perform these tasks; and (iii) the use of cognitive and metacognitive strategies for solving task problems, including the self-regulation of achievement behaviour [31]. A study was done to understand the effect of achievement emotions in relation to goal revision within a digital learning environment [49]. Results from the study indicated that achievement emotions can be a mediating link to goal revision. Researchers observed the behaviour of down-regulating the goal set by participants if they failed to achieve their goal. The goal revision helped participants to build self-efficacy through the practice of down-regulating. The study suggested negative emotions like anger and frustration after failing to reach the goal encouraged a compensatory mechanism for a need to improve.

Regret and guilt were the third and fourth most associated emotions from the survey showing inner conflict with the goal. Both of the emotions showed higher mean value for reasons related to internally directed reasons. Time-related reasons for goal failure can be associated with guilt and regret [25]. The majority of reasons tagged with time indicate participants' desire to exercise but some external entities took priority over PA which could lead to feelings of guilt and regret. Both guilt and regret are a reaction to the bad consequences of something an individual did earlier, and both involve desires to undo this thing. In most cases, the case of guilt can be attributed to harm an individual has done to others but with regret, the focus is more on the decision or action that led to the bad outcome.

Some interesting observations were found from the categorization of responses into themes, Participants failing goals due to health-related reasons were associated with disappointment, sadness, and worry. Reasons were tagged as health-medical reasons where Individuals may have fallen ill or injuries that inhabit them from taking part in PA activities. Sadness and worry could be due to health conditions and the inability to perform PA on the previous level. This

reasoning could also be a disappointment where participants would like to perform PA and achieve their goal but have no ability to reach the desired goal. Participants who were lacking motivation for performing PA were associated with regret and disappointment. An interesting pattern was observed in reasons related to procrastination and lack of interest. Participants who procrastinated showed a range of negative affective states besides anger. In case of lack of interest, there is a dissociation with a range of negative affective states besides disappointment. Participants who lacked interest in goal or PA activity showed not much change in affective state when goal failure occurred as the most associated emotion was boredom. These conclusions could be studied carefully in further studies as there were only 3 tags that were counted for procrastination and lack of interest.

The least associated emotions were the positive affective states of pride, relaxation, relief, and hope. From these emotions, hope could have been misinterpreted by some participants who might have interpreted it as a loss of hope. Pride is the least associated emotion with the lowest mean and high aggregability among the participants. An interesting observation from the data shows that participants did not associate shame with failure to achieve a goal. One possible reason could be the use of a personal tracking device offers privacy and the lack of a social presence on the goal progress alleviate a feeling of shame when failure of a goal occurs [59].

3.5 | Conclusion

The results from the study showed evidence consistent with past studies, where Negative affective states were present in the event of goal failure. The 4 most associated emotions were Disappointment, Frustration, Regret, and Guilt. Among these emotions Disappointment is considered a deactivating emotion according to the theory of achievement emotions "with the management of expectations for the goal and self-ability can be identified as key to reducing the intense feelings of disappointment experienced [32]. Frustration is an activity-related emotion where the intrinsic value of the activity is preserved as negative from an individual. Although frustration is categorised as a negative emotion it is an activity emotion which can increase motivation and interest in the activity if the need for improvement is recognised by the individual. This finding answers the RQ1 and RQ2 posed in Chapter 1.2.

Additional insights gained from the study indicated that lack of time is identified as a primary barrier for PA showing consistent results with the previous studies done within the domain. Analysis of other barriers showed some interesting results but the sample sizes for those responses prevents us from making any concrete conclusions on those findings. The most commonly associated emotions and their potential impact on the goal progress were considered the focus of the ideation session in the next chapter.

4. Designing for Goal failure

The results from study 1 showed frustration and disappointment are the two most associated with PA-related goal failure. The lack of research conducted from the perspective of goal failure in the PA application space highlights an opportunity. Expanding upon the finding further and utilising it to help alleviate the negative emotions associated with goal failure. Previous studies utilise creative methods to represent PA with the use of abstract representation through storytelling [18] or creating tangible objects that can be interacted with [52] [51]. Inspiration was taken from the previous studies done to ideate representation methods for PA. This chapter will outline design requirements for designing a representation. The requirements were used in evaluating the ideas generated and the chapter outlines the prototyping details for the final concept.

4.1 | Ideation phase

The ideation phase outlines the method used for ideation and the procedure carried out to select an idea for the conceptualisation stage.

4.1.a | Design requirements

A set of design guidelines were presented in Chapter 2.5. The guidelines presented provided a base structure to expand and create a list of requirements based on the findings in Chapter 2 and Chapter 3. A list of functional requirements was formed which is presented in Table 6, The requirements were used in the ideation phase to generate and evaluate the ideas. The requirements were categorised into three sections called "Representation method", "Representation" and "Goal failure". Each category presents a set of functional requirements (FRs) for designing a representation method in case of goal failure. The FRs were derived from the literature analysed in Chapter 2 and the discussion presented in Chapter 3.

Each FR has been marked with priority order for consideration while designing the representation method for PA in case of goal failure. Two priority types were used where "*must*" represents vital requirements for the representation and "*should*" represents requirements which can help add value to the representation method but are not vital. A points system was used to help evaluate the ideas. Requirements with "*must*" priority were offered 2 points and requirements with "*should*" priority were offered 1 point.

Table 6. Functional design requirements for the ideation phase.

ID	Functional Requirements		Priority	Points
1	**Representation Method**	Use of abstract data representation.	Must	2
2		Use of Tangible objects for representation.	Must	2
3		Use of Numbers and graphs for representation.	Should	1
4	**Representation**	Provide additional contextual information Supplementing the PA data	Must	2
5		Data represented should respect the privacy of the individual.	Must	2
6		Allowing the ability to observe past days' PA data	Must	2
7		Representing activity level performance with respect to goal	Must	2
8		Provide a way to balance the goal between a busy and active day	Should	1
9	**Goal failure**	Indicate the lack of progress made towards the goal	Must	2
10		Provide credit for efforts taken towards the goal regardless of the goal state.	Must	2
11		Avoid highlighting the Failure of the goal within the representation	Must	2

The first category presents three FR for representation methods. Chapter 2.4 highlights the need to explore alternative methods of representation for PA. Previous research has shown the use of tangible and abstract representation can create an engaging experience for an individual where they felt rewarded for the PA performed and intrigued to learn more about their PA data [18], [51], [52]. The discussion in Chapter 2.4 also points towards the current PA applications' reliance on numbers and graphs as means of representation, thus Representation relying solely on numbers and graphs was given a lower priority compared to abstract and tangible representation

The second category presents the requirements for representation. FR 4-7 presented within this category are inspired by the research previously done to outline design requirements for PA applications [60]. The study advises that only providing accurate data on PA is not sufficient and there is a need for additional contextual information related to the PA. Contextual information related to why an individual did or did not achieve the goal can help in understanding the change in performance. The study points towards access to historical data on PA helping individuals understand their performance. FR 5 was included to consider the information being shown in representation can not reveal personal information related to an

individual which they would not want to be shared with others. The representation should respect the privacy of individuals and provide a way to hide sensitive information if they want. Requirement 8 was inspired by the results presented in chapter 3, findings from the study showed an interesting observation about participants demanding a way to balance their goals between busy and active days. Some of the participants overperformed on their active days to compensate for the busy days. The consideration of external factors influencing the ability to perform PA should be considered while designing the representation method.

The third category represents the requirements related to representing goal failure. The discussion within Chapters 2.2 and 2.3 show a need to focus on FRs 9 and 10. The previous research done representing goal failure points towards the acknowledgement of goal failure is essential while showing the progress made towards the goal. If the progress made towards the goal is not acknowledged it could lead to individuals experiencing negative affective states and loss of the desire to pursue the goal [21]. FR 11 was inspired by the previous research done to investigate the rumination effects of different representation styles [17]. The study suggested avoiding highlighting the goal failure with striking colours or other visual elements in representation. The study suggests representation with monochrome visuals for representing PA was favoured by participants and showed less association with negative affective states.

The requirements listed in Table 6 were used during the ideation session and later to evaluate the generated ideas.

4.1.b | Ideation Session

In the ideation phase, the three most associated emotions from the emotions survey were chosen, "Frustration", "Disappointment" and "Regret". The decision to choose these three emotions was made to target the most associated emotions with goal failure from study 1. A guiding question was created to give direction and scope for the ideas generated within the session. The guiding question is as follows:

How might we alleviate feelings of disappointment, frustration, and regret when encountering a goal failure (PA-related)?

Participants
The ideation session was performed with 3 participants. 2 participants were recruited and the researcher was the third participant in the session. All participants had previous experience using fitness tracker devices.
Tools used
The session was conducted in an online setting with the use of a free digital whiteboard software called FIgjam [61]. This software was used to organise the ideas presented.

Session procedure

A 30 min ideation session was designed. The outline for the session procedure is represented in Table 7. The session was divided into three 10-minute phases. Before phase 1 began, participants were introduced to the guiding question and emotions by the researcher.

Table 7. Ideation session procedure.

Activity	Time	Task performed
Phase 1	5 min	Idea generation
	5 min	Exploration
Phase 2	5 min	Idea generation
	5 min	Exploration
Phase 3	5 min	Idea generation
	5 min	Exploration

After the introduction, the three phases of the ideation session were performed. Each phase was structured around two tasks to be performed by participants. The first task was idea generation was performed within a 5-minute time limit. Within this task, each participant was asked to generate ideas related to the guiding question posed for the ideation session. After completion of the first task, all the participants presented and discussed the ideas for 5 minutes. During the second task, participants were free to discuss the ideas generated and make changes to them collaboratively. Completion of task 2 concluded phase 1 of the ideation session.

Phases two and three followed the same procedure as phase one but participants were given the freedom to introduce any new ideas or expand upon the ideas presented in phase one further. The exploration of ideas presented within phase one was connected as a web of ideas making the link between notes. This process is similar to mind mapping [62]. During each activity, participants were asked to colour-code the idea notes. Ideas/thoughts addressing disappointment were represented in pink, Regret was represented in orange, and frustration was represented in cyan. Red was used for ideas addressing the failure of the goal with more than one emotion addressed. colour coding was introduced to create a visual representation of ideas generated for emotions while performing the activity. A visual representation of the session results is presented in Figure 5. Successful conduction of phase three resulted in the completion of the ideation session.
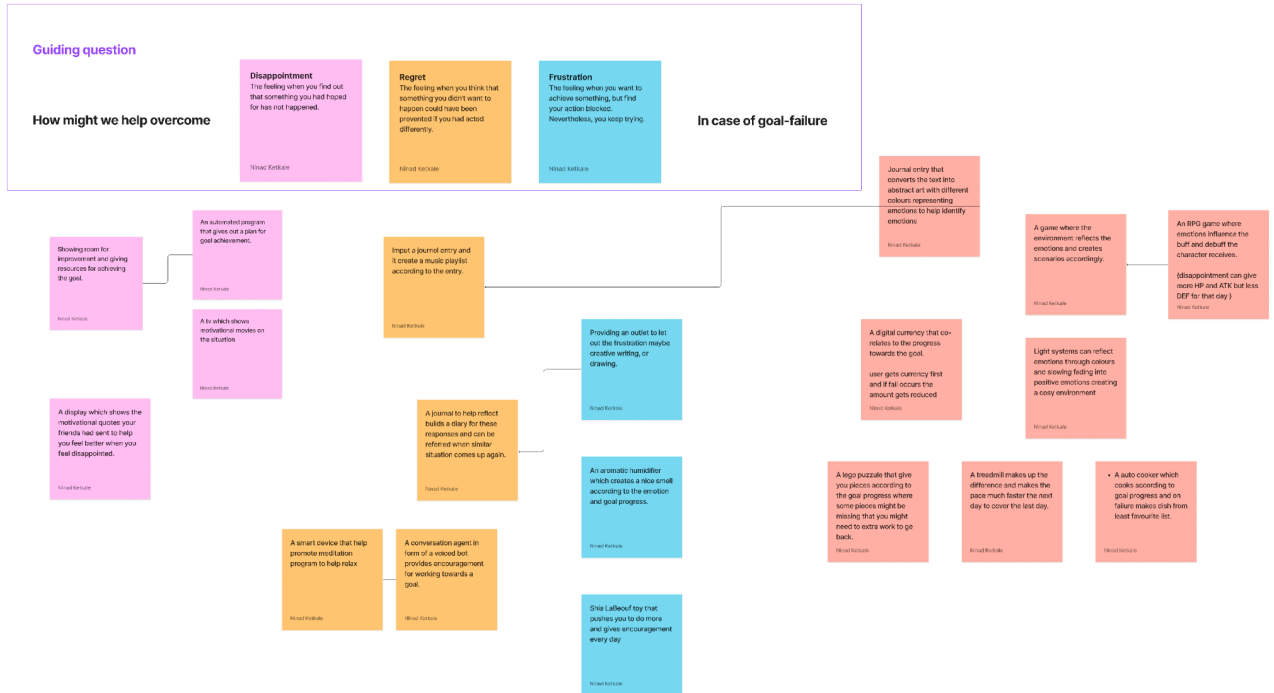
Figure 5. The result of the ideation sessions is represented in a mind map.
(Pink: idea addressing disappointment, Yellow: idea addressing regret,
Blue: idea representing frustration, Red: idea addressing more than one emotion
High-definition images are present in Appendix (B))

4.1.c | Analysis

The ideas generated during the session were collected by the researcher and analysed further. All the ideas generated within this activity were categorised into three broad categories. The categories were determined by combining similar ideas together until they could be associated with a broad category of Journals, Apps, and Physical objects (Tangible interactive objects). These categories are represented in dark blue in Figure 6.
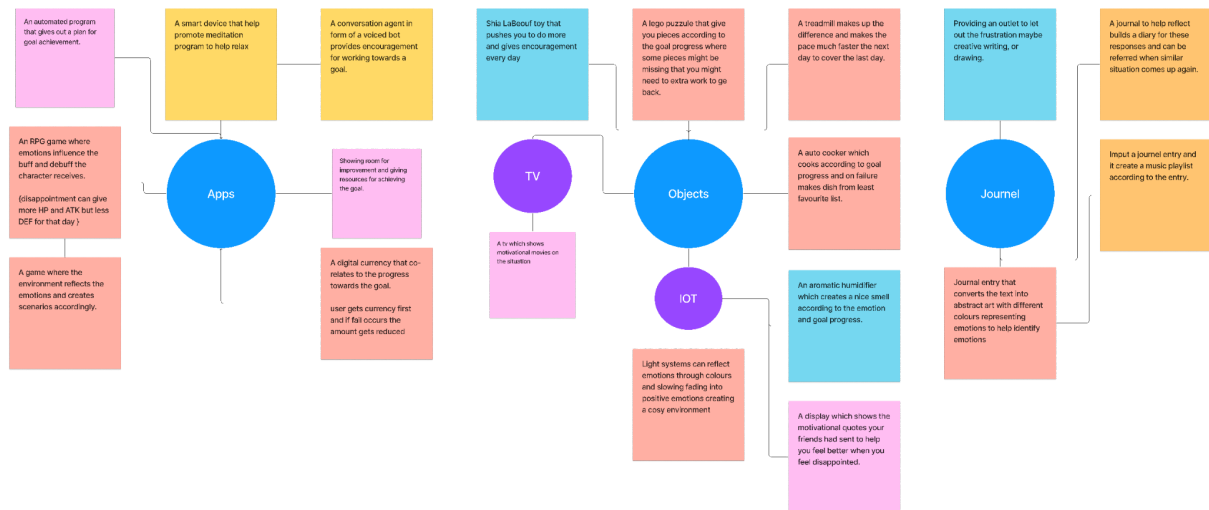
Figure 6. Categorization of the mind app done within the analysis
(High-definition images are present in Appendix (B))

4.1.d | Results

19 ideas were formed within the ideation session. Instead of discussing all the ideas generated within the ideation session, the three most relevant ideas were selected for discussion. The ideas chosen represented three categories made from the analysis. The three ideas were E-paint (Emotion paint), LEGO puzzle, and the Emotions-Role playing Game(E-RPG). The discussion related to the ideas and their initial sketches is presented below.

The first idea was selected from the journal category, Ideas collected within the journal category were related to individuals taking time to record activities performed in a day either manually or by reviewing automatic PA records. One of the ideas proposed was E-paint, which utilises the PA record of an individual for making abstract music or art. AI models were proposed to create the music/image visualisation. This idea revolved around making individuals aware of the activity being performed and providing a creative outlet to express their PA to address emotions of frustration and regret.

The concept idea is depicted in Figure 7. Two scenarios are presented for an individual feeling hopeful and frustrated about their goal non-achievement. In step 1, Journaling was performed where the individual will log their emotions after reflecting on their PA activity. The results of logging the emotions produced a unique representation in step 2. The unique representation will be shown in terms of abstract shapes with different colours, the "Hopeful" feeling is represented with purple shade and the frustrating feeling is represented with orange. The shape of the objects can be related to the different PAs performed where the size of the object represents the progress made towards the goal with a PA.

If an individual fails to achieve the goal the representation will be presented with fewer colours filled in showing a lack of progress made towards the goal. The final edit stage allows individuals to modify representation by changing colours and shapes as they would see fit to make an art piece. The abstract art created could be modified further by an individual to provide a tool of creative expression and as a reward for their self-reflection and journaling their entries.

a variation of the idea was suggested during the ideation session, to use music instead of abstract art. When individuals fill in the journal entry the results will be given in the form of music created according to the responses present in the journal entry. The music could be modified to changes in emotions, with negative emotions could be represented as sad music and later moving towards hopeful music. Some examples of modalities within the music are tempo, the inclusion of vocals, instruments present, and the presence of harmonic melody.
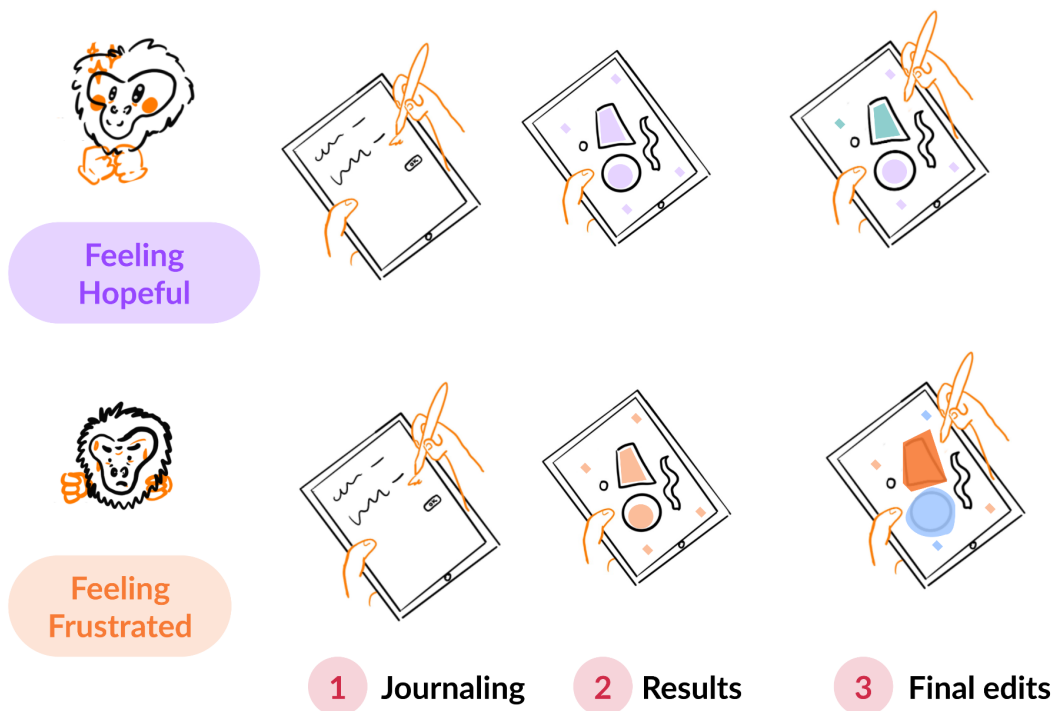

Feeling Hopeful

Feeling Frustrated

1 Journaling   2 Results   3 Final edits

Figure 7. Concept design for journal entries used to make abstract art from the entries related to PA.

Idea 2 was selected from the objects category and an idea for utilising LEGO bricks to create a random puzzle representing the PA was conceptualised where an individual can assemble a puzzle based on their goal state. On achievement of a goal, the full solution/ instructions will be provided whereas in case of non-achievement of the goal will lead to incomplete instructions. The motivation behind this thought was to provide a tangible interactive object in the form of LEGO. In case of failure, participants could still complete the puzzle with imagination and creativity while achievement provided a complete solution. It could help in engaging with the

PA in a different manner and encourage individuals to experiment with their PA to see changes in the representation of the LEGO puzzle in the form of different shapes. A sketched concept is presented in Figure 8 of the LEGO puzzle. The concept design for this idea where dotted lines in the image represent the missing piece resulting from non-achievement of the goal, but due to the nature of LEGO, they could be made into one of the multiple possible combinations of pieces of art, limited only by the individual's creativity (and influenced by the hints earned through the result of their PA). The incomplete puzzles can be completed when an individual overachieves their goal giving them the ability to gain incomplete pieces for the previous puzzles. This addition could help in addressing FR 8 where individuals have the option to push beyond their goal in an attempt to gain missing pieces for previous incomplete puzzles.
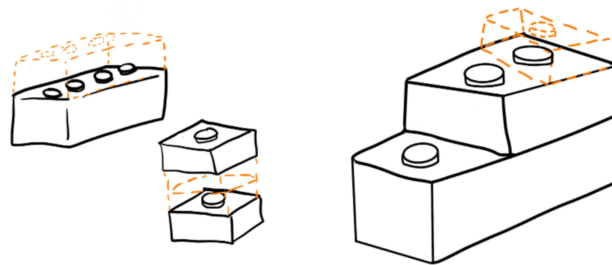
Figure 8. LEGO Puzzle represents when an individual fails to reach the goal.
The yellow dotted lines represent the missing pieces indicating the incompleteness of the goal.

Lastly, Idea 3 was chosen from the application category. A concept for an E-RPG was introduced where individuals can interact with a video game and effects/interactions within the game will be affected by the emotions of the individuals. Automated or manual logging of emotions could be utilised to detect the emotions present when participants reflect upon their PA goal. When emotions are recognised, the video game would react accordingly to the participant whenever rewards are given and the difficulty of the video game would be adjusted to fit the characteristics of the emotions associated. One example can be when an individual is feeling Pride or Joy (Positive emotions) the attack-related ability could be increased whereas if the individual experiences negative emotions their defensive-related abilities would be increased, as shown in Figure 9. Hence the idea presented a concept which could be addressed for negative as well as positive emotions. Although the idea presents an interesting concept, potential difficulties with accurately determining the cause behind the failure and determining the cause behind the emotions could lead to difficulties in implementing the concept. Due to this reason, the idea was not considered for further consideration in the ideation process.
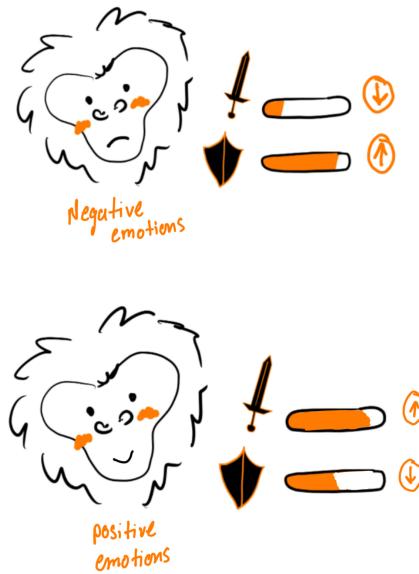
Figure 9. Concept design for a game where emotions influence the user's in-game statistics. Depicting positive emotions gives more ability related to the attack and negative emotions provide defensive ability in a game setting.

4.1.e | Decision towards conceptualization phase

The FR presented in Table 6 was used to help in evaluating the ideas presented in the previous chapter. , One idea will be selected for conceptualisation and prototyping, following the double-diamond design process [27].

The ideas presented were scored based on whether they satisfied the FR presented in Table 6. If an idea met the requirement, then points corresponding to that requirement were awarded to the idea. FRs with "must" priority that was satisfied earned 2 points, while those with "should" priority earned 1 point if satisfied. Ideas with higher total scores would be considered for the conceptualization phase. A tally of scores offered is shown in Table 8. Ideas 1, 2 and 3 represent E-paint, LEGO puzzle, and E-RPG respectively.

Table 8. Evaluating the ideas with the requirements presented

ID	Functional Requirements		Idea 1	Idea 2	Idea 3
1	**Representation Method**	Use of abstract data representation.	2	0	2
2		Use of Tangible objects for representation.	0	2	0
3		Use of Numbers and graphs for representation.	0	0	0
4	**Representation**	Provide additional contextual information Supplementing the PA data	2	2	0
5		Data represented should respect the privacy of the individual.	2	2	2
6		Allowing the ability to observe past days' PA data	2	0	2
7		Representing activity level performance with respect to goal	2	2	0
8		Provide a way to balance the goal between a busy and active day	0	1	0
9	**Representing goal failure**	Indicate the lack of progress made towards the goal	2	2	0
10		Provide credit for efforts taken towards the goal regardless of the goal state.	2	0	2
11		Avoid highlighting the Failure of the goal within the representation	2	0	2
	Total		**16**	**13**	**10**

(Idea 1: E-paint, Idea 2: LEGO puzzle, Idea 3: E-RG)

Evaluation of the ideas

Idea 1 scored the highest number of points signifying that it does satisfy most of the design requirements presented. The idea utilises abstract representation with shapes and colours to represent PA and emotions within the same space. A variation of the idea discussed proposes the use of music instead of visuals to communicate emotions. The creative representation of PA with music and visual elements satisfies FR 1. The use of different shapes and sizes to represent PA and the intensity of activities helps satisfy FR 7. The representation helps highlight the activities performed and gives focus to the emotions. The proposed representation method provides contextual information related to building links between PA and emotions. The abstract representation helps respect the privacy of an individual while the

representation can be archived thus satisfying FR 5 and 6 respectively. The idea does not satisfy FR 8 to provide a method for balancing the goals between busy and active days. The idea presents a novel way to incorporate emotions while representing PA. The idea provides methods to satisfy FR 9 to 11 with the use of colours to represent the lack of progress made. However, it does provide a way for an individual to turn that into a creative outlet to explore with the ability to edit the representation with painting.

Idea 2 scored the second highest points while failing to satisfy FR 10 and 11. The *LEGO puzzle* idea proposes an alternative way to represent the PA but it fails to provide credits for the activity performed. The idea could contribute towards feelings of frustration due to receiving an incomplete puzzle after failing to reach the goal thus failing to satisfy FR 10 and 11. The puzzle can be kept as mementos thus allowing individuals to view previous data through the puzzles collected. The nature of the puzzle allows for it to be rebuilt into different shapes so it could be argued that it does fail to satisfy FR 6 if the individual decides to modify the puzzle. Although the Idea presents a creative way to address FR 8, further exploration is needed to consider FR 10 and 11 to create a representation method that could help in alleviating negative affective states when goal failure occurs.

Idea 3 scored 10 points while failing to satisfy FR 4, 7, 8, and 9. The idea utilises the medium of digital games to represent the PA but it does not provide many details regarding how the PA will be presented in the game. The lack of exploration does lead to not satisfying FR 4 and 7. No exploration has been done to provide a way to balance goals between busy and active days thus the idea fails to satisfy FR 8. The idea lacks a clear indication of the lack of progress made towards the goal thus failing to satisfy FR 9. The environment does change and different boons were received depending on the goal state and emotions but these changes are not enough to signify the goal state clearly to an individual. The idea does provide an interesting method for reflecting the PA and emotions on the elements in the digital environment. The elements in the game do reflect on the goal state and emotions while providing credit for performing PA with changes in boons received for the digital characters. The idea does satisfy FR 10 to 11 but further exploration is necessary to define the elements being modified.

Selecting an idea for the concept phase
From the idea presented, ideas 1 and 2 earned 16 and 13 points respectively. The difference between points for the ideas can be considered narrow so further analysis was required to select an idea for the conceptualisation phase.

One of the common themes within the ideas presented was the use of alternative methods to represent the PA, where the use of video games, music, and LEGO bricks was discussed. Within these modes of representation, further research was performed to see the saturation of each type of method for representing the PA. Abstract visual and tangible object methods have been

explored in [Chapter 2](#). The use of music for representing PA has remained dormant, music can be a great tool to influence emotions and convey broad messages of success and failure [63]. Research performed by Webster and Weir [64] shows the potential of music to influence emotions where music played with major chords and harmonic progression was associated with positive emotions and music played with minor chords and non-harmonic progression was associated with negative emotions. These findings provided interest towards designing a concept where music is used to explore representation methods for PA.

Exploration of music in representing PA and emotions is an interesting opportunity to explore, within the ideas discussed one of the variations of idea 1 proposed to use music for representing emotions. From the ideas discussed, idea 1 proposes an iteration for representing the PA with music. The idea can be used as a good starting point to build upon since it does satisfy the majority of the requirements presented and provides an innovative method for representation.

Idea 1 failed to meet FR 8, which was offered a lower priority. Both ideas 2 and 3 failed to satisfy 3 FR which were assigned a higher priority. Idea 2 failed to satisfy FR 6, 10 and 11 whereas idea 3 failed to satisfy FR 4, 7 and 9. These ideas could be iterated further to address the unmet FR but Idea 1 does provide a good starting point to ideate upon for the conceptualisation phase. Ideas 2 and 3 could be explored further in future studies. These ideas utilise concepts similar to tangible objects and serious games whose role in representing PA was previously explored with research discussed in [Chapter 2.4](#). On the other hand, the role of music in the representation of PA is not explored, Thus the E-paints idea was chosen for further iteration for the conceptualisation phase.

4.1.f | Conclusion

The ideation process highlighted a novel mode of representation for PA by utilising music. The use of music for representing PA could provide the ability to support an individual when encountering goal failure. The emotion paint idea was chosen from the ideation phase to iterate further, as it provided a strong starting point to expand upon. The idea satisfied most of the requirements posed for the ideation session but FR 8 remained unsatisfied. The idea will be explored further in the conceptualisation phase to address the unsatisfied requirement and explore the role of music in representing PA in case of goal failure.

4.2 | Conceptualization phase

The E-paint idea illustrated a method for the musical representation of emotions. The initial idea proposed to ask individuals to journal their emotions as well as PA for generating the representation. This step was removed and replaced with automatic tracking of PA with the help of fitness tracking devices. Automatic tracking of PA will allow for better tracking of PA, as it will eliminate cases where individuals forgot to log their activity and the passive activity performed. The idea was expanded upon to envision supporting features to help the musical representation of the PA. The improved idea revolved around a web application that can collect information from the fitness tracker and generate a unique music production based on the PA performed by the individual. The three added features are storytelling, musical sheets, and moving sheets. Each feature is explained in detail later in this chapter.

4.2.a | Features of the initial concept

Feature 1: Storytelling
This feature explored the possibility of creating a unique experience for the individual with the use of storytelling. Previous research showed participants making positive associations with the characters presenting PA and the use of narrative creates an engagement for participants, in turn, motivating them to perform PA [18]. Taking inspiration from their finding, a basic narrative with a main character was developed.

The outline of the story is as follows: A beginner pianist with aspirations of becoming a great pianist needs help or assistance to craft his music. A user will be tasked to help the pianist in creating a sheet of music every day. The pianist will perform each day in front of an audience. The User's PA goal is tied to the progression of the pianist's career to rise within the music industry. It creates a connection between higher and lower-level goals for the individual. The pianist's progress reflects the user's PA progress, keeping them motivated to reach higher PA goals. Linking abstract goals to PA can improve an individual's expectation management and reduce negative associations like disappointment which can result in less association of negative affective states such as disappointment since the perceived value of the outcome will be realised by the individual [37], [65].

Feature 2: music sheet
Building on the narrative outline proposed in Feature 1, Each day the pianist will ask for help from participants in creating a sheet of music, each sheet will be representing the PA of an entire day for the user. The sheet will be divided into time segments of the morning, afternoon, and evening. When PA is recorded it will be represented in the form of a note in that time segment. At the end of the day, users will receive a sheet filled with notes representing their PA which will be converted into music that they could hear. Figure 10 shows the initial design for the musical sheet. Since each day's activity pattern would be different, the resulting music will

reflect the uniqueness of each day's activity pattern. The initial idea represented within Figure 10 shows tracking of multiple parameters like sleep and heart rate (HR).
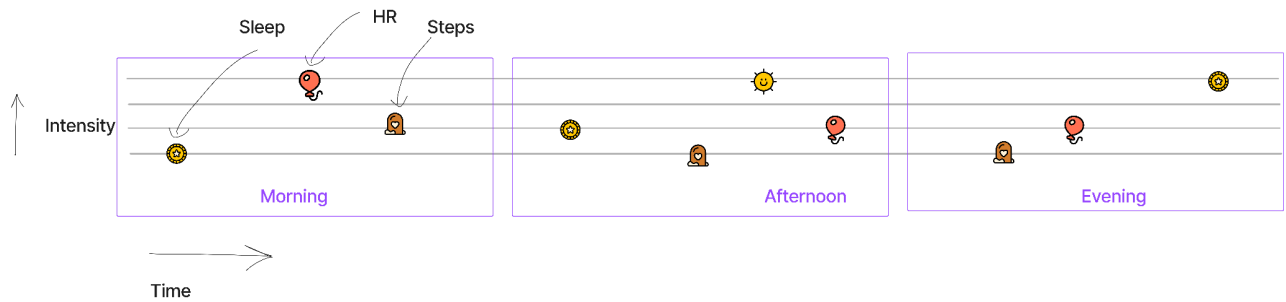

Figure 10. Initial sketch depicting the music sheet with PA marks in form of a stamp

When the pianist performed the song of the day in front of the audience, users will see an animation of a crowd listening to the music and cheering for the performance. The number of people that would be present in the audience would be tied to the goal progression of that day. If the user has achieved their goal, there will be a large audience present. If the user fails to reach their goal, the audience size will be smaller. A representation of the crowds' relation to the goal state is shown in Figure 11. The design promoted reflection on an individual's PA performance with changes in music. The design rewards the individual for the efforts taken towards the goal in the form of music and crowds' reactions to the performance being played. Regardless of the goal state, individuals will receive representation in the form of music. The number of people in the audience should provide an indication of the goal state and motivate users to do a performance with a bigger audience. Acknowledging individuals' efforts will increase their self-persistence to reach PA goals, increasing the self-efficacy of PA [20].
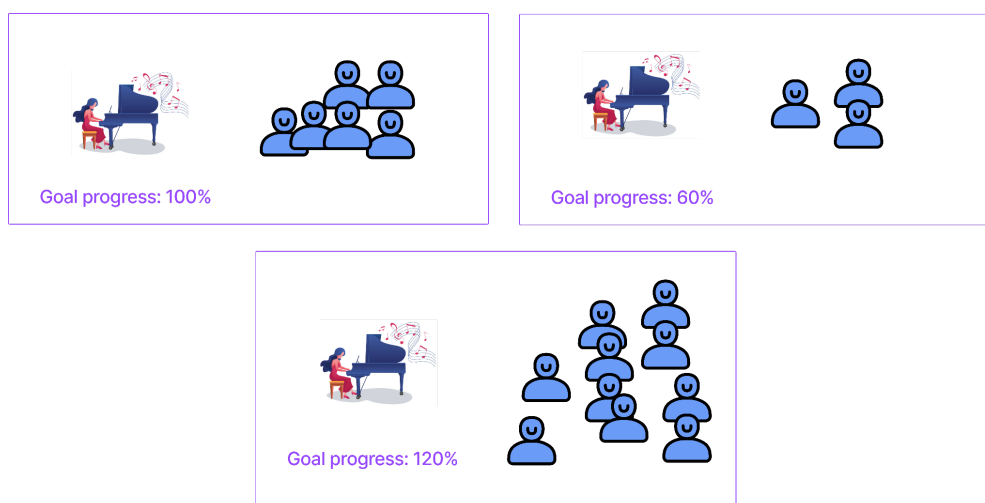

Figure 11. Component 2's concept:
The sketch represented a change in the number of participants with the goal state

Feature 3: moving sheets

The study 1 results showed an interesting pattern where participants showed a tendency to perform more PA on free days compared to working days to compensate for less work done on the free days. Some participants expressed frustration with the inflexibility of goal-setting in PA applications. It showed room for flexible goal-setting methods where participants can choose a different goal for their active and inactive days.

This finding inspired Feature 3. To understand the feature let's consider an example; Three days goal state is represented in Figure 12. On day 1, an individual achieved their goal but on the second day, they failed to reach the goal by 40% so the music sheet will reflect that by showing only 60% of the music created. On day 3 the individual overachieves their goal by 40%, in that case, an extra block of music will be generated as a reward for overachieving. The extra block created can be used by individuals to fill any gap they might have up to 40% of progression. Figure 12 shows the concept sketched for this feature where an individual could use their day 3 extra block to complete the music sheet for day 2. This feature was designed to help with giving more agency to the individual in goal achievement and how they want to reach their goal.
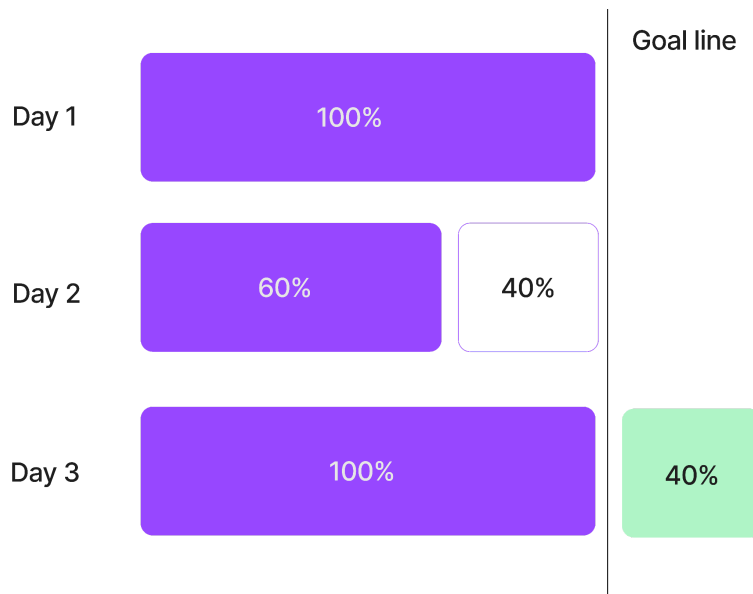

Figure 12. Component 3's Concept:
Purple blocks represent the progress made towards the goal and
green represents blocks that could be assigned to an outlined space.

4.2.b | Evaluating features for final concept

From the features mentioned above only Feature 2 was chosen for the final concept design and prototyping phase. Feature 1 could give emphasis to the music sheet created in Feature 2 by utilising the narrative as a tool to create an engaging experience for the individuals and motivate PA [18]. The crafted story and the potential bond created with the presented character could help individuals to make connections between higher and lower-level goals. Besides its potential benefits, The potential role of visual representation and narrative-based PA representation has been explored in previous research. The exploration of music as a method for representation should be explored solely to understand its effect on emotion. The inclusion of Feature 1 in the final concept could introduce another variable that influences emotions. Once the potential effect of music as a representation method has been explored, Features 1 and 2 can be studied in future studies to explore their combined effect on emotions.

Feature 3 was not selected due to the potential interference with Feature 2. Feature 3 could help in fulfilling FR 8 presented in Table 6 but there can be cases where a mismatch between segments when merged together. The feature allowed the merging of music sheets from different days to fulfil the goal on inactive days. The interaction can lead to unpleasant music production when merging sheets of different days. One possible solution could be to make the music pre-defined but in that case, it can lead to receiving unfinished music for a day. Due to these complications, Feature 3 was not considered in the final concept design.

Selecting only one feature also helped narrow the focus and iterate further to explore the use of music in representing PA. The idea presents the PA on the music sheet and their PA level throughout the day, providing the ability for an individual to investigate and make conclusions about their performance. Feature 2 will be explored further in the final concept phase to create a concept. Without the presence of Feature 1. Some of the concepts in Feature 2 would need to be redesigned. Discussion related to changes made within Feature 2 is presented in Chapter 4.3.

4.3 | The final concept design

Feature 2 proposed within the previous chapter showed potential for representing PA in the form of a music sheet. To develop the final concept from Feature 2, A co-creation session with a musician was held. The aim of the session was to delve into music production details and collaborate on developing the final concept. The musician contributed towards making a selection of music notes and advised on the music production procedure. The contribution details will be discussed in this chapter. From this session, a final concept named 'Melody' was created as a result.

4.3.a | The Melody concept

The concept was designed to address multiple emotions rather than hyper-focusing on one. Melody concept was proposed to provide PA information using music to help alleviate negative emotions associated with goal failure. The concept was thought of as a web or mobile application. The overall concept consisted of recording PA related to steps over a period of 24 hours and using an automated program to generate the visual and audio components of abstract representation to create a video representation of PA. Within each hour, a musical note will be played signifying the number of steps taken. Audio will be accompanied by visual representation in the form of activity spikes over a timeline. This representation can be used by an individual to self-reflect on their daily activity. The concept was divided into two components. The first component revolves around the visualisation aspect of PA representation and the second component revolves around the audio component concerning music production.

Visual representation

Using the findings from the studies done previously about abstract representation to create meaningful experiences that will help participants self-reflect on the goal progress and PA. From Feature 2 some refinements were made specifically to the music sheet. The initial concept of representing multiple PAs on a music sheet was discarded due to possible complications created while producing the music. For the concept and prototype phase, only one PA was chosen to be represented. The chosen PA goal is the step taken daily, This PA goal is one of the most common PA goals presented within most of the mHealth applications [22]. The focus of PA represented within the music sheet narrowed and some changes to the music sheet were introduced.

The music sheet from the initial conceptualisation phase becomes a canvas where the PA (steps) will be represented in time segments of 1 hour instead of the three 3-time segments proposed in the initial idea. Each segment will be represented with activity spikes indicating the number of steps taken within that time segment. Having a clear division of time allows individuals to interpret the presented data easily and activity spikes can allow them to easily

understand the activity levels. The depiction of the activity spikes is shown in Figure 13. The sketch shows activity spikes in the orange colour and the level of activity can be interpreted with Y-axis. The X-axis within the sketch shows the time of the day where the left edge represents the start of the day and the right edge represents the end of the day.
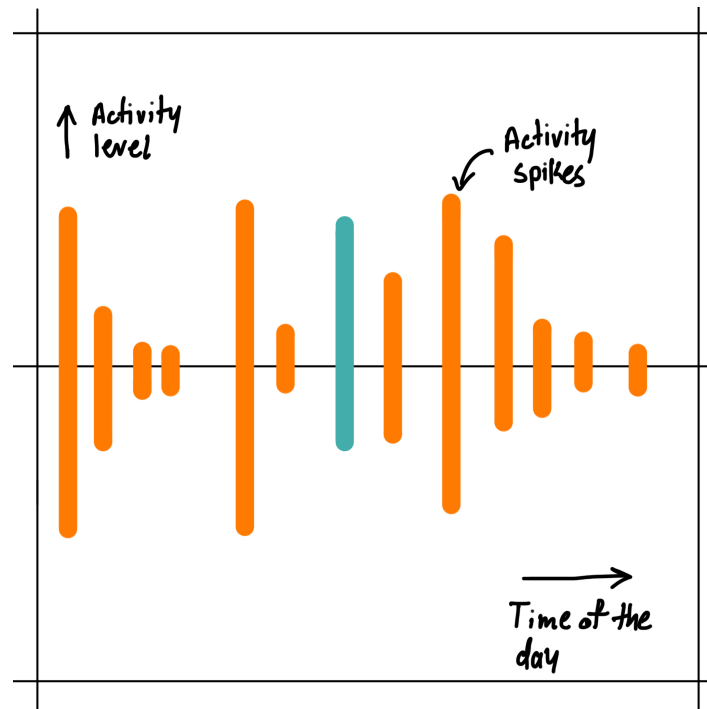

Figure 13. Initial concept design after finalisation of Idea
(X-axis representing the time of the day, Y-axis representing the number of steps. Activity spikes are represented with orange and the current note being played is associated with cyan-coloured activity spikes)

Audio representation

Each activity spike represented in Figure 13 will be accompanied by a music note. To represent the activity and the assigned note indicates the change in activity levels. Within the co-creation session, 5 Major and Minor keys were chosen for the production of the music. The selected major and minor chords are as follows.

<div align="center">

Major chords ('Bb', 'F', 'C', 'G', 'D')
Minor chords ('Gm', 'Dm', 'Am', 'Em', 'Bm')

</div>

The chords were selected from the established music theory principles for the creation of a music progression [66], [67]. Chord 'C' is considered a central chord and the rest of the chords were selected to create a 5-note chord progression. Chords 'G' and 'D' will produce a higher tone than 'C', inversely chords 'Bb' and 'F' will produce low tones compared to chord 'C'. The same logic is applied to the selection of minor chords. Within the chords, the progression

created with major chords is mostly associated with positive emotions and the progression of minor chords is associated with negative emotions. These findings were presented in a study performed by Webster and Weir [64]. The study shows the potential of music as a tool to inspire emotions, The chords could be used to highlight upward and downward trends within the activity levels. If the activity spike pattern shows an upward trend then major chords will be assigned to those activity spikes. Similarly, if the activity shows a downward trend then minor chords will be assigned to those activity spikes. Variation between major and minor chords will help in representing a change in activity levels. The methodology of assigning chords to activity spikes will be detailed in Chapter 4.5. The selected chords were further tested within the co-creation session to make sure the production of music with these chords will produce harmonic music. The activity was essential for avoiding the creation of un-harmonic music, considering the potential random nature of the activity pattern from an individual.

Goal state representation

The concept of utilising crowd applause from Feature 2 was not considered within the concept phase. Since the storytelling aspect presented in Feature 1 was not considered for the final concept phase, The concept to represent the goal state needed to be modified. While designing the final concept different variables like tempo, audio levels, and changes in the instrument within music were explored as means of representing the goal state.

While analysing the potential of different variables present within music, one study provided an interesting insight where a faster tempo in music was associated with positive emotions and a slower tempo was associated with negative emotions [68], [64]. The decision to use the tempo as an indicator of the goal state was inspired by the results shown in this study. The music consisting of 24 notes could be modified to have different tempos. The tempo of music makes the notes play in a faster progression or slower depending on where the tempo is set. A tempo of 80 bpm(Beats per minute) will produce a very mellow and slow progression of music which was decided to be used to signify the goal of non-achievement. On another hand, a tempo of 120 will create upbeat and fast-progressing music which was used to signify the goal achievement [64].

Combining all the components

The representation was decided to be implemented in a video format to combine the audio and visual components creating a cohesive experience. Representing both components together will help in visualising the PA to an individual. The visual representation will help in grounding the PA with time since the edges of the representation show the start and end of the day. individuals can understand the timeline of their activity with visual and audio components. Playing music notes highlighting the activity spike it is associated with will help in associating the music with a visual component. To show an association between music and activity spike,

when a music note associated with the activity spike is being played that activity spike will be represented in a different colour, this can be seen in Figure 13 with the activity spike represented in cyan.

The video file created could be shared with an individual from the application at the start of a new day. Since the representation takes 24 hours into the consideration, the representation can be sent for self-reflection on the next day.

4.3.b | Conclusion

Feature 2 discussed within Chapter 2 was developed further within a co-creation session The result of this session was a final concept called "Melody," which is designed to represent PA through music and visual representation. The Melody concept involves recording PA for 24 hours and generating a visual and audio representation of that PA through an automated program. The visual representation consists of activity spikes over a timeline, while the audio component involves playing a music note for each activity spike, with the choice of major and minor chords being determined by the change in activity levels. The Melody concept is designed to help individuals self-reflect on their daily activities and alleviate negative emotions associated with goal failure with help of music production.

4.4 | Specifications for prototyping

A list of the specification requirements (SR) were created from the final concept outlined in the previous chapter to help in the development of the prototype. The SR is classified into 4 categories as PA tracking device, Data collection, Data processing and Post-process presented in Table 9. Each specification was given the priority of must or should for considering the value of the given specification for the prototype.

Table 9. Specification requirement (SR) for prototyping.

ID	Specifications		Priority
1	**PA tracking device**	Ability to track steps in intra-day intervals.	Must
2		PA tracked automatically.	
3		Provide a non-intrusive experience while performing PA.	
4	**Data collection**	A glanceable display for showing PA data.	Should
5		PA data should be retrieved from the device wirelessly	
6		Steps data segmented into intervals of 60 minutes.	Must
7	**Data processing**	Depict steps taken in the form of activity spikes.	
8		Each activity spike must be assigned to a music note.	
9		Assignment of music notes according to the progression of PA.	
10		Inactivity of PA represented in empty space and silence.	
11		Ability to change the tempo of music from 80 bpm to 120 bpm.	
12		Music progression exported in the format of Wav or MIDI	
13		Visual representation exported in PNG format.	
14	**Post-process**	The representation must be in a monochrome colour scheme.	
15		Each music note is played in sync with the activity spike it represents.	
16		When a music note is played the corresponding activity spike must be highlighted.	
17		Final representation exported in an MP4 format combining Audio and visual representations.	
18		A device with a digital colour display(at least 720p) and speakers.	

PA tracking device requirements were designed to help narrow down a device that can be used in tracking the PA activity of steps taken in a day. The device must provide the ability to

automatically track and log the steps taken by an individual. An automated PA tracking device will reduce the burden on individuals to manually log their activity which can lead to inconsistency in the recording of data. The device used to track must provide a non-intrusive experience while performing the PA and outside of the PA as well. The comfort of the tracking device can ensure that participants will wear it for an extended period. The concept required collecting the data related to steps for a period of 24 hours. An addition of a glanceable display can allow an individual to keep track of their activity. Previous research indicates that using a glanceable display can increase individuals' awareness of their PA [69]. SR 4 has been given a lower priority as the addition of a glanceable display could help an individual keep track of their data but it won't be vital for the functioning of the prototype.

Data collection requirements were designed to facilitate the retrieval and collection of PA data. SR 5 should be taken into consideration when selecting PA tracking devices as wireless retrieval will help automate the data collection process with minimal human intervention. The collected PA data should be divided into intervals of an hour for a day for creating the representation mentioned in the concept phase.

Data processing requirements were designed to facilitate the creation of an automated program or system which can represent the number of steps taken per hour as an activity spike and assign a corresponding music note. The variation of the music note will be performed with a change in activity spikes. The inactivity during PA should be represented by silence in the audio representation and a blank space in the visual representation. The representation must accurately reflect the goal state by adjusting the tempo of the music accordingly. SR 12 and 13 were introduced to export the data in a manipulable format for the creation of the final representation.

The post-processing requirements propose that in the final representation, each activity spike should be paired with a corresponding music note. The change in notes should be correlated with the change in PA performed. The created representation should be displayed in monochromatic colour, results from a previous study recommend using mono-colour representation rather than multi-coloured representation when showing goal failure [17]. Highlighting goal failure with a different colour can lead to focusing on that aspect which can lead to experiences of negative affective states. The concept requires highlighting the activity spike when playing the music note corresponding to the spike. The final representation must be in a widely used video format like MP4 where visual and audio representation created in the data processing stage will be combined. Finally, a device supporting a digital display is required to view the representation created. The display must support at least 1280x720 pixels resolution which is capable of clearly representing the visuals. The device must support at least a speaker to play the audio representation.

4.5 | Prototyping

According to the requirements presented in the previous chapter, a prototype was created to represent the PA in visual and audio formats. This chapter will outline the details regarding the implementation of the prototype.

4.5.a | Tracking device and data collection

PA tracking device
A PA tracking device was required to gather data related to the steps of an individual. From the available fitness tracking devices at the University of Twente, the Fitbit Versa 2 [19] was chosen for prototyping, The Versa 2 is an on-wrist fitness tracker allowing to gather data related to the steps taken in a day. The fitness tracker allowed the ability to gather data through an online Fitbit account. Versa 2 provides a digital glanceable display to quickly glance over PA performed and goal progression. Versa 2 fulfils SR 1 to 4 mentioned in Table 9.

Data collection
The only necessary data required for the prototype was the number of steps taken by an individual. The Fitbit Versa 2 was chosen as a device to build a prototype around. Fitbit Versa 2 allowed the ability to collect data related to steps taken within a maximal interval of 15 min through Fitbit Web API [70]. SR 6 requires the data must be collected in intervals of 60 min, The 15 min intervals retrieved were combined to make intervals of 60 minutes. The data was collected in a JSON file containing information about step counts. Paired with Fitbit versa 2 and Web API, SR 5 and 6 were satisfied.

4.5.b | Data processing

A custom Python script was written to process the data collected and create the final representation. The flow chart depicted in Figure 14 shows the logic used to create the representation. The script was subdivided into 3 stages, Data collection, Visual component, and Audio component. A brief description of how the scripts work is provided below. Data collected from the Fitbit Web API was converted into 1-hour time segments as per the requirement for the representation. The array of 24 data points is provided to visual and audio processing components to export a PNG image and a MIDI file respectively.

The Fitbit web API provided step data in a time interval of 15 min but the prototype required it to be of 1-hour time intervals as mentioned in SR 6. To make 1-hour segments for the prototype, four 15-min segments were combined to make one segment consisting of 1 hour for the day. Data containing 24 points were forwarded to visual and audio components for further processing.

Visual component utilised a graphing library within Python called 'Multiplot' [71]. The library provided the ability to represent the steps in the form of an area graph. The 24 points of data collected were provided to the library and converted into activity spikes. The Audio component utilised a custom Python program to assign a music note to each of the 24 data points collected.
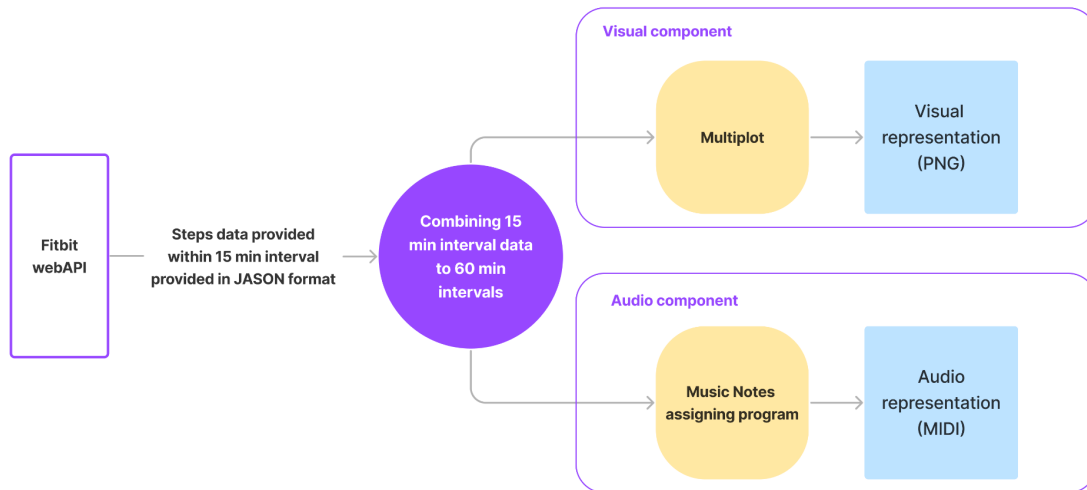

Figure 14. Flowchart diagram depicting the function of the Python script

Visual component

The received step data was inputted into a graphing library in Python called 'Multiplot' [71]. The library provided the ability to represent the steps in the form of a mirrored area graph on the X-axis. The mirrored area graph was chosen to create a representation that resembles the concept sketched in Figure 13. The X-axis represents the time of day and the Y-axis represents the number of steps taken. The prototype does not have any markers on the X-axis and Y-axis to indicate the time and number of steps respectively to keep the data representation abstract. The representation is kept in the colour blue to satisfy SR 14. The output from the visual component is represented in Figure 15.
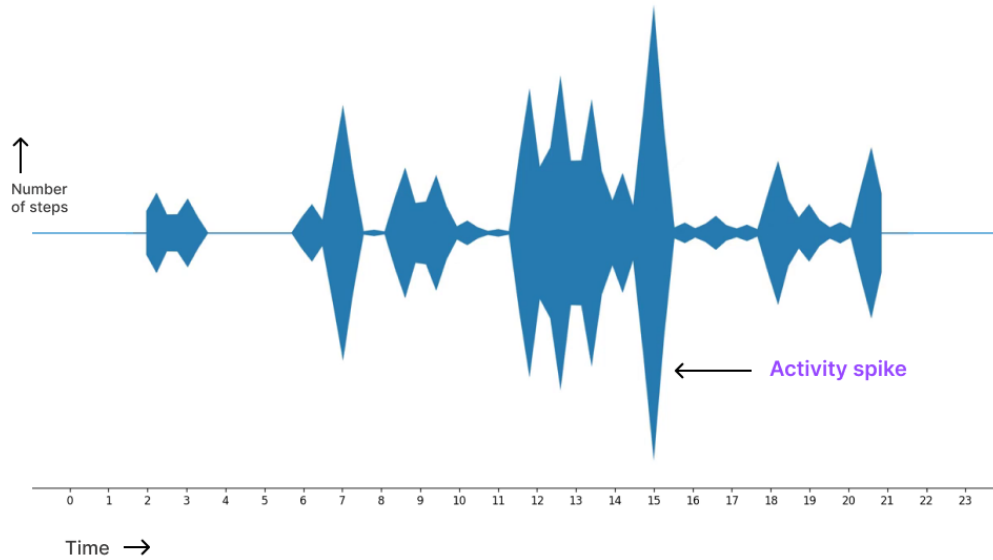
Figure 15. Representation created from prototype showing activity of 24 hours.
The X-axis represents time and the Y-axis represents the number of steps taken within an hour.

Audio component

The program utilised the step data collected in music production. Within music production, an assignment algorithm was developed. To understand the assignment algorithm a set of rules were created. The rule set is presented in Table 10.

Table 10. Rule set for assignment of music notes.

Rule	Condition	Base index	Note assignment
1	**First instance of Cu**	BI = 3	Major note
2	**P<Cu**	BI +1	Major note
3	**P>Cu**	BI -1	Minor note
4	**BI > 5**	BI =3	Major/ Minor note
5	**BI <0**	BI =3	Major/ Minor note
6	**Cu = 0**	No change	X

(Cu: Current instance of step data, P: Previous instance of step data, BI: Base index)

Cu represents the current instance being analysed. P denotes the previous instance. BI indicates a variable used to keep track of which note is being assigned to the activity spikes. The major and minor chords used are shown in Table 12.

The first instance was always assigned a base index of 3. Rules 2 and 3 compare Cu and P instances to determine which one is higher or lower and assign the note accordingly. Major chords were used to denote an upward change in steps and minor chords were used to indicate a downward change in steps taken by the individual. If there's an instance with no steps taken, no note is assigned and the output is silent, represented by 'X'. If the base index exceeds the value of 5 then that assignment is reset to base index value 3. Similarly, if the base index is reduced below 1, the assignment resets to a base index of 3. The major and minor note assignments will be determined with the assignment done for the previous instance.

To understand the assignment of musical notes easier, an example is shown in Table 11 where a number of steps taken (Input) are assigned a musical note (Output). Within the music assignment algorithm, the first instance of an input is always assigned as a 'C' chord from Table 11 and the **base index is set to 3**. In the second instance, steps taken are 0; it is assigned as 'X' and no change in the base index is made. The 'X' note within music production is represented as silence. In the 3rd instance in the example, there are 10 steps taken which is more than the last instance of steps taken within instance 2. So the base index will be increased by 1 making a new **base index = 4**, and the note from major chords will be assigned within that base index, which will be 'G'. For the fourth instance of input, there are 24 steps taken which is more than the last instance(3) so the base index will increase by 1 making **base index = 5** and a major chord will be assigned within that base index, which will be 'D' note from Table 12. On the fifth instance the input, 8 steps taken, is smaller than the previous instance (4) so the base index will be reduced by 1 making **base index = 4** and a minor chord will be assigned which will be 'Em' from Table 12. The logic outlined before will follow until all the step data is processed. If the base index exceeds 5, it will be reset to 3 again and similarly, if it goes below 1 it will be reset to 0. If there is a case of a number of steps being the same within two instances then the base index is increased and a major chord is assigned. The Python script depicting the note assignment algorithm is represented in appendix (C).

Table 11. Music notes assignment example showing conversion
of the input (steps) to output (Music notes).

Step Instances	1	2	3	4	5
Input (Number of steps)	51	0	10	24	8
Output (Music notes)	C	X	G	D	Em
Base index	3	3	4	5	4

Table 12. Major and minor chords are used for music production.
The base index denotes which chord will be assigned from the major and minor chords

Base index	1	2	3	4	5
Major chords	Bb	F	C	G	D
Minor chords	Gm	Dm	Am	Em	Bm

The assignment algorithm produces a string which will be used to generate the music component. Finally, for assigning the tempo to representation. The total number of steps taken by an individual was compared with the daily step goal. If they achieved their goal then the tempo for the music will be set to 120 bpm and if they fail to achieve the goal the tempo will be set to 80 bpm. The string and tempo parameters are passed to the library 'Chords2MIDI' to generate a MIDI file.

4.5.c | Video creation

The output of the Python program consisted of a visual representation in a PNG format and a MIDI file representing the Music associated with the representation separately. Both components need to be merged into a single video format to make the association with music and corresponding activity spikes. HitFilm Express [72] is a video editing software used to combine the visual and audio components produced from the Python script.

Both of these files were used for the creation of the video representation in a video editing software where the addition of a seeker synced with music was added. The seeker was added to provide clarity towards the connection between activity spikes and music notes being played. The Seeker object was chosen as the seeker in the representation as represented in Figure 16. The only intervention from the researcher within the prototype was syncing the seeker with the audio and visual components. After the creation of the video,

the representation could be viewed by individuals showing tier PA in the form of audio and visual representation. The video was exported into MP4 format which is supported by the majority of smartphones and computers. A link will be provided to a video in appendix (D) to see the final product done from a prototype with music.
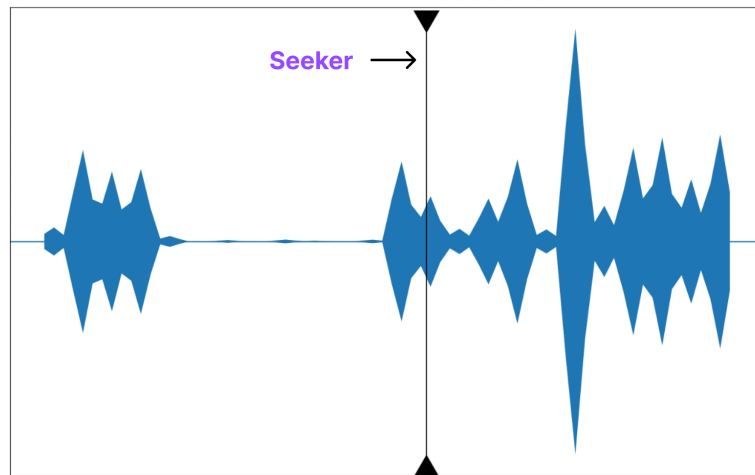

Figure 16. Representation created from prototype showing activity of 24 hours.
The seeker is represented in black colour.

5. Study 2: Evaluation of melody concept

The Finalised prototype was evaluated within a study, the design of the study and the procedure. The chapter also includes a discussion related to the results presented from the study.

5.1 | Introduction

To evaluate the prototype, some assumptions were made before the conduction of the study. The study provides rewards to participants, regardless of the outcome of their goal. in the form of unique music representation. The effects of receiving these representations will be analysed with 8 emotions. Instead of evaluating the prototype with all 14 emotions used in study 1, only 8 emotions were chosen to represent the most and least associated emotions with the failure of the goal from study 1. The negative emotions included disappointment, frustration, regret, and guilt. The positive emotions of pride, hope, relaxation, and relief. The results within study 1 point to these emotions being influential within the goal failure state so these emotions will be used to evaluate the effectiveness of the prototype in alleviating some of the negative emotions. changes in these emotions were observed, with a reduction in disappointment and frustration among negative emotions, and increased curiosity regarding pride in the case of goal failure. A research question was formed with several sub-questions exploring different aspects of the prototype.

Research question:
How does the use of music as a representation of PA help alleviate negative affective states associated with goal failure?

Sub-questions:
1. Can participants understand the relationship between representation and their PA?
2. How does the representation help reduce the negative affective state related to the failure of the goal?
3. How can music within representation inspire a feeling of pride?
4. How does Music inspire a feeling of relaxation while reflecting on representation?
5. Could music alone facilitate an indicator for goal state?

A study lasting one week was designed to evaluate the prototype. The study was conducted as a field trial where participants were given and asked to use a Fitbit Versa 2 device, The participants were asked to wear the fitness tracker throughout the day to get information related to steps within a day. After the handout of the devices to every participant is complete, the study period will initiate. This period lasted 7 days, during which participants' step data were logged by the device and each day participants will receive a representation of their PA

from the previous day. On each day of the test period, participants' goals were increased. The goal was increased to make it more challenging to achieve and ensure that at least one case of goal failure will occur among the participants.

On day 3,6,8 of the study period, participants were asked to fill in a check-in survey. This survey asked questions related to the experience with the prototype with reflection on the previous day's representation, the details about the survey will be included in Chapter 5.2. After the conclusion of the test period, a follow-up interview was scheduled with each of the participants individually. The follow-up interview was designed to be a semi-structured interview about their experience with the prototype. After the follow-up interview, all the data collected during the study period were used for analysis.

5.2 | Study Design

5.2.a | Participant Selection

Inclusion criteria
- Participants should be of at least 18 years old.

Exclusion criteria
- Participants should be able to read and write in English.
- Participants suffering from physical injuries or an illness that might prevent them from performing PA

Participants who could not read or write in the English language were excluded as the study was communicated in English. Participants who were suffering from any physical injury or illness that can prevent them from performing PA were excluded. The study asked participants to perform PA and the inability to perform PA would lead to further health-related risks for the participants.

Participants

A limitation on the number of participants was imposed by the number of Fitbit devices available to hand out. Due to the limited number of available Fitbit devices, only five participants were recruited, who met the criteria mentioned above. Participants were recruited through online forums and direct messages from online platforms. All five available spots were filled within one week.

The recruited participants were within the age group of 18-25. All of the participants were familiar with fitness tracking devices and had used them in the past.

5.2.b | Study Setup

Device setup

Five Fitbit versa 2 devices were made available for the study from the University of Twente. Fitbit versa 2 requires a Fitbit account to be able to use the device. Each device was set up with a temporary Fitbit account. The creation of a temporary account allowed the personal data of participants to be kept anonymous.

The Versa 2 devices' watch faces were altered to show only essential information, this included step count for the day, time, date, and battery percentage. An example of how the watch face was set can be seen in Figure 17. The design was kept intentionally minimal since the versa 2 can track and show data related to sleep, heart rate and calories burned. Only step data relevant to the study were shown to participants to keep the focus on the step data. Keeping the focus solely on step data might allow participants to make connections with the steps taken in the representation and keep track of their goal progress.

Figure 17. Versa 2 watch face setup. Showing data related to steps taken, date & day, time, and battery percentage.

Step goal changes

The test period lasted for 1 week (7 days). Participants' goals will be increased every day using the following formula:

New *step goal = Current step goal + (10% of Current step goal).*

Step goals for the first day were determined by the response provided by the participants before the start of the study. Using the formula each day a new goal was set for each participant individually. The scaling of the goal was introduced to create a scenario where participants might fail at least some of their goals. The scaling of the goal made the step goal more challenging each day which increased the probability of a participant experiencing goal failure. Each day, participants received their representation of the PA performed on the previous day through an email with communication-related changes in the daily step goal.

5.2.c | Study procedure

The study was divided into three phases, each phase is discussed in detail below. All the procedure details were reviewed and approved by the ethics committee at the University of Twente under application number: 220020.

Phase 1: Handout of the devices
The Fitbit versa 2 devices were set up with a temporary Fitbit account and selected participants were asked to fill in an introduction form. The introduction form consisted of two sections, the First section provided a consent form to the participants and the other section collected some information related to their familiarity with fitness trackers and current step goals with their email addresses.

On successful completion of the introduction form, Participants were given the Fitbit Versa 2 devices. The device needed to be paired with the participants' personal smartphones with the temporary account provided by the researcher. Participants were asked to keep the device on their wrists for the whole duration of the day if possible.

Phase 2: Test period
The test period lasted for 1 week (7 days). Each day participants will receive an email to notify them about the change in step goal for the day with the representation of the previous day attached as a video file. Alongside the representation information related to the change in step goal was communicated to the participants.

The check-in survey was the only exception to this process. The check-in survey was sent to participants on days 3, 6, and 8 of the study period. The check-in survey was distributed through email and participants were asked to fill in the check-in survey online.

Phase 3: Follow-up interview
The follow-up interview was conducted individually and in person with each participant. Participants' devices were collected and reviewed for the safe return of all items. Available dates for interviews were provided to the participants on day 3 of the test period. Participants chose the date that best suited their schedule. The interview was scheduled for 60 minutes.

During the interview, participants were asked questions regarding their experience with the prototype. With the use of a presentation on a laptop, participants were shown the representation of their step data for each day. After the successful completion of all interviews, the study period was completed.

5.2.d | Data collection

Fitbit device

Steps taken by participants in a day were recorded within the Fitbit application and queried by research through Fitbit Web API. The number of steps taken within a day was used to determine the goal state for each participant.

Introduction survey

While handing out the devices to the participants, they were required to fill in an Introduction survey which collected consent from each participant to participate in the study. Additional information related to their familiarity with fitness trackers and current step goals was collected. Participants' emails were collected to send a representation of the previous day, the check-in survey, invitations for the follow-up interview, and any important study-related announcement. The emails collected during this phase were destroyed after the successful conduction of the follow-up interview. The introduction survey will be included in appendix (E). The responses to the survey were collected in a spreadsheet format.

Check-in survey

On day 3,6,8 of the study period, participants were asked to fill in the check-in survey. In the survey, the video of their representation from yesterday was present. A series of questions were asked to be filled out after watching the video of representation. A Likert scale was used to record responses for association with 8 emotions presented. 8 emotions included Disappointment, Frustration, Regret, Guilt, Pride, Hope, Relief, and Relaxation. The Likert scale was presented on a scale of 1-5, where 1 represented the least association with emotion and 5 for a strong association with emotion. In addition, the survey included 3 open-ended questions for the participants which were as follows:

1. *Could you elaborate in a few lines on the reasoning behind any emotion you scored above?*
2. *If you had experienced other emotions which are not included in question 2 (Likert scale table), you can mention them here*
3. *Could you elaborate shortly your interpretation of the step data representation? You could try to connect the representation with activities from yesterday.*

Question 1 was used to gather additional contextual information related to the emotions they associated with and if they had any reason behind associating with that emotion. These responses were used to craft follow-up interview questions to gain insight into their emotional

state. Question 3 was used to gather information related to their interpretation of the representation received to investigate if they can connect activity peaks shown in the representation to their PA. The responses were investigated further in the follow-up interview.

The check-in survey used during the study will be included in appendix (F). After completion of the test, The responses to the survey were collected in a spreadsheet format.

Follow-up interview

The interview was designed in a semi-structured format. The question for the interview was formed from the check-in survey responses provided by the participants. The responses given by participants were further investigated to gather more contextual data related to the emotions they experienced. Participants were asked to explain why they felt a certain emotion and if needed further investigate the reason. These questions provided contextual information beyond the association to make a conclusion about the effects the prototype had on the affective states of participants. Some questions related to music production were asked as well to investigate the participants' interpretation of what music represented in the representation.

With questions, some activities were included in the interview. Activities like guessing games where participants were only allowed to listen to audio of a random representation chosen by a researcher from their test period. After listening to the audio, participants were asked to make a guess on which day from the test period the audio belonged to. This activity was designed to test if participants can recognise their activity pattern and make guesses about which day it is. Another activity included participants comparing the representations of a day where they took the highest amount of steps with the least amount of steps taken within a day. In the last activity planned for the interview, Participants were asked to compare their representations of the goal achieved with those of goal-not-achieved representations. Within all activities, participants weren't informed about which day's representation they were observing. The last two activities mentioned investigated if participants were able to recognise changes in goal state and activity pattern between two representations. A generalised interview questionnaire prepared will be included in appendix (G).

The follow-up interview data were collected in the form of audio recordings, these recordings were transcribed to perform qualitative content analysis for each of the emotions analysed within this study. After the successful transcription of the recording, all the recordings were destroyed.

5.3 | Data Analysis

5.3.a | Analysing survey and step data

The step data collected during the study was used to analyse the goal state of the participants over the test period of the study. Total steps taken for a day were compared with the goal set for that date to determine if they achieved their daily goal. The data for all the participants are shown in Table 13. The table is colour coded to represent the goal state, green colour is used to represent the goal achievement state and yellow is used to represent the goal non-achievement state. Additional information related to the discrepancy between the goal and the steps taken was also determined.

Table 13. Goal state of each participant with goal discrepancy to reach the step goal.

Participant/ Day	DAY1	DAY2	DAY3	DAY4	DAY5	DAY6	DAY7
1	-1,957	-2,104	-844	-2,085	-3,534	9,579	13,939
2	1,597	1,900	995	9,757	115	2,132	1,327
3	1,383	1,262	-2,713	-1,401	1,174	256	-228
4	1,056	-666	10,201	-512	8,613	-6,575	-5,135
5	-1,364	195	-6,662	-812	-5,158	-452	-2,257

(Colour coding: green represents goal achieved, Yellow represents goal non-achievement)

Reflection of Days 2,5 and 7 representation was recorded within the check-in survey. Participants recorded their association with 8 emotions presented. This data was collected in the form of a Likert scale. All the entries collected were filtered with the goal state of participants and represented in Tables 14 and 15.

A colour coding method was used for analysing the results, The values from the Likert scale were converted into colour blocks representing positive or negative outcomes related to emotions. The Likert scale represented 1 for the least association with emotion and 5 for a high level of association with emotion. For negative affective states of Disappointment, Frustration, Regret and Guilt responses recorded with a lower level of the association are colour-coded green as it refers to positive emotional outcomes. Responses recorded with higher levels of the association are colour-coded as yellow as it refers to the negative emotional outcomes. For positive affective states of Pride, Hope, Relief and Relaxation

Goal achieved								
		Positive affective states				Negative affective states			
Day	participant	Pride	Relaxation	Hope	Relief	Regret	Guilt	Disappointment	Frustration
7	Participant 1	5	4	5	5	1	1	1	1
2	Participant 2	1	3	4	3	2	1	2	2
5	Participant 2	1	3	4	3	1	4	1	1
7	Participant 2	2	4	2	3	4	4	3	3
2	Participant 3	4	2	4	3	3	2	2	2
5	Participant 3	3	2	2	2	2	4	4	4
5	Participant 4	4	1	3	2	1	1	1	1
2	Participant 5	4	4	3	4	2	1	2	1

(The responses were recorded on a scale of 1-5 of association with emotion.
The colour-coding approach is explained in Table 16)

Goal non-achievement								
		Positive affective states				Negative affective states			
Day	participant	Pride	Relaxation	Hope	Relief	Regret	Guilt	Disappointment	Frustration
2	Participant 1	4	3	2	3	1	2	2	3
5	Participant 1	3	4	5	4	2	1	2	4
7	Participant 3	2	1	2	2	2	1	2	4
2	Participant 4	4	2	2	2	1	1	1	3
7	Participant 4	2	3	2	2	4	2	3	1
5	Participant 5	2	3	4	2	4	1	4	3
7	Participant 5	4	3	4	5	2	2	3	2

(The responses were recorded on a scale of 1-5 of association with emotion.
The colour coding approach is explained in Table 16)

responses recorded with a lower level of the association are colour-coded yellow as it refers to negative emotional outcomes. Responses recorded with higher levels of the association are colour-coded as green as it refers to the positive emotional outcomes. In both cases, the responses recorded as neutral were colour-coded as grey. The coding methodology is represented in Table 16.

Table 16. colour coding methodology used for the analysis of the survey entries shown in Tables 14 and 15.

	Higher association	Lower association	Neutral
Positive affective states	Positive outcome	Negative outcome	Neutral
Negative affective states	Negative outcome	Positive outcome	Neutral

5.3.b | Follow-up interview analysis

After concluding the test period of the study, a follow-up interview was conducted to gather more information about the experience of participants with the prototype. The data collection was an audio recording, which was later transcribed for analysis purposes.

The analysis of the interview was performed with two stages of thematic analysis, The first stage of analysis focused on comprehending emotions and responses related to influencing the emotions mentioned in the follow-up interview. The results from this stage of analysis are discussed in Chapter 5.4.b, the chapter on follow-up interview data analysis.

In the second stage of thematic analysis, The interview responses underwent analysis and were grouped into three broad themes: Reflection, Behaviour Change, and Music. The theme of Music was highly prominent as it was one of the focus points for the study but the reflection theme formed from collecting codes related to participants describing their interpretation of representation and how they perceived their PA within the representation. The Behaviour Change theme was developed from the coding of responses related to participants describing any change in behaviour that was inspired by representation. The outcomes from this stage are discussed within the Chapter thematic analysis (5.4.c).

5.4 | Results

The results of the study have been divided into three categories, Qualitative, Follow-up interview data analysis and Thematic analysis. Each of the categories will contain a presentation of the results found within the analysis stage.

5.4.a | Quantitative data analysis

Data collected from the introduction survey showed that all of the participants had used a fitness tracking device in the past and regarding the reflection period, 2 participants responded more than once a day; The remaining responses were either daily, weekly, or monthly and each received only one response

The goal progress of each participant reveals an intriguing observation where Participant 2 managed to achieve every goal set within the study period. Therefore, there is no data on participant 2's failed goal state for the study. A summary of the goal states of all participants can be seen in Table 13.

From the analysis of Tables 14 and 15, some interesting observations were found. Regarding the goal achievement state, there are instances of association with a range of negative affective states reported by P2 and P3. On non-achievement of the goal, there is only one instance of disappointment recorded by P5. There are no instances of guilt association among any participants. Only two instances of frustration and regret were recorded within the survey entries. Given the nature of the data collected, these instances will receive further analysis in the qualitative data analysis. Drawing conclusions solely from the quantitative data may result in false assumptions.

5.4.b | Follow-up interview data analysis

Pride

Within the goal-achievement state, only P2 reported not associating with pride for the whole period of the study even though they did achieve every goal set for them. During the follow-up interview, P2 expands to mention that achieving these goals(step goal) does not make them feel prideful whereas completing a marathon or intense PA would make them feel prideful. Showing more evidence of the subjective importance present in determining the value of the outcome. Since P2 did not value the outcome associated with achieving the step goal, they did not experience any feeling of pride whereas a more challenging goal like running in a marathon would make them feel prideful about achieving their goal.

In the goal non-achievement state, there is only one instance for P5 who felt prideful about their representation although they failed to achieve the goal with a discrepancy of 2257 steps on Day 7. P5 mentioned, *"I've been more active last evening compared to the past few days, so the sounds reminded me that there is room to do more and that I'm not doing too bad in trying to achieve the goal..."* P5 noticed a change in music for Day 7 compared to the previous day, which made them feel better about the performance for that day.

P1 also recorded associating with pride on Day 2 where they failed to reach their goal with a discrepancy of 2104 steps. *"After seeing my results, I felt satisfied & I felt like I actually accomplished something."* P1 further explained that they were feeling sad from external circumstances and seeing the visualisation made them feel happy and provided them with a sense of achievement. The sense of achievement could be tied to a drastic change in the representation between day 1 and day 2 can be observed in Figure 18a and Figure 18b. Even though P1 failed to achieve the goal with a bigger discrepancy on day 2 there are more visible activity spikes in the representation which could point towards their feeling of being satisfied with the result.
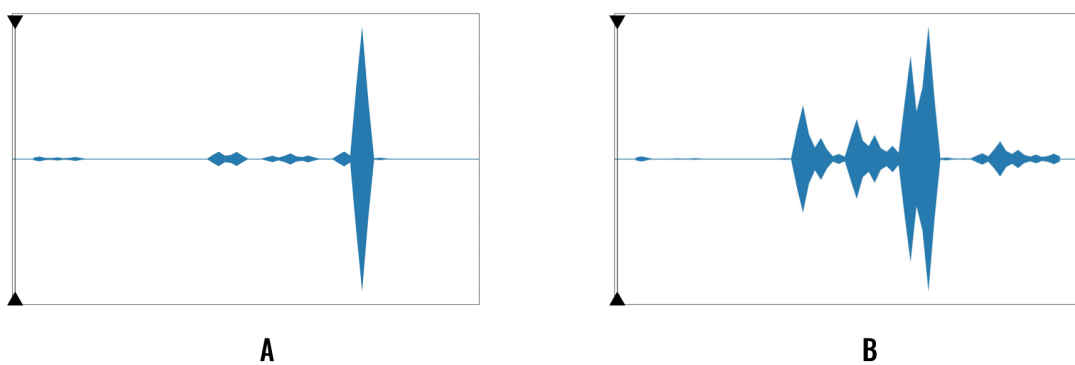

A   **B**

Figure 18a and 18b: Representation of P1 for day 1 and day 2 respectively.

P4 showed similar behaviour on day 2, and the representation inspired pride for P1 despite failing to reach their goal by a discrepancy of 666 steps. In the follow-up interview, P4 explained further that they were happy with their performance as long as they could see activity peaks with few gaps in the representation, regardless of their goal state.

Relaxation and Relief

From the results, P1 mentioned feeling relaxed on day 5, when they failed to achieve their goal by 3534 steps. In the follow-up interview, P1 mentioned that relaxation mostly attributed to taking a walk which had a calming and relaxing effect on them. The responses collected from all

participants there is no association with relaxation related to the goal state. Three participants mentioned music creates a calm and relaxing environment. One instance of this can be observed on day 2, P5 achieved their goal and elaborated that the music inspired them to feel relaxed. *"The sound is relaxing and powerful. Hence I felt relaxed and had pride"*

The instance of association with relief found was related to the music as well. One instance from P5 on day 5, where they failed to reach the goal with a discrepancy of 5158 steps. P5 mentioned the feeling of relief in the survey entry. During the follow-interview, P5 explained, *"Sounds better than the previous sound so I felt relief, and there's hope to get something better next time."* For P5, music produced from the representation was an important factor for self-reflection, and observing the change in music made them relieved about their performance. Expanding further on the sound P5 mentioned they interpreted the sound notes increasing or decreasing in the progression as directly related to their level of performance or activity. A PA representation of day 5 can be seen in Figure 19b.
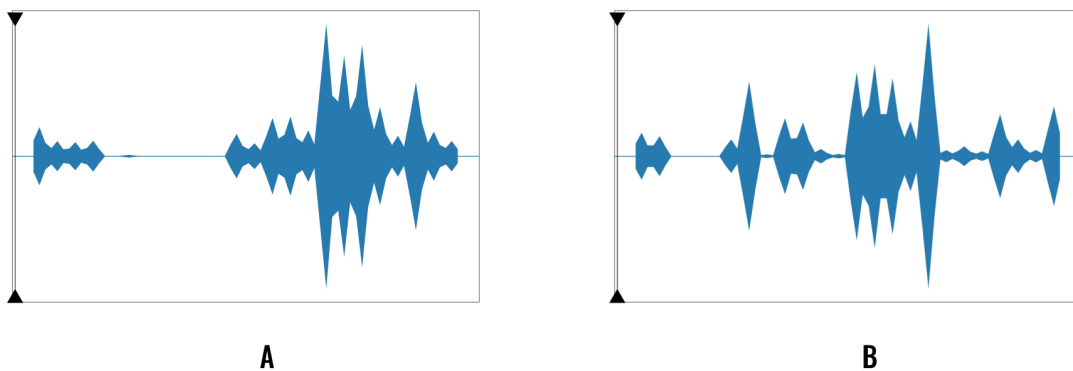

A   **B**

Figure 19a and 19b. Representation of P5 for day 4 and day 5 respectively

Hope

One example of Hope inspiring motivation can be seen within P1 during the interview when asked about what inspired hope for them, P1 responded with *"since I saw the big peaks(activity spikes), I felt like I'm doing some stuff here. I'm doing something actually good here and seeing these(representation) actually motivated me to keep pushing for the rest of the days"*
The activity spikes within the representation became an indicator of their activity and motivated them to strive for more activity spikes. In the case of P3, The representation design highlighted their inactivity, resulting in a decreased association with hope. The discussion about P3's emotions of frustration will be covered later as it provides more context for this association.

Guilt and Regret

From the results, there is no association of guilt within the goal non-achievement state. There were 3 instances of participants associating with guilt in the case of goal-achievement. During the follow-up interview, P3 commented that they associated guilt with day 5. *"I think mostly, it's just the flatline. because I believe it represents the steps during the day and those flatlines are just really like, you're just sitting and waiting and you feel like, you start to feel like I should have done something in this. But that makes me feel a bit bad about myself for not having done something at those times and for not taking any steps there."* P3 mentioned that the representation highlighted their inactivity. P3 had a pattern in their physical activity, in the evening P3 would go out for a walk which would contribute a significant amount of steps each day. In the representation, it would be represented as a single activity spike and a single note of music since the activity was done within an hour. Aside from this activity, P3 typically did not engage in much physical activity. The combination of these events created a scenario where the representation highlighted P3's inactivity, leading to feelings of frustration with the representation and guilt about not engaging in enough physical activity

Two instances of guilt were recorded for P2. Although the participant did accomplish their goal on both of these days they felt guilt. The follow-up interview provides further insight into these instances. *"Just the tones didn't connect to the activity, just like the song that the song was, the notes were pretty low, and then this felt like some sort of guilt. I don't know. Maybe it was my power while I was feeling and stuff coming into the mix as well. Now that I'm thinking about guilt again, I'd still feel like I'm guilty of something."* The tones(Music notes) are connected with the activity and with some descending activity spikes can create lower tones. Although P2 did achieve their goal that day, P2 also mentioned that external influences could have contributed towards the emotions and not necessarily the representation. Considering these records, P2 responses recorded during the survey might not represent an accurate view of P2 feelings about representation. Although the emotions of guilt could be caused by activity unrelated to PA, the participants' emotions were intensified with lower tones produced with the downward progression of the music.

P4 reported feeling regretful on Day 7 when they failed to reach their goal with a discrepancy of 5134 steps. This was the biggest discrepancy to reach the goal achievement for P4 during the test period. P4 mentioned *"I felt that I could've moved more or gone outside a few more times making me feel regretful"* The representation pointed to them that their level of activity is less compared to the previous days compared to the representation of Day 7. The representation of day 6 and day 7 could be seen in Figure 20a and Figure 20b. This made them regretful about their decision not to go outside, which could have contributed to an active representation and probable goal achievement.
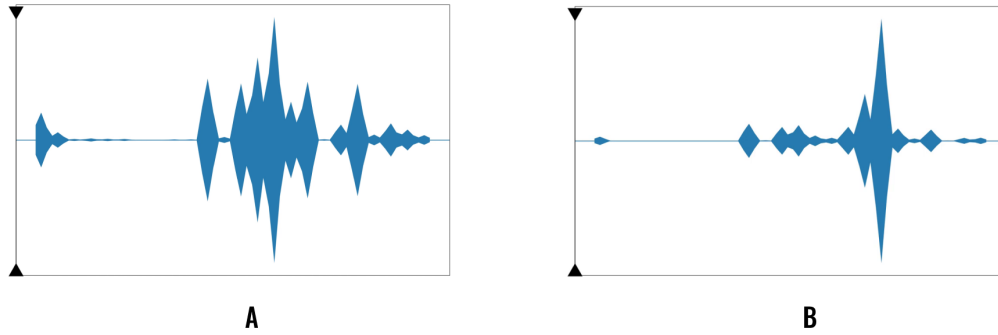
Figure 20. a and 20b: Representation of P4 on day 6 and day 7 respectively.

P5 reported feeling regret on day 5 where they failed to achieve their goal with a discrepancy of 5158 steps. P5 mentioned that they could see the frequency of the activity spikes but the music produced in the representation gave them a sense that they did not reach their goal for that day. P5 mentioned ***"The sounds seem duller, but it is relaxing and there is some hope. Feel a bit of regret, since it maybe would've sounded nicer if I did more steps."*** On this day P5 mentioned feeling disappointed due to their performance.

Frustration and Disappointment

From the results, 2 participants recorded 3 instances of associating with frustration. P3 recorded 2 instances of frustration. P3 recorded frustration on day 5 and day 7, from these two instances on day 5 they overachieved their goal by 1174 steps. Although P3 did succeed in their goal the pattern of activity was still dominated by empty space and some activity spikes sprinkled. The representation of day 5 and day 7 for P3 can be seen in Figures 21a and 21 b.
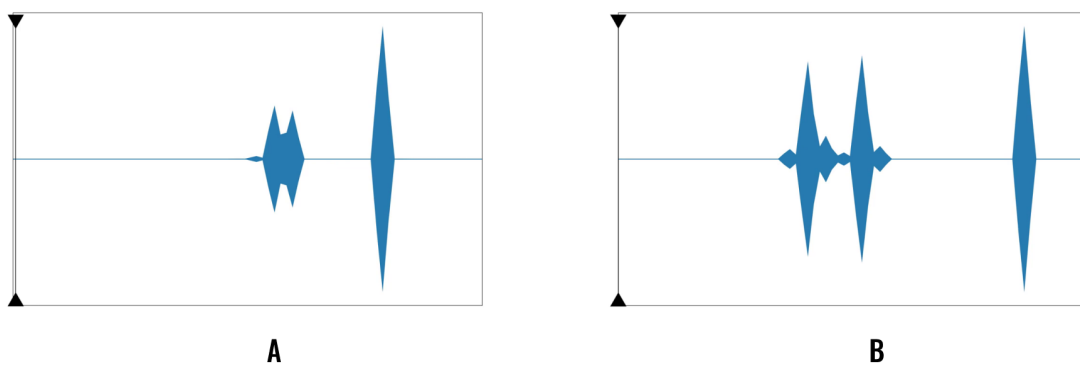

Figure 21a. and 20 b. Representation for P3 on Day 5 and day 7 respectively

P3 mentioned after day 2, they started to become frustrated with the representation. P3 mentioned having a positive reaction towards the first couple of representations but the realisation of representation highlighting the inactivity made them frustrated. According to P3, the representation highlighted their inactivity more than the activity. A majority of the

activities performed by P3 took place during their evening walk. P3 commented *"I wanted to (be more active) but my own physical ability didn't allow me to have those days where I could actually change things because it was often like, the third or fourth day where I would actually want to change things that were a day I just needed rest. Because if I kept pushing on my legs, it would just hurt"* for P3 the intrinsic value from performing more PA diminished once they realised that within their schedule and own ability to perform PA, they would not be able to reach the state of PA they desired. This realisation made them frustrated and the representation highlighting empty spaces made the realisation more intense for P3.

For P1, they recorded frustration on day 5. Previously P1 had failed to reach every goal set. On this day P1 failed to achieve the goal by the discrepancy of 3534 steps which was their highest discrepancy. Considering this the only negative emotions registered in the survey were frustration. P1 expands further on their reflection in the follow-up interview.*"After seeing the number of steps I took that day, I was expecting more. I wasn't checking it regularly and when I was getting close to home, I was like, oh, no, I didn't accomplish it and I didn't think I did like the amount I wanted to so I felt frustrated because of that"* P1 mentioned they noticed they are lacking steps needed to reach the goal after they finished with their daily walk and they could have taken more steps if they realised it before. The ability to not reach the goal made them frustrated.

Besides P3 there was only one instance of disappointment recorded by P5 after failing to achieve their goal, On day 5 P5 failed to reach the goal by the discrepancy of 5158 steps. Where the descending tone in music compared to the previous day indicated to them that they had done less PA on that day. For this instance, they had recorded feeling regretful for not doing enough PA and disappointment seems to be correlated.

5.4.c | Thematic analysis

The interviews were analysed further using thematic analysis, The interviews were analysed into three broad themes Reflection, Behaviour change, and Music. The theme of Music was highly prominent as it was one of the focus points for the study but the reflection theme formed from collecting codes related to participants describing their interpretation of representation and how they perceived their PA within the representation. The Behaviour Change theme was developed from the coding of responses related to participants describing any change in behaviour that was inspired by representation.

Reflection

Each participant's interpretation of the representation could differ, as the nature of the representation allows for open interpretation. This section presents results related to how the participants used the representation for reflection on their PA performance.

During the follow-up interview, participants were asked to describe their day after viewing the representation of the seventh day. During this activity, P3 and P4 explained their PA by highlighting the visual aspects of the representation. Within visual aspects, Participants preferred to describe the activity in relation to the activity spikes. Participants associated the frequency of activity with the frequency of spikes on the timeline showing how active they were during the day. P4 mentioned during the follow-up interview *"I thought going through the first 3-4 days I saw that there were a lot of solid blocks and I felt that. I'm doing a lot better."* P4 refers to activity peaks appearing near each other forming 'solid blocks'. As long as P4 could see these blocks in a day's representation, P4 was happy with their performance. This showed a preference for visual components as a means of providing feedback on their PA. P3 made an interesting observation about the representation, P3 stated that during the first couple of days, they felt proud of their representation and hopeful to achieve the next activity goals. But after the third day when they failed to achieve the goal, they became frustrated with the results shown. Their response to seeing the representation on day 5 was *"Now that I've seen it for a few days, the long silence at the start is starting to annoy me."* P3 further elaborated in the follow-up interview *"I believe it represents the steps during the day and that flatline is just really like, you're just sitting and waiting and you feel like, you start to feel like I should have done something in this. But that makes me feel a bit bad about myself for not having done something at those times and for not taking any steps there."* [Figure 21a](#), Shows the representation of Day 5 for the P3 where they overachieved their goal by 1174 steps. The single walk performed by P3 is represented in [Figure 21a](#) as the largest activity spike. Besides that activity spike, there are very few activity spikes present and the rest of the representation is empty showing the inactivity of P3, Music produced from this representation was disjointed as the gap between activity spikes wasn't assigned any music notes. This production created a scenario where most of the representation would be empty and void of music. P3's frustration was motivated by seeing the empty spaces even in cases where they reached since the most active PA they performed was only represented as a single activity spike in most cases for P3.

P1, P2 and P5 showed a preference towards interpreting the representation with audio as the focus rather than focusing on visual elements. P5 commented after reflecting upon Day 7 *"I've been more active last evening compared to the past few days, so the sounds reminded me that there is room to do more "* Although P5 did make some comments about the visual representation, they drew more of their conclusion about the representation from the music. P5 explained *"That sound really is an easy way for me to recognise the differences in my activities. because I like music a lot. So it's easy for me to interpret the information to sound."* From the follow-up interview analysis, If the music produced ascending tone, P5 felt hopeful and relaxed but when music produced descending tones they felt they have been lacking in PA towards their goal. P2 also showed similar behaviour when comparing two representations *"The first one builds up slowly like it goes day in day and then the active part like ding, ding, ding ding."* This response showed their preference to understand the representation with music and it also shows in

another scenario where P2 mentioned their desire to replace the current style of music note production with a more upbeat style of music as they thought it represented their activity better. P1 also showed an intent to utilise the music for reflection as they mentioned *" I know when I listen to the music, I know that I either take fewer steps or more steps, I can visualise it in my head. like the periods of time, my walk took more steps or less."* The response highlights the emphasis on the audio aspects as it was an indicator for the PA for P1.

An interesting observation was made when asked if participants had attempted to share the representation with anyone, P2 and P1 mentioned sharing the representation with each other. Since both of the participants were living in the same household. They mentioned comparing the music with each other and trying to see any differences between their representation as a fun activity. P3 also showed interest in sharing the music under circumstances where they were familiar with someone who was using the method of representation for PA.

Behaviour change
This section will explore participants' behaviour change intent and what action they took to pursue that change within the period of the study. For P1 and P5, Representation highlighted the inactive zone in a day, which led them to be more aware of their activity pattern and they mentioned taking an effort to do little activities like walking around in the house. P1 commented *"I liked the music as well. So I was like, why would I walk in a very small amount? why not Just, I don't know how to explain it, divided it all. So I get a good beat as well. So I tried staying active throughout most of the day."* This shows an indication of doing some PA to avoid the empty spaces within the representation to have a representation with more music. This motivation to receive the music motivated them to be active throughout the day. P3 also mentioned that they were motivated to take an extra walk beside their regular scheduled PA. P3 mentioned *"The representation did motivate me to get more steps on more days. I believe sometimes I indeed went for the afternoon walk as well as for a shorter walk next to the evening walk to try to achieve more steps."* Signifying that they had made efforts to be more active but they did not want to exert themself physically, If the goal scaling within the study were not present it could indicate more motivation to perform PA since the goal will remain the same.

 For P2 they did mention making changes in the pace of their walking and other activities to see changes in the representation. P2 commented *" Yeah. Actually, in my daily walk, I would go slower than do fewer steps because I did a time walk not to step work, I would see changes."* It showed a tendency to compare the representation and curiosity to experiment within the PA. Participants felt motivated to take some action to modify their PA to be more active in the representation. Both visual and audio methods did help in motivating the participants. Although some participants mentioned they failed to act upon their findings or take significant actions to make a behaviour change. P4 mentioned *"I saw the thing (representation), and then I remembered. I should walk more on the current day or something. But then I just got busy with my*

work and I Forgot" even though the representation did make them aware of their inactive zones and provided some motivation to take action, due to external factors they could not make any significant change in PA during the period of the study. P5 mentioned *" It (Representation) made me aware and just aware that I wasn't so active. That was enough to just do a little bit more, but it wasn't a very significant change. But I was definitely aware of it."* The representation made them aware of the activity pattern but did not motivate them to make a significant change in their activity pattern.

Music

In this section the role of music will be explored from the responses of participants to understand how participants related to music. Having music accompanying the representation made the participants curious about their representation which led them to explore different ways to modify their activity by either changing pace or performing some PA like taking steps in the room.

P3 described *" it (Music) put a bit more weight on the representation. It's not just you're seeing this spike somewhere. And I'm like, Yeah, that's a spike. You actually hear something as further feedback"* Music notes created another layer of feedback on top of the visual representation. This observation can be seen with P2 and P5 as seen in the reflection theme also. P2 commented *"I'm getting the feeling that I get something done from the song. Because the constant sounds told me that I was active and I was doing something. And that makes me feel better about myself and my healthy life"* This observation provides more evidence that music can be used as a tool to represent the PA. P2 emphasises notes within the music gave them a sense of how active they were in a way. With connections made between ascending and descending patterns of music notes, they could visualise their activity pattern without relying on the visual method.

The activity of listing to the music led to a calming and relaxing experience for participants where P3 mentioned *" The moment the music is playing, it's a nice touch that is, in a way a bit calming and gives some weight to the number of steps you've set"* P2 shared similar sentiment commenting *"The low-tone sounds also bring you a relaxed feeling, you feel a bit more chill. This constant flow of music is pleasing to the ears."* Both participants had a pleasing experience with the presence of music even in cases of failure of goal. Besides providing a calming experience, P4 mentioned *"Music just kept me curious, I wanted to see what was going to happen the next day. So maybe that made me focus that okay, I need to go back again to see what was the result actually. So that was just a factor that kept me coming back to view this graph,"* music motivated them to be involved in checking on PA during the study period and this behaviour could be seen in other participants to a different degree where participants were making changes in their PA to see them reflected in the music. P2 mentioned that music played a primary role while reflecting on the representation. P2 mentioned *"The secondary role, I guess, was the graph that it formed. But the music was the defining factor, in my opinion."*

One of the objectives of music in representation was to signify the goal state to participants, music failed to convey to participants about the goal state. To signify the goal state the tempo of the music was changed, but when asked participants to notify of any change between the goal achieved and non-achievement state. Most participants did not make a direct connection to the goal state but participants did notice the change in tempo. P5 made the connection of tempo with the frequency of workouts, commenting *"The first one is faster. The first one seems to go faster. And I'm not sure why. More frequent workouts? So there are more frequent sounds in the representation."* For the same representation after a short while, P5 provided more explanation *"This sound has a bit more descending or augmented notes, and I didn't think I was almost at my step goal. I wasn't quite there yet and compared it to the previous day. As you can tell, the sound is a bit more diminished"* when shown representations of goal failure and success. This was the only instance where a participant provided some explanation about the change in tempo.

Some of the participants pointed out that sometimes music produced a series of notes within the representation that seemed misplaced, as explained by P4 *"The chords were a bit confusing for me because I didn't know what to make of it, maybe I assumed it was gonna go like a higher octave"*. This quote referred to P4 observing a sudden change in notes within the representation. One possible reason for this behaviour can be designed for the music note assignment as once the highest note is assigned to an activity spike if the next instance of the activity spike is higher than the previous activity spike, the loop of assigning notes will reset which results in assigning notes 'C' which could be 2 steps below the highest note. A similar remark was made by P5 about the progression of the music and pointing out sudden changes when ascending levels of activities are present.

5.6 | Discussion

In this chapter questions posed in Chapter 5.1 will be answered. The subquestions outlined will be discussed, using the findings from the results and discussion.

5.6.a | Discussion related to affective states

The analysis shows that emotions related to achievements are based on subjective values that individuals attach to the outcome or activity of physical activity (PA) itself. This effect is evident in the results, P2, even after reaching every goal set during the test period, did not associate with pride due to perceiving the intrinsic value of the outcome as lower. Whereas P1 and P4 were associated with pride showing evidence towards the representation of inspiring pride where the intrinsic value of the outcome is perceived at a higher level. These findings correlate with the theories presented within the achievement emotions theory [32], Pride is elicited by the subjective value assigned to the outcome of the activity [31]. The design for affective states should consider the perceived values of outcome and activity from individuals as they can influence the emotions associated with the outcome.

Emotions like frustration and disappointment were attributed to comparing the representation with the previous days. In the case of failure of goal, If participants observed upward progression within the representation it indicated to them that they had performed some activities that they can feel proud about. Respectively if the representation showed a downward progression with visual and music representation it was perceived as undesirable. This helped inspire participants to take a closer look at their PA patterns and find ways to improve their PA.

Disappointment is considered an outcome-related emotion [32], within the study one instance of disappointment was observed within the goal fail state. One of the possible reasons for low association with this emotion can be the intrinsic value attached to the reward obtained. Even if the goal wasn't achieved, participants received the reward for doing the PA and making progress towards the goal. This acknowledgement could be a factor in the reduction of intense feelings of disappointment. The changes in the PA pattern were observable from participants and they could notice changes made in the activity pattern which could also help in feeling a sense of achievement from the representation presented. This phenomenon can be observed in another study where 3D printing was used to represent the PA of individuals [52]. The study also points towards the showing representation of PA in a personalised form helps in creating a sense of achievement for the PA performed.

Frustration is classified as an activity-related emotion [32], The intrinsic value of the activity performed contributes to this emotion. This emotion was experienced when participants failed to reach their desired activity levels. The lack of activity was shown in representation in the form of silence and black space. If the occurrence of these black spaces were frequent emotions of frustration could be experienced. Although it is considered a negative emotion the occurrence of frustration could be motivating [49]. P1 reported feeling frustrated with their performance from day 5 but they experienced feelings of hope due to the representation and reward of music production. The feeling of frustration can be understood as a driver to motivate participants to reach their goals.

The instances of associating with regret in case of goal failure were related to external circumstances preventing individuals to perform PA or their decision-making ability to perform PA. Although getting an overview of PA performance helped in reducing some of the intensity, there can be cases where the effect of low progression of tone in music could lead to feeling negative emotions. As shown in a study by Webster and Weir [64] shows that lower tones and anharmonic music could lead to feeling negative emotions. If the participants were inconsistent with their PA in a day it could lead to representation being represented in the empty spaces. This was mostly observed in the case of P2, and they did mention that the negative emotions they were experiencing could be a result of external influence but the possibility should be considered that it can be due to the representation as well.

There was no association with feeling guilty when failing to reach the goal. The results show the prototype helped individuals understand their PA and the representation method could be used to reduce the feeling of guilt associated with goal failure. Individuals might feel guilty if they sense due to their actions the result has come to a goal failure state [25]. The representation showing the PA performing in a day can reduce the chances of experiencing feelings of guilt since they could see the PA perform and receive rewards although they failed to reach the goal.

The results only mention two instances of pride within the goal failure state but representation did manage to inspire a sense of achievement for all of the participants. The music within the representation was attributed to the feeling of a sense of achievement. The personalised music received by participants as a reward for performing the PA can explain the association with a sense of achievement. Participants valued the reward received as the prototype acknowledged the efforts taken towards their goal. The representation did not hold back rewards from participants even when they failed to achieve the goal. Acknowledging efforts increases the self-efficacy of an individual [73].

The theory of self-efficacy posits that individuals will be more likely to engage in behaviours they believe they can successfully perform and avoid behaviours in which they feel they will be unsuccessful. Self-efficacy perceptions help to shape individuals' efforts, affective experiences, and enjoyment of physical activities [74]. The sense of achievement inspired by the prototype could help in building self-efficacy in individuals to help in their goal journey.

Relaxation and relief, both considered deactivating emotions, were not associated when analysed with the goal non-achievement context. Within a goal-achievement context experiencing relief and relaxation could inspire less motivational effects to create a feeling of stagnation [21]. This implementation of representation showed music could help create a relaxing environment and provide relief in some cases while avoiding stagnation of motivation to perform PA. Emotions like relaxation and relief can have deactivating effects in the case of goal achievement if an individual perceives it as there is no room to improve which could lead to stagnation of performance [75]. The representation motivated participants to be more active throughout the day as they showed aspiration to see more activity peaks and variations of music.

Hope showed similar results where if the representation consisted of frequent activity spikes, it provided a feeling of hope to participants. The relation between hope and motivation to perform PA to reach the goal is explored within a sports context. Participants who reported a higher hope association led to better performance and better self-confidence perception than participants who reported less association with hope [43]. It was observed that all the emotions related to hope, relief, and relaxation show a positive association with the production of music. A similar effect can be observed within P1 and P5 where both participants mentioned music created a calming experience and provided them hope when they encountered some external factors influencing their emotions.

P3 highlighted an interesting observation, P3 became frustrated with the representations as they believed that the representation highlighted the inactivity within their PA. P3 could observe the representation being dominated by empty spaces which led them to feel guilty about not performing enough PA. The empty spaces in representation could inspire some negative affective states if the individual recognises they can not make the desired change in PA. One of the possible reasons for this behaviour in the study could be contributed to the study design. During the test period, the step goal for each participant was increased daily which could have contributed to negative emotions as the test period carried on. The constant change in step goal could have prevented P3 to make the necessary changes in behaviour in the time. Another reason contributing to the negative emotions could be that the prototype design does not emphasise the PA when the individual only performs one activity in the whole day. Since it will be only represented as a single activity spike and the rest of the representation will be dominated by empty spaces.

5.6.b | Exploration of research questions

SQ 1: Can participants understand the relationship between representation and their PA?

The study shows promising results for representing the PA with music. The prototype provides two ways to interpret the presented PA data, Participants showed preferences for both of the methods. The visual representation utilised the activity spikes to show the PA performed, and the musical representation associated a music note with each activity spike. This collaboration between visual and musical elements helped participants understand their activity patterns. Inactivity within the representation was shown with emptiness. Looking at the gaps in representation and the music, participants could easily gauge their activity level and observe their active zones in a day. These observations Inspired participants to be more active throughout the day in the hope to achieve a representation with fewer gaps.

The prototype is very effective in showing the activity performed in a day, The activity spikes and accompanied music were regarded by participants for easier understanding of the activity pattern. Participants were able to listen to the music produced for a day and get a sense of which period of time they were being active. The results show that participants were able to associate the music with PA and it effectively reflected the changes in PA throughout the day. This behaviour has been shown to motivate participants to come to make their own conclusion about the activity and current progress towards the goal to make a change in the activity pattern. The representation was successful in depicting the PA of participants, allowing participants to self-reflect and motivating them to make connections between the data represented and PA performed. The prototype shows positive results in representing the PA and providing motivation to participants to perform PA.

SQ2: How does the representation help reduce the negative affective state related to the failure of the goal?

The results presented above show a low association with the negative affective states when encountered with goal failure. Disappointment and frustration were identified as the most common emotions experienced when encountering a goal failure. The results within the study show a handful of instances of association with those emotions. The representation method helped participants to understand their PA pattern and be rewarded for the PA performed Even if the goal wasn't achieved. The combined effect of the representation mentioned inspired a sense of achievement for participants which could be contributing towards less association with negative emotions.

The sense of achievement can be linked to participants' self-efficacy. The prototype design shows potential for using this representation method to help build self-efficacy for permitting the PA. Although the study did not measure the self-efficacy level of participants, future studies could explore the effect in greater detail and make more concrete statements regarding self-efficacy. Other emotions related to self-efficacy like guilt have no instances observed within the data analysed.

SQ3: How can music within representation inspire a feeling of pride?

The representation helped participants in building self-efficacy and inspiring a sense of achievement even in the case of goal nonattainment. This finding shows that creating a representation method where an individual can observe their intra-day activity and be encouraged to self-reflect on their activity can lead to creating a sense of achievement feeling associated with the PA performed. The sense of achievement is tied to the personal evaluation of an individual of their capability to perform PA. Acknowledging the efforts performed by participants towards reaching the goal is a successful technique used to help build self-efficacy within individuals [35] [20].

As discussed within achievement emotions, some of the negative emotions can be classified as activating emotions helping individuals to motivate towards a goal. The study shows personal perspective on the goal and motivation to perform PA is an important factor for experiencing an affective state associated with achievement. A design emphasising and acknowledging the efforts of individuals towards a goal can inspire a sense of achievement by building self-efficacy related to PA. The prototype shows an alternative method of representation that can be effective to prompt PA.

The reward received from the prototype was considered rewarding by participants due to its personalised music production. Personalised music can be explored as a type of reward given for performing PA replacing the less effective but popular methods of reward like badges and ribbons [76]. The prototype helped in making a connection with the rewards presented to participants, making them more valuable than a digital trophy. The possibility of receiving a new reward each day enticed participants to self-reflect and perform PA.

SQ4: How does music inspire a feeling of relaxation while reflecting on representation?

The results indicated that the prototype created a calm and relaxing environment, allowing participants to reflect on their PA patterns. Participants reported feeling relaxed and calm upon listening to the music. The music's tones were associated with inducing a calm and relaxing feeling. Although the music did achieve an inspiring calming effect. The downward

progression of music in some cases was associated with negative emotions and amplifying those emotions. Music can be an influential factor in experiencing emotions so the use of music should be designed carefully.

From the results, two participants mentioned music creating a relaxing or calm effect where their emotions were being influenced by external entities. The production of music helped in the creation of an environment for self-reflection where participants reported feeling relaxed and calm. The use of music in anxiety control has been studied before where calm and relaxing music was recommended for individuals suffering from anxiety [77], [78]. Music also has been studied as a good influencing factor for emotional regulation [64], [79], The study shows how music can be utilised to create a relaxing and calming effect paired with a change in the progression of notes showing changes in PA.

The discussion shows music within the representation managed to help motivate individuals to perform PA while avoiding the negative effects associated with relaxation and calm feelings to demotivate individuals. .

SQ5: Could music alone facilitate an indicator of the goal state?

The goal state was conveyed with a change in the tempo of the music, the goal-achieved state representation was produced with 120 bpm and the goal-failed state was produced with 80 bpm. Although participants noted the change in the tempo of the music they were unable to make the connection between them. The prototype failed to convey the goal state to participants. The change in the tempo of the music alone was not enough to indicate a change in the goal state. The relationship between the tempo and goal state was never communicated to participants during the testing of the prototype. One participant misinterpreted the change in tempo as a representation of the activity level of the day.

The prototype attempted to convey the goal state through a change in the tempo of the music, but failed to effectively communicate the change in goal state to participants due to a lack of communication about the relationship between the tempo and the goal state.

5.7 | Conclusion

The results and discussion point towards the prototype showing positive results in alleviating certain negative affective states, disappointment and frustration which were identified as the most common emotion when goal failure occurs. The study highlights the use of music as a way to represent the PA and provides evidence that this method could be a good tool for rewarding individuals and supporting them in alleviating negative emotions in case of goal failure.

The evaluation shows that there were fewer instances of participants experiencing disappointment and frustration, which were the most associated emotions with goal failure in study 1. The ability of representation to acknowledge the efforts of individuals towards goals helped to inspire self-efficacy to perform PA. The prototype shows positive results towards utilising music for the representation of PA and supporting individuals to inspire behaviour change. Music within the prototype provided a relaxing and calming effect to the participants to self-reflect on their PA. The prototype highlights music can be a great tool for rewarding individuals as the participants appreciated the music and considered it the primary motivator for them to self upon their activity.

6. General discussion

From the discussion and results presented in both studies, the research provides evidence on how to tackle negative affective states in the event of goal failure. Study 1 helped in understanding which emotions would be prominent when a goal failure occurs in PA-related cases. Study 2 built upon those findings and designed a prototype to represent the PA in the form of music and visual representation. The overall discussion related to the finding will be done within this chapter.

Study 1 revealed that disappointment and frustration are the most common emotions associated with goal failure. In Study 2, there was only one instance of disappointment and two instances of frustration recorded during the study period. Study 2 shows a lower instance of emotions experienced related to goal failure. It is important to mention the sample sizes for both studies are different and study 2 should be performed with a bigger sample size to make conclusive statements. Study 2 suggests that creating interventions to promote self-efficacy may alleviate negative emotions experienced. Within study 1, guilt was the fourth most associated emotion but there were no instances of guilt in the case of goal failure in study 2. The representation recognized the participants' efforts towards their goal, which may have contributed to the lower incidence of guilt observed in Study 2.

Study 2 shows the representation method helped in the inspiring feeling of accomplishment and sometimes prideful feeling. The use of music in the representation method was reported to create a relaxing and calming effect when reflecting on PA. The combined effect of the representation methods helped in creating a positive experience for individuals. The recognition of the efforts towards the goal helped in inspiring a sense of achievement and a feeling of pride towards the PA.

6.1 | Reflection and behaviour change

In Study 2, the prototype presented PA using abstract visual and audio mediums, and participants expressed a preference for using either of the two mediums The study showed participants were able to identify the activity patterns within the music progression. The upward progression of the music was associated with an increase in PA and positive emotions and the downward progression of the music was associated with a decrease in PA and negative emotions. In the case of P2, the downward progression of the music amplified the experienced guilt they were experiencing due to some downward progression of music in the representation. P2 mentioned that the guilt they experienced may not be related to PA or the representation, but it is noteworthy that music may amplify certain emotions. Besides this instance, the use of music as a way to reflect on PA showed positive results towards affective

states and created a relaxing and calm experience for the participants. The prototype created differentiable music production and by analysing the gap between notes participants could make a guess about which day might be associated with the music. The ability to recognise patterns and recall the day associated with just music shows the ability of the prototype to be used as an alternative method for representing PA. To help understand the reflection done on the representation, the level of reflection presented by Fleck & Fitzpatrick [80] can help with understanding how impactful representation can be for individuals.

The five levels of reflection are as follows:
(0) **Revisiting**: Description or statement about events without further elaboration or explanation. Not reflective
(1) **Revisiting with explanation**: Description including justification or reasons for action or interpretation, but in a reportive or descriptive way. No alternate explanations were explored, limited analysis and no change of perspective.
(2) **Exploring Relationships**: A different level of thinking about, Looking for relationships between pieces of experiences or knowledge, evidence of cycles of interpreting and questing, consideration of different explanations, hypotheses and other points of view.
(3) **Fundamental change**: Revisiting an event or knowledge with the intent to re-organise and/or do something differently. Asking fundamental questions and challenging personal assumptions leading to a change in practice or understanding
(4) **Wilder implications**: Where social and ethical issues are taken into consideration.

The ability of participants to draw a conclusion and make relations between representations could be associated with level 2 of reflections. Within this, reflection goes beyond the previous level 1 of reflection to build relations between the description provided. Level 2 reflections' ability to create and explore relationships between pieces of information and experience is crucial in the understanding of the presented data. The prototype provided an incentive in the form of unique music and visual representation every day. Besides P3 rest of the participants mentioned comparing their representation with the previous days. The motivation to compare the representation was associated with observing the change in music production and activity patterns. The most common desire to make behaviour change was related to being more active and having varied representation in both audio and visual mediums. This observation suggests that prototypes provide encouragement for participants to self-reflect on the representation and establish a relationship between their activity pattern and the representation.

Reflection made within level 2 helped participants change their perspective on their activity pattern. Some participants realised that they were more active than they realised before looking at representation whereas others felt that they should be more active to reach their goal. These perceptions about their activity patterns lead them to take action or change their

fundamental understanding related to PA. Participants did show the intent to be more active after looking at the representation and taking action in their own capacity to make the behaviour change. The prototype appears to have inspired participants to make behavioural changes to become more active throughout the day. The ability to inspire participants to make behaviour change can be associated with Level 3 of reflection. Based on the interview responses, it was observed that the prototype was able to inspire behaviour change in some participants without providing direct prompts or nudges.

The prototype encouraged participants to draw their own conclusion about the activity pattern by highlighting the inactive zones in representation. Since there was no direct direction given to participants to make the behaviour change, they had agency in choosing how they wanted to perform the PA. Providing agency to participants can help the individual to be self-confident in their activity which is associated with positive affective states [35], [73]. The provided agency to make decisions can lead to negative outcomes when the representation gives an indication of a lack of progress made towards the goal. The representation showing fewer activity spikes was related to the lack of progress. This could explain the observation made by P3, as they might perceive the lack of activity spikes as an indication of not enough progress made which resulted in feelings of guilt and frustration.

Although some of the participants failed to make a significant behaviour change, the prototype inspired them to self-reflect on PA patterns and motivate them to perform PA. This behaviour shows a level of interest in the process of music production tied to PA. This effect had been studied previously to represent the PA of individuals with the use of 3D printed objects [52] and inflatable objects representing PA [51]. Showing more incentive for creating experiences where creative ways of representing PA are utilised.

A study exploring reward presented within PA-related applications shows the current popular methods of rewarding individuals are insufficient in motivating them to perform PA [76]. The use of music can be explored as an alternative for rewarding individuals. The participants appreciated receiving the music as a reward and regarded music as a primary motivating factor to reflect upon the PA. The music produced could be shared between individuals to compare the PA and music production. Two of the participants within the study shared the representation with each other, showing the representation is being valued by participants.

6.2 | Exploring thesis research questions

SQ1: Which emotions are prominent when goal failure occurs related to physical activity?

The thesis analysed the effects of utilising music as a representation method for physical activity. Relationships between representation and affective states associated with goal failure are explored. Study 1, the emotions survey attempted to fill in the research gap investigating emotions related to goal failure within PA. The study showed disappointment, frustration, regret and guilt were the most associated emotions when an individual failed to achieve a goal. Disappointment is an outcome-focused emotion, the experienced emotion intensity depends on the individual's perceived value assigned to the outcome of an activity. Conversely, frustration is an activity-focused emotion, where the intensity of the emotions felt depends on an assigned perceived value within the activity itself, irrespective of the outcome. Emotions were linked to the self-efficacy of an individual where the perception of self-ability to perform an activity can influence the intensity of the emotions experienced. Thus highlighting the need to consider emotions within the design process and create experiences that support the alleviation of negative affective states associated with goal failure.

SQ2: How do emotions associated with goal failure affect goal progress?

Goal failure often leads to negative emotional states, including disappointment, frustration, regret, and guilt. Factors that influence the intensity of these emotions include the individual's expectations for the goal, self-efficacy, and the perceived value of the outcome. The goal-setting theory promotes the use of challenging goals, however, setting unrealistic expectations can lead to negative goal commitment. The fantasy realisation theory suggests that creating favourable expectations can help with goal commitment. The implementation intention formation strategy can also be employed to promote the realisation of desired outcomes by facilitating goal striving and preventing it from straying off course. Outcome-related emotions, such as disappointment and regret, depend on the perceived match between expectations and the actual outcome with the subjective importance of the achievement outcome. Self-efficacy, or the individual's perception of their ability to perform a task, can also influence the intensity of emotions related to goal failure. Guilt and shame are emotions that are often linked to actions or decisions rather than outcomes and can be influenced by the individual's sense of responsibility and moral values. To design goal-related applications that support individuals in their goal progression, it is important to consider the role of emotions and strike a balance between positive and negative emotions.

SQ3: How can physical activity be represented to help alleviate negative emotions associated with goal failure?

The thesis explored alternative methods for representing PA in the case of goal failure. A set of guidelines and design requirements were presented within the study to guide the design process. The guidelines and design requirements were used for ideation which highlighted the underutilised method for the representation of PA. The Melody concept was designed to utilise music as a means of representing physical activity. The prototype collected steps as physical activity and represented them with the use of visual and audio components. The representation consisted of two components, first was the visual component where activity spikes represented the number of steps and each spike was assigned a musical note which became the second component. The result of the prototype created a representation that provided a unique representation for an individual depending on their PA. The visualisation method was designed to support the efforts taken by individuals towards their goals.

The design of the representation inspired a sense of achievement within the participants Even if the goal wasn't achieved. These results show that the prototype can be used as a tool to help build self-efficacy within participants. Self-efficacy is promoted by acknowledging the efforts taken by participants towards the goal by visualising the PA. The music used to represent PA was shown to be a good tool as it was effective in conveying a general level of activity within a day, the gaps within the notes of music encouraged participants to be more active and see the progression of activity within the form of music. Music helped in creating a calm and relaxed environment when participants were reflecting upon their performance. The study highlights that personalised music could be used as a tool rewarding individuals and create a stronger incentive to engage in physical activity and self-reflect on their representation.

7. Conclusion

The use of music as a representation method for PA has the potential to support individuals in their goal pursuit and alleviate negative emotions associated with goal failure. Personalised music can be used as a tool to acknowledge and reward individuals for their efforts towards their goals, and encourage self-reflection on their PA. Further research should explore the potential of music as a method of representation to create better incentives for individuals to engage in physical activity and increase self-efficacy in regards to PA.

7.1 | Limitations

Sample sizes

One significant limitation of the results presented in the study is the small sample size of participants used. Both studies had relatively small sample sizes. It remains unknown if a larger sample size will have an impact on the results presented. The emotions survey recorded responses for previously failed goals within a timeframe of one month. Some of the recorded affective states within the survey may have been influenced or falsely reported by participants, as recalling past events can lead to a stronger response to extreme emotions experienced.

During the ideation phase, the ideation session performance could be expanded to a co-creation session with a group of potential users of the application. The insights gained from potential users could help in exploring more creative ideas to better support individuals in their goal journeys.

Long-term effects

The duration of Study 2 was one week, and its long-term effects are unknown. A study performed by Murnane et al. [18], reported a drop off within PA of participants after the first week of study in a 3-week long study. A similar pattern may also be expected with the melody prototype. The results related to behaviour change show some interesting findings, but the participants' perception of their activity level was not measured before or during the study. The study presents the results related to behaviour changes as a potential for future research to be explored through long-term studies to produce conclusive results regarding behaviour change.

7.2 | Future works

The study provides interesting insights into the utilisation of emotions as indicators for physical activity and constructing experiences centred around emotions. Findings from study 2 indicate that music can serve as a means to depict physical activity and incentivize participation.

Understanding emotions related to goal failure

Although study 1 provides interesting insights, it would be beneficial to conduct a similar study with a larger sample size. Future studies could include the relationship established between self-efficacy and evaluating emotions with self-efficacy as well. The study developed a categorization method for the causes of goal failure. This categorization could be further expanded and analysed to examine barriers to goal failure and determine if the reasons are internal or external. Understanding this categorization can help with future design processes to create experiences that can address certain emotions and scenarios. The framework and theory presented within achievement emotions [32] and emotions theory [25] provided interesting insights which could lead to the creation of interventions to motivate PA. The study provides guidance for utilising this theory to promote physical activity and support affective states in the context of goal setting. Future studies could utilise this framework to enhance the design considerations related to goal setting.

Melody prototype: Visual representation

The melody representation depicts physical activity over a 24-hour period but the duration of the time represented can be reduced to only active hours or exclusion of sleep period for the participants. Identifying active hours may pose a challenge but can be done with the use of the sleep tracking feature available on some fitness tracking devices. Modifying the time frame from 24 hours to active hours will eliminate the silence at the beginning and end of the current representation. Excluding sleep, the period should result in a representation that emphasises the physical activity performed by the participants. The prototype representation was only designed with step data. In future studies, other data like sleep, heart rate, running pace, and weight can be represented within a similar implementation of the prototype.

Melody prototype: Music production

Participants expressed a desire to have different options for music production and more variation within the number of tones available. The study utilised capability provided by within the library Chords2MIDI [81], In the future, using a more flexible library could allow for the creation of a wider range of musical productions. The study utilised a set of five note progressions within the prototype, different note progressions can be created to represent different states of goal or to create a more varied soundscape. The influence of music on different sex can be different in their interpretation of emotions as seen in a study performed by Halbrook and Anand [68] to test the effect of variation in music on emotional states. Their

finding suggests that female participants associated emotions with music more frequently than male participants. Future studies could test the claims of intersex variability in the interpretation of music in relation to emotions using the melody prototype. The prototype failed to represent the goal state solely through music representation, future studies can utilise different aspects like pitch and intensity of the music to create representation where the goal state can be represented with music alone.

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Appendix

A. Study 1 survey

Information brochure

Purpose of the research

Physical activity applications that allow us to monitor/ track our fitness activities are becoming more popular and accessible with smartphones. Among these applications, goal setting is a popular method for bringing desired behaviour change. The set goals sometimes can lead to non-achievement and this survey will provide an indication of which emotions might be dominant in case of goal failure and their reasoning behind failure. The survey is conducted to provide more information for my final master's thesis where this data will be used.

Session Details

The session will consist of an online survey within Microsoft forums. In the survey, multiple questions will be asked concerning the participants' emotional responses (ex. sadness, pride, anxiety, anger) about not achieving a goal set in the fitness activity application. There will be a few open-ended questions which are required to answer. The survey will take 5 min to complete.

Potential risks of participating

Some questions require the participant to reflect and describe a failed goal which may cause emotional discomfort from remembering those memories.

Withdrawal from the study

Participation is entirely voluntary. You have the right to choose to withdraw from the survey whenever you feel necessary without a reason.

Data collection, confidentiality, and usage

This study does not collect any personal information.Only the data from the survey questionnaires will be collected and stored for 5 years after this project. This data is anonymous and records responses about emotional state, goal set and reason for non-achievement of goal as quotes. It can also be used by other students at the University of Twente in the future.

Figure 22. Study 1 survey: Information brochure

Consent form

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Study contact details for further information:
Master student, Ninad n. ketkale, n.n.ketkale@student.utwente.nl, University of Twente

1. I consent to the following statements:

   1. I have read and understood the study information and I have been able to ask questions about the study with the email provided and my questions have been answered to my satisfaction.

   2. I confirm that I am over age of 18.

   3. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

   4. I understand that taking part in the study involves the following risks: Reflecting upon potential goal-failure memory might cause emotional discomfort.

   5. I understand that information I provide will be used for Thesis, reports and paper publications and students within university of Twente. Some responses might be used as quote. *

   ○ Yes

   ○ No

Figure 23. Study 1 survey: Consent form

Emotion questionnaire

please answer the following questions

2. Have you used a fitness application before? (ex. google fit, Fitbit, Mifit, Samsung fit etc...) *

○ Yes

○ No

3. Have you failed to achieve a goal set from your fitness application within the last month? *

○ Yes

○ No

4. Describe the goal you failed to achieve. (ex. walking 10,000 steps a day, running 5 km a week, etc...) *

[   ]

5. What was the reason you failed to achieve this goal? Please describe it below *

[   ]

Figure 24. Study 1 survey, Emotion questionnaire Q 1-5

6. How do you associate with following emotions when you failed physical activity goal? *

Remember the last time you used a fitness app/tracker. Almost all of them have a goal setting feature, which you would have used. You would've felt something if you achieved it but that's not always possible, right? Remember a scenario when experience non-attainment of set goal. How did you feel in such a situation?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Anger	○	○	○	○	○
Frustration	○	○	○	○	○
Relaxation	○	○	○	○	○
Sadness	○	○	○	○	○
Pride	○	○	○	○	○
Regret	○	○	○	○	○
Relief	○	○	○	○	○
Worry	○	○	○	○	○
Anxiety	○	○	○	○	○
Boredom (indifferent)	○	○	○	○	○
Hope	○	○	○	○	○
Guilt	○	○	○	○	○
Shame	○	○	○	○	○
Disappointment	○	○	○	○	○

Figure 25. Study 1 survey, Emotion questionnaire: Q6

B. Mind map

A smart device that help promote meditation program to help relax

Ninad Ketkale

A conversation agent in form of a voiced bot provides encouragement for working towards a goal.

Ninad Ketkale

An automated program that gives out a plan for goal achievement.

Ninad Ketkale

Showing room for improvement and giving resources for achieving the goal.

Ninad Ketkale

Apps

An RPG game where emotions influence the buff and debuff the character receives.

{disappointment can give more HP and ATK but less DEF for that day }

Ninad Ketkale

A digital currency that co-relates to the progress towards the goal.

user gets currency first and if fail occurs the amount gets reduced

Ninad Ketkale

A game where the environment reflects the emotions and creates scenarios accordingly.

Ninad Ketkale

Figure 26. Mind map showing application-related ideas.

A lego puzzule that give you pieces according to the goal progress where some pieces might be missing that you might need to extra work to ge back.

Ninad Ketkale

A treadmill makes up the difference and makes the pace much faster the next day to cover the last day.

Ninad Ketkale

Shia LaBeouf toy that pushes you to do more and gives encouragement every day

Ninad Ketkale

A auto cooker which cooks according to goal progress and on failure makes dish from least favourite list.

Ninad Ketkale

Objects

An aromatic humidifier which creates a nice smell according to the emotion and goal progress.

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TV

IOT

A tv which shows motivational movies on the situation

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A display which shows the motivational quotes your friends had sent to help you feel better when you feel disappointed.

Ninad Ketkale

Light systems can reflect emotions through colours and slowing fading into positive emotions creating a cosy environment

Ninad Ketkale

Figure 27. Mind map Showing objects category within the ideation phase.

Journel

Providing an outlet to let out the frustration maybe creative writing, or drawing.

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A journal to help reflect builds a diary for these responses and can be referred when similar situation comes up again.

Ninad Ketkale

Journal entry that converts the text into abstract art with different colours representing emotions to help identify emotions

Ninad Ketkale

Imput a journal entry and it create a music playlist according to the entry.

Ninad Ketkale

Figure 28. Mind map Showing journal & objects category ideation.

C. Python script snippet for music note assignment

```
########################
# Chordify the steps
########################

lettersbig = ['Bb', 'F', 'C', 'G' ,'D']                    # chords set 1
lettersmall = ['Gm', 'Dm' ,'Am', 'Em' ,'Bm']              # chords set 2

# Presets
z = 1
baseindex = 2
chords = []
chords.append(lettersbig[baseindex])                      # setting first as 'C' chord

steps_chords = y

while z < 23:
  z = z+1

  if(steps_chords[z] < steps_chords[z-1]):                # if less asssign the appriate chrod from set 2
    baseindex = baseindex - 1
    if(baseindex < 0):
      baseindex = 2
    chords.append(lettersmall[baseindex])

  elif(steps_chords[z] >= steps_chords[z - 1]):           # if less asssign the appriate chrod from set 1
    baseindex += 1
    if(baseindex > 4):
      baseindex = 2
    chords.append(lettersbig[baseindex])

  elif(z == 23):
    break

chords_op = ' '.join(chords)                              # convent output as string

# print(output)
```

D. Video link showing the prototype representation.

The video link to the representation produced from the prototype. The video gives an example of how a participant in study 2 would see the representation.

https://www.youtube.com/watch?v=wdWYAHNqSGk

E.Introduction survey

Basic information survey

This section of the survey is used to get some basic information that will be used to create a custom goal setting for each participant and understand the familiarity with the tracking devices. The email address collected in this survey will be used to contact participants during the study period for announcements and reminders.

4. Have you used a Fitness tracker application/ devices (Fitbit, MIfit, Samsung fit) in past? *

○ Yes

○ No

5. What is your current step goal? *

If you don't have any, what would be a goal you would be comfortable with?

> The value must be a number

6. How often do you reflect upon your current physical activity goal? *

○ More than once in a day

○ Daily

○ Weekly

○ Other

7. Please provide your email address *

Email addresses will be used for communicating changes in step goals, an invitation for follow-up interviews, a daily online survey, and any important notices regarding the study.

> Enter your answer

Figure 29. Introduction survey used in study 2,

F. Check-in survey

2

How do you associate with emotions mentioned below after reflecting on the representation shown above. *

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Frustration	○	○	○	○	○
Pride	○	○	○	○	○
Relaxation	○	○	○	○	○
Hope	○	○	○	○	○
Relief	○	○	○	○	○
Regret	○	○	○	○	○
Guilt	○	○	○	○	○
Disappointment	○	○	○	○	○

3

Could you elaborate in a few lines on the reasoning behind any emotion you scored above? *

Enter your answer

4

If you had experienced other emotions which are not included in question 2, you can mention them here

Enter your answer

5

Could you elaborate shortly your interpretation of the step data representation shown above? You could try to connect the representation with activities from yesterday. *

Enter your answer

Figure 30. Check-in survey used in the study 1

G. Questionnaire for the follow-up interview.

Below, a generalised questionnaire is presented, The questions outlined below were used to create personalised questions depending on participants' check-in survey responses.

1. Could you elaborate on an instance of a physical activity you performed from the representation shown? (Showing one of the day's visualisation)
   a. Could you elaborate on this peak or valley (choose one) in this representation and give your interpretation of what happened there?
2. Approximately how much time did you spend reflecting on yesterday the data?
   a. Which day do you spend the most and least time on reflection?
   b. The first day, last day reflection time
3. How do you interpret the music/rhythm associated with this visualisation?
   a. in your opinion what role does music play in this visualisation?
   b. Were there any instances when you felt like sharing the music created in the prototype?
   c. Can you associate the rhythm with any activities that you performed during that day?
   d. An interesting finding from them*
4. Can you try to recognise just from the music which day of the week it was?
5. What behaviour change if any that you made in your behaviour for physical activity throughout this week?
   a. How does the prototype help in that change?
   b. Did you make any PA-related behaviour change?
6. Could you reflect upon these two representations and point out any difference you can observe?
   a. (goal) success and failure representation
   b. The least walked representation vs most walked representation
   c. Fitbit graph compares activity
7. Could you point out any standout visualisation from the week in your opinion?
8. Could you elaborate on the emotions you felt when you saw the visualisation of today? (Most likely a visualisation of failure)