Investigating Gamification Modalities in Running: A Comparison of Auditory and Visual Feedback on User Performance and Experience

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Abstract

Gamification has been widely researched to increase user engagement in physical activities. Often, these interventions rely on visual elements, neglecting the impact of non-visual modalities. Especially during physical activities like running, visual game elements are not always feasible and displays not always available. By utilizing auditory counterparts to game elements like progress or badges, users could benefit from unintrusive, auditory feedback. To gain first insights into the effectiveness of auditory gamification in this context, we conducted a mixed-design lab study (n=20) where participants ran without gamification and once more with either visual or auditory gamification. Our results indicate that gamification, independent of the type of intervention, increases enjoyment and the distance covered. To our surprise, despite covering larger distances, participants did not report increased exertion in either condition. Differences regarding user experience and performance between auditory and visual gamification themselves were not observed.

CCS Concepts

• **Human-centered computing** → *User studies*; *Laboratory experiments*; **Empirical studies in HCI**; **Auditory feedback**.

Keywords

gamification, running, feedback modalities, lab study

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1 Introduction

Gamification describes the use of game elements in non-game contexts [14], enhancing user engagement towards various activities [18, 27]. Following *goal-setting theory* [26] extrinsically driven game elements such as points, achievements and leaderboards serve as motivators by providing goals for users, which they can aim to achieve. Based on this, specifically in the context of sports, gamification has found its way into various tracking applications, from apps for tracking lifted weights like Hevy[1] to running trackers, such as Strava[2]. These applications not only grant rewards in the form of achievements and badges, or allow to compare one's performances to friends on leaderboards, but also enable live-tracking said activities. Progress bars indicate how far one's workout session has been completed already and awards can highlight new personal records alongside the workout. While this type of gamification has been shown to have beneficial effects on user performance and experience on a wide scale in the past already, including exercise [18], research often focuses on the visual implementation of these game elements, neglecting potential and flexibility, e.g. towards improved usability or user experience, by appealing to different or additional human senses, such as hearing. In contexts like sports, auditory game elements could even enhance the effectiveness, as displays are

[1] https://www.hevyapp.com/, last accessed on August 14, 2025
[2] https://www.strava.com/, last accessed on August 14, 2025

either not always conveniently available during a workout routine, or require shifting the attentional focus away from the activity to the digital application. In gamification research, this effect has already been reported outside of the sports context, for example during an image tagging task, where participants reported to get distracted from their ongoing activity by the visual game elements, while the auditory counterparts helped them to maintain their focus [37]. While works investigating audio interventions in sports exist (e.g. [11, 15]), a systematic comparison between visual game elements and sound effect counterparts is lacking.

In this work, we want to contribute to the aforementioned research gap by addressing the following research question: **What is the impact of auditory gamification on user performance and experience in running and how does it compare to visual gamification?** To this end, we conducted a study with n = 20 participants, where we compare visual gamification to auditory gamification and a baseline run without gamification in a controlled lab environment. With this, we take a first step into the direction of systematically comparing different game element modalities in the context of physical activities like running. We contribute valuable insights for researchers and practitioners in the field of multimodal gamification and provide implementation specifics for future studies, as well as future directions that have emerged from the evaluation and discussion of our study.

2 Related Work

In the following sections we will provide an overview on fields relevant to our research question. First, we will shed light on how gamification has been used in physical exercise to date, as well as its effects on users in terms of engagement and experience. Second, we will describe recent advances in the field of multimodal gamification, and lastly, we will look at how audio in general already had an impact on physical activity in sports-related contexts in the past.

2.1 Gamification in Physical Activity and Exercise

Gamification has long made its ways into everyday sports-related activities and workout-routines. Through the integration of short-term rewards into fitness-tracking applications for example, users can find more motivation to perform sports [4, 5, 21, 27], stick to regular exercise [42], increase their performance [3], or they benefit from an enhanced experience [33]. Commonly, visual gamification is implemented into digital applications that require users to look at a device like smartphones or gadgets such as smartwatches. Given the disruptive nature of smart devices found in a variety of fields (e.g. [16] and [39]) leading for example to reduced concentration and focus [41], a recent study showed that the use of smartphones in resistance training can decrease the enjoyment of the workout, as well as the productivity during the workout [34]. In physical activities visual gamification could similarly distract users from their ongoing activity. Jackson and Csikszentmihalyi say that "sport presents a special opportunity for flow to occur" [19] and describe it as "a state of consciousness where one becomes totally absorbed in what one is doing" [19]. Visual gamification requires looking at a display, which could disturb this state of flow. Shifting the focus from the common visual implementation of gamification to auditory gamification could reduce the immediate necessity to unlock and look for example at one's smart-device during sports.

2.2 Multimodal Gamification

Research in the gamification domain often (though not exclusively) focuses on the impact of visual game elements, either by utilizing visual elements without an auditory component (e.g. [24, 29, 30, 35]), by neglecting the impact sound as a mediator could have had on the user (e.g. [13]), or by utilizing vocal sound feedback (e.g. [8, 9]), which potentially confounds observed effects, as it remains unclear whether they stem from the auditory modality itself or from the semantic content of the spoken message. Altmeyer et al. come to the conclusion that complementing visual game elements with sound effects has "less impact than expected" [2] on user performance and experience in a gamified image-identification task. Another study goes one step further and systematically investigates visual, audiovisual and audio-only gamification in an image-tagging task [36]. While an impact on user performance specifically through audio remains statistically insignificant, users report that auditory feedback improves their focus on the task, as visual game elements are perceived as more distracting in a visually intensive task [36]. Consequently, avoiding disturbance through gamified interventions by making the right choice of modality should not be overlooked. While running is not specifically a visually intensive task like image-tagging and rather a physical exercise, the comparison holds as looking at one's smartphone or smartwatch display for example might lead to similar distractions in a state of focus.

2.3 Effects of Audio on Sports

In the past, audio in general (i.e. in the form of sound effects, but also music), has been shown to have beneficial effects in sports-related contexts. For example a meta-review by Terry et al. [40] could show that listening to music positively impacts the performance and perceived exertion of athletes. Similarly, Jarraya et al. [20] found that music listening in the warm-up phase positively impacts the power output of athletes during the Wingate test. Regarding sound effects, Agostini et al. [1] looked at and classify different methods utilizing sounds to improve motor skills in sports. For example a study on rowing found that providing sound feedback on the boats current speed via speakers significantly increased boat speed. Lastly, Lin and Lu [25] took a similar approach to our research question outside of the gamification domain by comparing the effect of video stimuli versus audio stimuli during stationary bike exercises, finding that the audio intervention leads to increased physical performance and lower perceived exertion.

In their work on the design of interactive jogging systems Mueller et al. [32] highlight several prototypes and applications using audio interventions for running specifically. *Jogging over a Distance* [31] for example utilizes spatial audio to connect and motivate two runners by synchronizing their individual target heart rates. Similarly, *PaceTunes* [10] makes use of spatial music during a run to keep runners at a pre-defined pace. If a runner's pace is slower than the target pace, the music is playing "in front" of the runner. If they are faster, it plays "behind" them. An example of a commercial application in this domain is *Zombies, Run!* [38], a smartphone app based on narrative storytelling, where the sound of approaching

(a) Sketch of the experimental setup.

(b) Photo of the treadmill setup.

Figure 1: Overview of the experimental environment, including a sketch of the setup and the treadmill used.

zombies cue a user to increase their running pace. In a study involving young participants, an 8-week training program was found to be more effective using the app compared to a no-intervention group in improving five kilometer running performance [15]. Similarly, *Time:Runner*, an audio storytelling game, has been shown to enhance users' enjoyment of physical activity before and after running [11]. However, the study lacks a baseline to assess effectiveness, and its use of spoken audio confounds whether effects stem from the narrative content or auditory engagement more generally.

2.4 Summary

Based on the works presented we can see that audio has been a successful intervention in sports in the past. A systematic comparison between audio and visual interventions in the domain of gamification and sports does, to the best of our knowledge, not exist yet, which is why we aim to fill this gap. Next to the positive outcomes of audio mentioned above, looking into auditive gamification in a flow-prone and widely adapted sport like running could prove fruitful not only for the individual performance, but also experience metrics such as enjoyment or perceived exertion.

3 Study System

For the purpose of investigating effects of auditory and visual gamification on user performance and experience, we adapted a treadmill in our lab to our needs. Compared to a run in-the-wild, a controlled lab environment allowed us to ensure that each subject in our study would face the same conditions in the same environment, independent of outer influences such as weather or reflective displays making visual game elements hard to recognize. A sketch of the overall setup is shown in Figure 1. In the following, we will shed light onto the used hardware, implementation details, as well as the choice of game elements and sound effects.

3.1 Game Element & Sound Effect Selection

We opted for simple and basic game elements as a direct translation to an auditory variant was necessary. Among the most used game elements in gamification literature are points, badges, progress bars and leaderboards [18]. For our purposes we opted to implement the game elements progress and badges. These are often found in common sports tracking applications on the one hand and are simple enough to create a non-verbal auditory counterpart to compare them to on the other hand, unlike e.g. leaderboards. In our setup, we utilized progress bars to display the achieved distance up to one kilometer, divided into eight intermediate steps, and badges to reward users for completing a full kilometer. Both elements are shown in Figure 2. Badges were displayed for a few seconds upon unlocking them.

Regarding the auditory counterparts for both elements, we picked one sound for badges, which was derived by Schubhan et al. [37] in the context of gamified image tagging. As a suitable sound for the element of progress was not part of their sound selection process, we picked the sound identified for points from [37] (A) and another sound from Mixkit[3] (B) and created three variants derived from earcon literature by Brewster et al. [7] to be able to reflect

[3]https://mixkit.co/free-sound-effects/game/, last accessed on August 14, 2025

(a) Progress (b) Badge

Figure 2: The game elements progress, divided into eight chunks (a) and badge, as a reward for completing one kilometer (b).

the state of progress with each sound: One variant with increasing volume levels, one variant with increasing pitch levels, and lastly, one variant with increasing complexity, i.e. playing the sound as an increasingly complex diatonic scale, with one further pitch-level added for each of the eight intermediate progress steps. Based on an informal user evaluation with n=9 participants drawn from the social circle of the authors, six out of nine participants favored sound B in the complexity variant to resemble the element of progress while running. Thus, we selected this sound effect. We provide each sound for badges and progress in the appendix of this work.

3.2 Technical Setup & Implementation

In order to gain full control over the contents displayed to the user, we covered the treadmill's original display as shown in Figure 1b. This way information for example on distance run, time elapsed or pace was not visible on the treadmill itself in order to exclude confounding factors that might impact user motivation. Instead, we placed a convertible notebook with a touch display on the treadmill, through which we could display instructions, information on the run, the visual game elements described before and play sounds. We refrained from displaying any additional information (like e.g. time elapsed) for the same reason we covered the treadmill's original display on the one hand, and to avoid displaying these visual contents alongside the auditory gamification in our study later to maintain comparability on the other hand.

To measure the distance covered, we added an Arduino Uno in combination with an IR-Reflector-Sensor right above the tread belt. A white piece of sticky tape placed on the belt was recognized by the sensor, indicating a full rotation of the belt. Each revolution equals a distance of 3.44 meters. Multiplying said distance with the amount of times the white strip was recognized by the sensor results in the total distance run, and allowed us to track the overall progress during each trial, as well as to react to the user's distance and milestones.

The frontend displayed on the convertible notebook was a simple React[4] web application guiding participants through their trial run, and allowing us to display either no game elements at all, visual game elements, or the respective auditory game elements reacting to the distance covered during a run.

[4]https://react.dev/, last accessed on August 14, 2025

4 Study

The aim of this study is to investigate the impact of and difference between auditory and visual gamification in the physical activity of running in terms of performance and user experience (UX). With the treadmill setup introduced in section 3 and based on related literature, we pose the following hypotheses:

- **H1** Gamification (audio and visual), increases the distance run compared to no gamification.
- **H2** Gamification (audio and visual) increases the UX (IMI [28], RPE [6], PACES [22]) compared to no gamification.
- **H3** Auditory gamification increases the UX (IMI [28], RPE [6], PACES [22]) compared to visual gamification.

H1 is based on general literature in the gamification domain and aims to replicate results. Multiple reviews and meta-analysis from various contexts, including sports, have shown that gamified interventions can increase user performance [4, 18, 23, 27]. Since auditory gamification only changes the means of communication and does not provide more or different information than visual gamification, we do not expect a significant difference between the modalities. While systems like *AIMFIT* [15] and *Time:Runner* [11] suggest positive impacts on user performance through audio experiences, they are not systematically compared to direct visual counterparts in their respective studies. Furthermore, preliminary studies from non-sports contexts found no significant difference on performance between users of auditory and visual gamification [37]. By supporting H1, we could still indicate that auditory gamification performs similar to the established visual counterparts - even without clear, readable indicators. With H2 we expect auditory and visual gamification to outperform a non-gamified variant in terms of user experience. User experience was assessed through established methods from both fields, gamification and sports, i.e. we used the *intrinsic motivation inventory* [28] (IMI) to assess general enjoyment of the gamified activity, the *rating of perceived exertion* [6] (RPE), as well as the *physical activity enjoyment scale* [22] (PACES) to get feedback on the enjoyment of the physical activity itself. More details on their usage are provided in the following section. Lastly, with H3 we expect auditory gamification to outperform visual gamification in terms of the same user experience measures. As outlined in section 2 audio in general has been shown to have positive impacts on physical activities and we expect the use of the auditory modality to lead to a better experience when compared to visual gamification, as we assume audio feedback to be less disruptive, similar to [37].

4.1 Procedure

Following a mixed-methods design, participants were divided into two groups: *auditory gamification* (AG) and *visual gamification* (VG). Participants from both groups completed one *baseline* (BL) run without gamification, and at another day a run with their respective gamification intervention, or vice versa, as the sessions were counterbalanced to prevent order effects. Consequently, assessments between BL and one of either AG or VG follow a within-subjects design, while comparisons between AG and VG are between-subjects. Through this design, participants were only required to take part in two individual trials instead of three, easing the study duration and

n = 20	**Sleep**	**Full Meals**	**Small Meals**
Baseline	7.62 (1.29)	0.75 (0.44)	0.45 (0.69)
Gamified	7.10 (1.32)	0.82 (0.49)	0.35 (0.59)

Table 1: Amount of hours slept before the respective running trial, as well as amounts of full and small meals eaten beforehand.

commitment to participate per participant. In order to assess confounding differences in each participant's physical state between both runs, we asked them at the beginning of each session how long they slept during the night before and how many small and full meals they had prior to their study trial. This allowed us to evaluate differences between the two sessions in order to prevent biased effects in either direction during the analysis. Additionally, we asked them about their physical activities that they already had done before participating on that day.

Upon arrival participants signed a data-privacy form explaining the procedure, as well as the anonymized collection and processing of study data, followed by a demographics questionnaire asking about their age, gender, and how regularly they go for a run during one week. Afterwards, we explained how the treadmill and its controls to adapt the speed work and participants were granted a practice period to warm up and get used to the treadmill. Next, their 20-minute trial run would start. Participants were allowed to adapt the treadmill's speed at any point during the trial. Depending on the BL or gamified run, they would additionally see the respective auditory or visual game elements on the screen in front of them as described in section 3. After completing the run and a short break, participants were asked to fill out additional questionnaires: First, the Rating of Perceived Exertion [6] (RPE), followed by the Physical Activity Enjoyment Scale [22] (PACES), the Intrinsic Motivation Inventory's [28] (IMI) subscales for interest & enjoyment, pressure and competence. As a last step, participants were offered to shower at our facilities. The study was approved by the Ethical Review Board of Saarland University (No. 24-02-07).

4.2 Participants

For our mixed-methods design (between and within-subjects) an a-priori power-analysis using G*Power [17] suggested at least 18 participants to find medium sized effects (Cohen's f = 0.25) with a power of 0.8, which is recommended by Cohen [12]. In addition we assumed a correlation coefficient of r = 0.75 for repeated measures, as the distance a person is able to run depends on each individual's condition, which would naturally lead to a high correlation between the BL and gamified conditions. A detailed overview of our power-analysis parameters and results can be found in Appendix A.

In total we recruited n = 20 participants via flyers, student chat groups for participant recruitment and the authors' social circle. 18 subjects were university students from sports-unrelated fields (e.g. computer science, psychology or medicine) and two worked in sports-unrelated fields. Ten of the subjects identified as male, four as female, four as non-binary, one as agender and one as genderfluid. On average they were 24.3 years old (SD = 3.87). Most of the participants (11) indicated that they do not follow a regular running routine, while four indicated to go running less than once per week, four once a week, and one participant twice a week. Participants were not paid for their participation, but were offered snacks after completing each study trial.

4.3 Results

To analyze our data, we used a repeated measures ANOVA (BL versus gamified conditions) with between-subject factors (AG versus VG) wherever a comparison between all conditions was applicable and insights into interaction effects might prove valuable. For comparisons between two conditions (e.g. to compare the amount of sleep between BL and the respective gamified conditions of each participant), we calculated the non-parametric Wilcoxon rank test (within-conditions), or the Mann-Whitney U test (between-conditions) due to violating the assumption of normally distributed data. An overview of our descriptive results including data on the achieved running distance, the respective IMI subscales, RPE and PACES is shown in Table 2.

4.3.1 Pre-Run Evaluation. As described in subsection 4.1 participants were asked about their amount of sleep and how many full and small meals they consumed before taking part in the respective trial run. The descriptive results can be found in Table 1. The Wilcoxon tests between the within-subjects conditions revealed no significant differences in terms of sleep (W=59.00, p=0.36), full meals (W=3.00, p=0.57), or small meals (W=17.50, p=0.59). Based on this, we can conclude that participants were likely in a comparable physical state on both trials.

4.3.2 Performance. First, a Mann-Whitney U test on the distance data from the baseline conditions revealed no significant difference between participants from the auditory, as well as the visual group (U=44.00, p=0.68), suggesting similar levels of running endurance in both samples. An ANOVA run on the distance metrics shown in Table 2 indicates a significant difference between the BL run and the gamified conditions (F=5.60, p=0.03, η_p^2=0.24). An effect of this size can be considered large according to Cohen [12]. Table 2 shows that participants in the visual intervention group increased their running distance by 422.43 meters in the gamified condition on average, while participants in the audio intervention group achieved an increase of 322.23 meters on average. No effects were found regarding the comparison between VG and AG (F=0.11, p=0.74, η_p^2<0.01), as well as the interaction between gamification, no gamification and audio or visual (F=0.10, p=0.75, η_p^2<0.01). This means that while gamification in general improved our participants distance measures, this effect was independent of the type of the gamification intervention. Furthermore, there are no significant differences between the audio and visual intervention themselves. This leads to **R1: Gamification generally increased measured distances, independent of its modality**.

4.3.3 Running Experience. Similar to the performance metric, the IMI subscale interest & enjoyment showed a significant difference between the BL runs and gamification in general (F=11.42, p<0.01, η_p^2=0.39). The effect can also be considered as large [12]. Again, the ANOVA showed no significant differences between VG and AG (F=0.70, p=0.42, η_p^2=0.04), as well as for the interaction effect

	Condition	Distance (m)	RPE	PACES	IMI Interest	IMI Pressure	IMI Competence
VIS	BL n=10	2183.71 (843.13)	5.30 (2.41)	84.30 (22.65)	3.79 (1.58)	2.58 (1.01)	3.80 (1.55)
VIS	VG n=10	2606.14 (1247.12)	5.40 (1.17)	90.10 (15.29)	4.36 (1.06)	2.42 (0.86)	3.88 (1.16)
AUD	BL n=10	2369.57 (908.87)	5.80 (1.81)	88.60 (18.92)	4.21 (1.07)	2.96 (1.01)	3.72 (0.90)
AUD	AG n=10	2691.80 (852.68)	5.30 (1.64)	95.60 (11.05)	4.76 (0.85)	2.90 (1.04)	3.76 (1.21)

Table 2: Score (and standard deviation) of our quantitative measurements during and after each run, divided into participants who were assigned to either the visual (VIS) or the audio (AUD) group.

(F<0.01, p=0.93, η_p^2<0.01), leading to **R2: Gamification in general improved the enjoyment of the run, independent of its modality**. Contrary to the interest & enjoyment scale, the pressure subscale showed no significant results, neither in terms of BL versus general gamification (F=0.18, p=0.68, η_p^2=0.01), VG versus AG (F=0.04, p=0.85, η_p^2<0.01), or the interaction of both (F=0.02, p=0.90, η_p^2<0.01). The same applies to the competence subscale comparisons for BL versus general gamification (F=0.14, p=0.72, η_p^2<0.01), VG versus AG (F=1.46, p=0.24, η_p^2=0.08) and the interaction effect (F=0.04, p=0.85, η_p^2<0.01).

Another measurement that we assessed after each trial was the perceived exertion. Following our ANOVA, neither BL versus general gamification (F=0.26, p=0.62, η_p^2=0.01), nor VG versus AG (F=0.08, p=0.78, η_p^2<0.01), and the interaction effect (F=0.59, p=0.45, η_p^2=0.03) resulted in significant differences. The same applies to the PACES comparisons between BL and general gamification (F=2.83, p=0.11, η_p^2=0.14), VG and AG (F=0.51, p=0.48, η_p^2=0.03), and lastly, the interaction effect between them (F=0.02, p=0.88, η_p^2<0.01). Consequently, we cannot say that our participants felt more (or less) exhausted depending on the trial, nor that they perceived the physical enjoyment differently in any of the conditions. While non-significances do not entirely exclude missing an effect, our results hint at similar exertion and physical enjoyment levels. Especially the perceived exertion becomes interesting in the light of R1, where an increased distance was measured in the gamified conditions, yet the impact on perceived exhaustion seems to be negligible. In terms of the audio intervention, at least the descriptive RPE values are even lower for AG than for BL.

5 Discussion, Limitations & Future Directions

Following our results, we can conclude that we are able to support **H1**. Based on R1 we saw that gamification, independent of the intervention, increases the distance run compared to not using gamification at all. This is in line with gamification research in the domain [23] and the lack of an interaction effect in this regard indicates that both, visual and auditory gamification, affect the distance metric in similar ways. While a significant difference in terms of distance was not expected based on prior literature from other domains (e.g. [2] and [37]), it would have been conceivable given our expectation for an improved user experience. With our results, we contribute one more example, where purely auditory gamification results in comparable performance measures to the well-established visual counterpart. Nonetheless, it should be noted that with regards to our sample size and statistical power, we cannot exclude the existence of medium to smaller effects in this regard.

With **H2** and **H3** we hypothesized that visual and auditory gamification increase the user experience compared to no gamification based on existing studies and that auditory gamification improves it once more compared to visual gamification in the specific context of running. Based on our analysis of the IMI, RPE and PACES scores we are not able to support these hypotheses. While R2 indicated a general improvement of the enjoyment of the activity through gamification overall, there was again no interaction effect, meaning that we cannot see an improvement between the modalities of gamification interventions. Furthermore, neither perceived pressure, nor the level of competence differed in any of the conditions, including the BL run. From this, we can derive that factors bound to the activity of running itself might be more important for perceived pressure or competence already, and the addition of gamification elements does not alter this perception to a notable degree. Similarly, no effects in terms of perceived exertion, nor the enjoyment of the physical activity itself were found.

A potential interplay regarding R1 is that while participants significantly improved their running distance through gamification by approximately 372 meters on average, they did not report a significantly increased perceived exertion. Although the non-significant result limits strong interpretations, the observed increase of 372 meters, while not substantial in absolute terms, could be a hint that the addition of gamification may positively influence perceived exertion relative to the distance covered during running. This would fit [25] or [40], who find similar effects through audio, although in the form of music. Future work should investigate a potential connection between gamification and perceived exertion to deepen our understanding of how game elements can affect perceptions in physical exercise beyond potential performance gains.

Regarding our methodology, we chose to conduct our study in a lab setting. This approach allowed us to keep the setup as comparable as possible between participants, but also between the individual assessments of a participant. While visual interfaces like displays are often more common to be found in such a setup, we removed any opportunity to perceive information on a screen beyond our own to make our results more applicable on a general level, including running outside. Nonetheless, our results might differ if they were assessed in an in-the-wild scenario. Furthermore, it should be noted that in our setup, the visual and auditory badges were only briefly perceivable, whereas the visual progress bar was displayed continuously to better reflect its intended functionality. Another limitation stems from the use of a treadmill itself: on the one hand it allowed us to precisely measure and react to the distances with our game elements, on the other hand using a treadmill comes with the disadvantage of set speed-levels. Our participants were allowed to choose and change their own speeds throughout each trial, yet an impact on our results cannot be ruled our entirely. Running outside might lead to more variable running speeds and consequently larger effects. R1, the significant difference between the distances in gamified vs. non-gamified conditions, hints at a low impact of this limitation. An in-the-wild study in the future should validate and strengthen our results in this regard. Lastly, as mentioned throughout our results and discussion, while 20 participants in our exploratory setup are sufficient to find large effects, we cannot exclude the existence of smaller effects. Future studies in this direction should aim for larger sample sizes to strengthen these insights and provide a more fine-grained look.

6 Conclusion

This builds the foundation for a systematic comparison of sound effect based gamification and visual gamification on the physical activity of running. While our results do not indicate a substantial difference in terms of user performance and experience when it comes to auditory vs. visual gamification, we did find that gamification independent of the intervention improves running distance and the general enjoyment of the activity. Based on this, we contribute insights to both, gamification and sports-related research, as audio gamification can be a viable alternative to visual game elements for running. In the future, both, researchers and practitioners from the field, can build on this knowledge to adapt applications based on their needs and which type of gamification is more applicable in their scenario.

Next to the future research directions outlined in our discussion such as validation studies with bigger sample sizes to gain more detailed insights, research should also investigate audiovisual gamification as a potential modality to improve user experience. While testing this would have inflated our study concept, results from a different context have already shown that combining audio and visual feedback can result in the best compromise for user experience [37]. Furthermore, findings revealed through our exploratory analysis, like the comparable perceived exertion despite significantly larger distances covered by our participants, should be investigated in the future.

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A Power Analysis

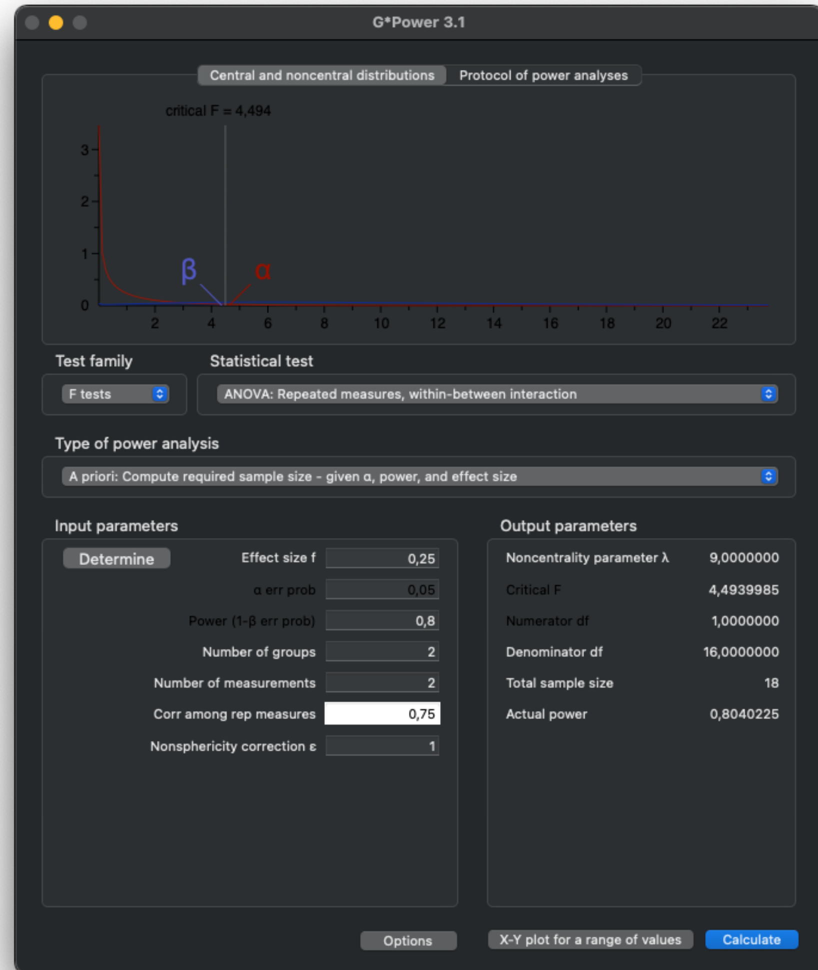

Figure 3: Overview of our power-analysis parameters and results.