Evaluating NFC and Touchscreen Interactions in Collaborative Mobile Pervasive Games

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Abstract
This paper presents the motivation, design, and pilot evaluation of CountMeIn, a pervasive collaborative game to improve the waiting time experience (e.g., waiting for a train, or traffic light to turn green). We tested two versions of CountMeIn, an NFC-based and touchscreen version in a small pilot study. Our early results showed that the NFC-based version increases collaboration, and was overall more positively perceived than the touchscreen version. We discuss the challenges ahead in deploying CountMeIn in a real-world setting.

Author Keywords
NFC; touchscreen; collaborative; urban; pervasive; games

ACM Classification Keywords
H.5.2 [User Interfaces]: Input Devices and Strategies; H.5.3 [Group and Organization Interfaces]: Collaborative Computing

General Terms
Experimentation, Design, Human Factors

Introduction
We've all felt bored, frustrated, or even aggressive while waiting for a bus/train to come, or for a traffic light to turn green. While the widespread adoption of smartphones has alleviated these long waits, they also

isolate us more than ever. To revive social interactions amongst people in such settings, we propose the use of pervasive games. Pervasive games eliminate these spatial and temporal constraints by expanding the play space to ones ordinary social life [6]. Social expansion, as noted in [6], encompasses not only participants who are part of a playful space, but also might include spectators or bystanders. From the work of sociologist Erving Goffman [1], public spaces, such as railway platforms or red pedestrian traffic lights, can be described as temporally short situated social gatherings. Here, a participant is involved with a social situation, with the acquainted and unacquainted persons around, and of course themselves. These situated social gatherings, therefore, present an ideal ground for exploration of pervasive gaming in the direction of social expansion.

The goal of our research is to create new urban experiences through mobile devices, to transform waiting in public places into a more fun, engaging and worthwhile social gathering. We hypothesize that incorporating Near Field Communication (NFC) can not only lead to interesting physical interactions between participants and (virtual) objects, as elaborated in [10], but also between participants, bystanders and spectators. The latter mode, also known as peer-to-peer NFC interactions, promises an interesting opportunity to evaluate these in the context of social expansion, because these interactions depend on proximate and physical (face-to-face) encounters between people within a social situation [3]. The foregoing motivation gave rise to our broad research question: Can a collaborative pervasive game improve the waiting experience of users in public places? For this paper, we specifically ask: does physical mobile interaction (using NFC technology) positively influence users perceived social presence in collaborative pervasive games?

Designing CountMeIn

To address our research questions, we have developed a prototype collaborative pervasive NFC-enabled mobile game we call CountMeIn. Our approach to designing CountMeIn followed closely the literature on pervasive game design [7, 9] and evaluation [4].

Design Requirements

CountMeIn has the following high level requirements:

- Provide a socially expanded experience (role switching, encouragement for bystander participation) [7], to improve the waiting time experience
- Provide a collaborative goal for 1-4 users [11, 9], with clear reward and punishment game mechanics [9]
- Can be played in a relatively short time frame (e.g. while waiting at a bus stop), so should be easy to learn and engage users directly
- Allow multiple interaction modes. In our case, a version featuring NFC-based physical interaction, the other with touchscreen-based interaction only

CountMeIn Gameplay

The goal of CountMeIn is that players create and play or just play sequences through the use of game boards (Fig. 1(a) & Fig. 1(b)). In CountMeIn, a sequence is an ordered collection of integers. Points are scored when users reproduce the created sequence. More points are rewarded when longer sequences are successfully reproduced. Upon the users choice to play a sequence, she is able to see the sequence on the mobile screen for a configured amount of time (currently set at 10 seconds).

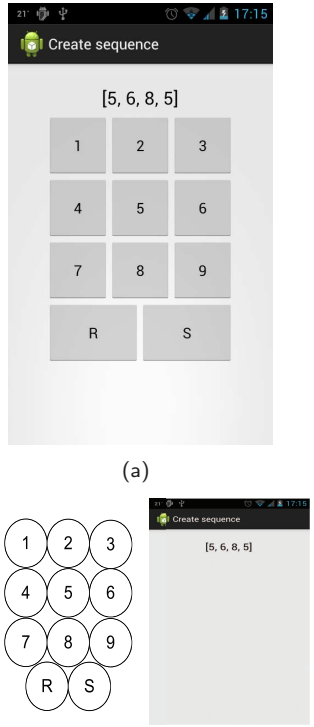


Figure 1: (a) Touchscreen version (b) NFC version. R = Reset Sequence; S = Submit Sequence

To make the touchscreen version comparable to the NFC version, the sequence is shown and updated on each player's screen in real-time. Thereafter users reproduce the sequence through the game board (either NFC-tags labeled on the poster or touchscreen buttons). While sequences from 3-6 integers are relatively easy to repeat by an individual, longer sequences may become a cognitive problem. This can be used to support collaboration, where we included a touch to invite feature for both versions of the game. In this case, users can invite others into a running game by touching the backs of their devices (Fig. 3(b)). For example, if a user is playing a sequence with a length of 9 but was not able to remember the last 3 integers, she is able to invite other people. An invited player is now able to see the sequence for 10 seconds and can invite more people. In this situation these users have teamed up and must manage to get the sequence right.

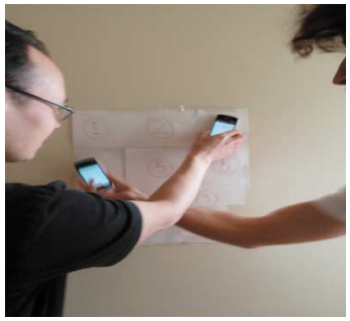
Current Implementation

Both NFC-based and touchscreen versions of CountMeIn (Fig. 1) are implemented on the Android platform. These versions differ on interaction strategies for the tasks: 1) initializing the game, 2) creating a sequence, and 3) playing sequences. In the NFC version users can physically interact with an NFC poster to perform these tasks. The touchscreen version lets users initialize the game via the game launcher on the Android home screen, where touchscreen buttons let users create and play sequences. The invite mechanism for both versions is implemented through Android Beam facilities of the Android system. CountMeIn currently supports the following feedback: a) NFC-tag and NFC peer-to-peer interaction have stock Android feedback; tactile and sound b) Touchscreen button presses have no additional feedback c) In both versions, when a sequence is created, played, won, or lost, the proper sound is played d) Visual feedback for scored points, invited players and active sequence.

Methods

To evaluate CountMeIn, we reused parts of the Game Experience Questionnaire (GEQ) [4] and the Social Presence Game Questionnaire (SPGQ) [5]. Especially the latter questionnaire, so that we gain insight on whether such physical interaction enhances social presence and facilitates social expansion. Additionally, since the NFC version requires users to become physically more involved which could arguably lead to increased workload, we additionally asked our participants to fill out the NASA-TLX [2] questionnaire. Finally, we gave participants post-session semi-structured interviews to get qualitative feedback on their experience with CountMeIn. Given the low participant sample, we make a qualitative assessment by visual inspection of the questionnaire findings.

To obtain preliminary results, we set up a free-form pilot study with 4 participants (m) aged between 25-60 (M=35.5, SD=16.4) in a 2x1 (NFC vs. Touchscreen) counterbalanced within-subject design. This was done in an informal home setting, where participants were acquainted. Participants received instructions for both versions of the game. For the NFC version, two game boards were set up, where participants were told that they can use one or two game boards. For both, participants were told that they could roam around the room freely and play the game at their own pace. We had a total of 4 play sessions, with 2 initial participants. Each session lasted approximately 20 minutes. In this setup, participants created 73 and played 68 sequences. 2 of the first and 22 of the latter were played collaboratively. Mean length of created sequences was 6.6. Additionally, we provided a set of 10 pre-made sequences for each session. These were predominantly longer sequences to provoke collaboration.



(a)

(b)

Figure 3: (a) Two players interacting simultaneously on an NFC board (b) Inviting another player to join the game.

Results

Public play

From the interviews, all but one participant (3/4) said they would play CountMeIn in a public setting with strangers to pass the time. P4 stated that it is a way to meet new people. P1 stated that there are times when he would rather not be bothered in public places due to personal reasons (e.g. "after long day at work"). However, P1 also stated that "if two strangers would come up to me and [enthusiastically ask me to help play a sequence], I would do so". P2 stated I do not see me touching phones with strangers and argued that "touching phones with strangers felt similar to casually talking to strangers". P3 stated it might be a burden to ask strangers to help play a sequence because it might lead to an awkward social situation. Furthermore, all participants indicated that such a game could pose privacy issues.

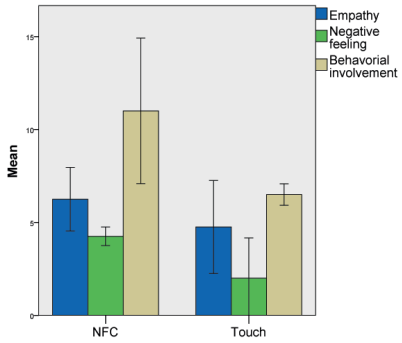


Figure 2: Social Presence Game Questionnaire (SPGQ) responses for NFC and Touchscreen game versions.

Perception Of Social Presence

In both versions, all participants enjoyed collaborating to make a sequence. This was supported by the SPGQ responses (Fig. 2). During play sessions, we observed that the NFC-based version triggered more collaboration (see Fig. 3). However for both versions, when sequences were won through collaboration, cheers and laughter increased. On the other hand, when sequences were lost, blaming and mocking increased. Furthermore, especially for the NFC version, we observed that participants took on different roles (e.g. leading, instructing, following) and tried to devise strategies for better collaboration. Interestingly, one participant in the touchscreen condition were looking at the new invitee's screen to remember the sequence as it was again shown for 10 seconds.

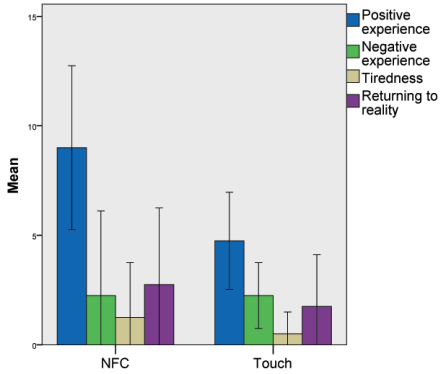


Figure 4: Game Experience Questionnaire (GEQ) post game responses for NFC and Touchscreen game versions.

Overall Game Experience

During interviews, most participants (3/4) indicated they preferred the NFC version, since they enjoyed the physical interaction. The GEQs post-game (Fig. 4) module complements this finding; an increased level of Positive experience for NFC (M=9.0, SD=3.7) over touchscreen (M=4.8, SD=2.2) interaction. All participants found the tasks of the touchscreen version as much easier to learn and perform. This is likely due to participants' familiarity

with touchscreen interaction, which is the primary mode of interaction in today's smartphones. Results from the GEQs core module (Fig. 5) support this for items Competence, Challenge and Annoyance and NASA-TLX items Frustration and Performance (Fig. 6).

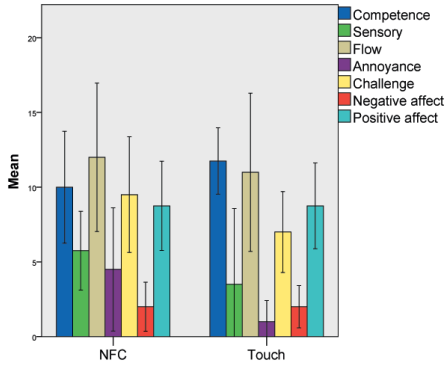


Figure 5: Game Experience Questionnaire (GEQ) Core responses for NFC and Touchscreen game versions.

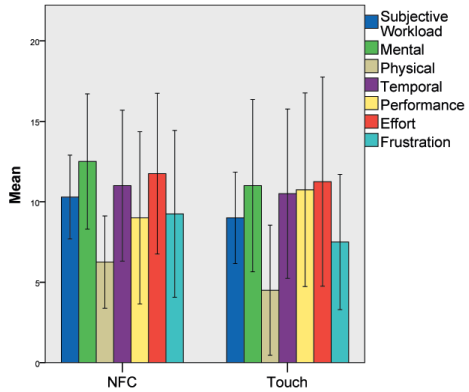


Figure 6: NASA-TLX responses for NFC and Touchscreen game versions.

However, P4 indicated that the NFC version was frustrating. In addition P3 noted that registration of NFC tags did not always provide a seamless interaction, which might explain the increased frustration. This was not surprising given the early stage of our prototype. Nevertheless, our preliminary results are promising and suggest that CountMeIn has potential to be deployed in an urban setting. While the touchscreen version provides a robust interaction strategy for creating and playing sequences, it was considered less fun. By contrast, physical interaction resulted in a a more fun experience with higher social presence, indicating that social expansion for collaborative pervasive games is higher when physical NFC interaction is employed. This is likely due to the naturalness of physical NFC interaction (cf., [8]).

Discussion & Future Work

NFC is currently not a standard capability of most mobile devices. The number of potential CountMeIn users is therefore reduced significantly if the game is released in the wild. Fortunately, several mobile device manufacturers also have lower-end NFC-enables devices (which have been used in our study). The current CountMeIn prototype is implemented as a native Android application. However, if this game is to fully support social expansion, then any user or player with an NFC-enabled mobile device should be able to play immediately without having to first download the game. Moreover, such a game makes the assumption that smartphone users have internet access (e.g., 3/4G) on their devices. This becomes less of a problem at public places with free Wifi hotspots (e.g., at some airports or train stations).

Since the NFC-based version of CountMeIn requires a physical game setup, deployment of such a game means we have to account for harsh weather conditions, ensuring

the game setup is durable against acts of vandalism, and so on. Placement, material choice and arguably aesthetics of the setup can lead to higher durability. In rainy cities, this means that the physical game setup should be sheltered (e.g., set up within public transport, inside the train station). While our game is meant to alleviate waiting time experiences, this could also backfire in very crowded places. For example, a crowded train stop might make it difficult for players to engage in tagging objects on an NFC poster. On the other hand, during certain early or late hours, during public holidays, or certain locations, may mean that very few people are present. If the pervasive game is inherently social (i.e., requiring at least 2 players), this would make the game unplayable. In this case, the choice of game becomes paramount, in that it allows both single-player and multi-player modes.

We received valuable feedback from participants in our pilot study on how to improve CountMeIn. These improvements covered: 1) game mechanics (e.g. rewarding players who collaborate, or incorporating gamification) 2) improving the mobile and physical interface design and 3) additional feedback from the mobile device (e.g., touchscreen buttonpress feedback). For later testing, we will additionally collect user performance data (e.g., in-game scores). Finally, we plan to evaluate the prototype in a real world setting (e.g., at a train stop) with unacquainted persons, with 4 participants per play session to fully test the collaborative character of the game.

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