Cooperation or Competition – When do people contribute more? A field experiment on gamification of crowdsourcing

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Abstract

Information technology is being increasingly employed to harness under-utilized resources via more effective coordination. This progress has manifested in different developments, for instance, crowdsourcing (e.g. Wikipedia, Amazon Mechanical Turk, and Waze), crowdfunding (e.g. Kickstarter, Indiegogo, and RocketHub) or the sharing economy (e.g. Uber, Airbnb, and Didi Chuxing). Since the sustainability of these IT-enabled forms of resource coordination do not commonly rely merely on direct economic benefits of the participants, but also on other non-monetary, intrinsic gratifications, such systems are increasingly *gamified* that is, designers use features of games to induce enjoyment and general autotelicy of the activity. However, a key problem in gamification design has been whether it is better to use competition-based or cooperation-based designs. We examine this question through a field experiment in a gamified crowdsourcing system, employing three versions of gamification: competitive, cooperative, and inter-team competitive gamification. We study these gamified conditions' effects on users' perceived enjoyment and usefulness of the system as well as on their behaviors (system usage, crowdsourcing participation, engagement with the gamification feature, and willingness to recommend the crowdsourcing application). The results reveal that inter-team competitions are most likely to lead to higher enjoyment and crowdsourcing participation, as well as to a higher willingness to recommending a system. Further, the findings indicate that designers should consider cooperative instead of competitive approaches to increase users' willingness to recommend crowdsourcing systems. These insights add relevant findings to the ongoing discourse on the roles of different types of competitions in gamification designs and suggest that crowdsourcing system designers and operators should implement gamification with competing teams instead of typically used competitions between individuals.

Keywords: Gamification, crowdsourcing, augmented reality, goal setting, social interdependence, collaboration.

1. Introduction

During the past decade, advances in modern information and communication technologies have enabled novel forms of economic coordination of under-utilized resources be it human capital, information goods, material goods, or even funding. Perhaps the most noteworthy Internet-based developments that have made resource coordination more effective in recent years are crowdsourcing (Estellés-Arolas and González-Ladrón-de-Guevara, 2012; Howe, 2006; Prpić et al., 2015a), crowdfunding (Agrawal et al., 2014), and the sharing economy (Hamari et al., 2016b; Sundararajan, 2016). Crowdsourcing in particular commonly uses the Internet to simplify the coordination of human capital and to employ the 'crowd' – a mass of people reachable via the Internet (Brabham, 2013; Estellés-Arolas and González-Ladrón-de-Guevara, 2012; Howe, 2006; Nakatsu et al., 2014) – for distributed cooperative problem-solving (Brabham, 2013; Doan et al., 2011; Prpić et al., 2015a). Especially crowdsourcing initiatives where large groups of people explicitly work together to jointly create solutions (Doan et al., 2011) has drawn attention in recent years. Popular examples, such as Wikipedia (a crowd-generated comprehensive online encyclopedia), OpenStreetMap (a crowd-generated digital world map), Waze (a navigation system with real-time, crowd-generated traffic information), TripAdvisor (an online portal for crowd-generated reviews of hotels, restaurants, and travel locations) Yelp (a crowd-generated world-spanning business directory), or Ingress (an augmented reality game with a crowd-generated database of landmarks and public art) have spawned comprehensive crowd-created solutions that have made our lives easier (Budhathoki and Haythornthwaite, 2013; Geiger and Schader, 2014; Haklay and Weber, 2008; Levina and Arriaga, 2014; Morschheuser et al., 2017c; Nakatsu et al., 2014; Nov, 2007; Prpić et al., 2015a; Takahashi, 2014). Inspired by these successful approaches, many organizations are now attempting to harness the collective potential of crowds in order to face the increasing need for extensive databases as part of the emerging digitalization. This includes initiatives such as the crowd-based collecting of data for smart cities (Cardone et al., 2013), the crowd-creation of ground truths for machine learning approaches (Rosani et al., 2015), or the distributed gathering of location-based data to enable autonomous driving (Hu et al., 2015).

However, any crowdsourcing initiative's success strongly depends on the willingness of a reserve of people to participate in collective value creation (Brabham, 2013; Doan et al., 2011; Law and Ahn, 2011). The design of appropriate incentive mechanisms that get people to participate in crowdsourcing and motivate active crowdsourcees to invite others via word of mouth is thus of great relevance for the designers and operators of crowdsourcing initiatives (Kaufmann et al., 2011; Zhao and Zhu, 2014a, 2014b). Studies have shown that extrinsic incentives, such as financial compensations or utilitarian benefits that arise from the purpose of a crowdsourcing initiative, often play a subordinate role in crowdsourcees' motivations (Kaufmann et al., 2011; Soliman and Tuunainen, 2015; Zhao and Zhu, 2014b). Various studies indicate that crowdsourcees are driven by intrinsic aspects, such as altruism, the sense of accomplishment, self-development, curiosity, competence satisfaction, or relatedness with a community of peers (Kaufmann et al., 2011; Lakhani and Wolf, 2005; Nov, 2007; Nov et al., 2010; Soliman and Tuunainen, 2015; Zhao and Zhu, 2014b).

Playing games is especially believed to be a culmination of autotelic activities (Przybylski et al., 2010; Rigby, 2015; Ryan et al., 2006). Therefore, crowdsourcing systems are increasingly *gamified* (Hamari et al., 2014; Morschheuser et al., 2017a, 2016), that is, designers enrich crowdsourcing systems with design features from games that address humans' innate intrinsic needs in order to transform participation in crowdsourcing more autotelic (Hamari and Koivisto, 2015a; Morschheuser et al., 2017a). While literature reviews have revealed that crowdsourcing is one of the most popular application areas of gamification (Hamari et al., 2014), and while most implementations of gamification seem to positively influence crowdsourcees' motivations and behaviors (Morschheuser et al., 2017a, 2016), there is a lack of comparative studies across different gamification designs. The research has primarily investigated the differences between gamified and non-gamified crowdsourcing (Brito et al., 2015; Massung et al., 2013; Prandi et al., 2016) or the effects of a specific gamification feature (Bowser et al., 2013; Pothineni et al., 2014); however, the differences between various gamification design features and particularly the effects of features that invoke different goal structures such as competition, cooperation, and inter-team competition have been largely ignored in gamification (Bui et al., 2015; Liu et al., 2017; Morschheuser et al., 2017a) and game design research (Liu et al., 2013). This knowledge gap prevents us from designing gamification that optimally harnesses the full potential of the crowd (Morschheuser et al., 2017a, 2016). Thus, while there is clear potential to use gamification in crowdsourcing applications, more granular research result would afford more effective gamification designs for crowdsourcing and similar systems where people cooperatively create emerging outcomes.

To address these gaps, this study investigates *how crowdsourcees' perceived enjoyment and usefulness, behaviors (system usage, crowdsourcing participation, engagement with the gamification feature)* and *willingness to recommend crowdsourcing approaches are influenced by the use of cooperative, competitive, and inter-team competitive gamification in crowdsourcing systems.* First, we conceptualize cooperative, competitive, and inter-team competitive gamification by drawing on social interdependence theory (Johnson, 2003; Johnson and Johnson, 1989) and gamification research (Morschheuser et al., 2017a, 2017b). Second, we advance the understanding of their effects on crowdsourcees' motivations and behaviors by conducting a large field experiment with a gamified crowdsourcing application called *ParKing*, which has been developed for the purpose of this research. Pursuing this research advances the understanding of competitive and cooperative settings in gamification and provides design knowledge relating to orchestrating competition and cooperation, especially in context of gamified crowdsourcing as well as in related fields.

2. Related Work and Theoretical Foundations

2.1. Gamification in Crowdsourcing

Crowdsourcing harnesses the potential of the Internet to reach large groups of people – the so-called *crowd* (Brabham, 2013; Doan et al., 2011; Estellés-Arolas and González-Ladrón-de-Guevara, 2012; Howe, 2006) – and involve them in distributed problem-solving. Crowdsourcing has become popular in recent years as organizations have begun to increasingly employ the crowd instead of traditional employees or supplies (Doan et al., 2011; Gatautis and Vitkauskaite, 2014; Geiger and Schader, 2014; Zuchowski et al., 2016). Crowdsourcing is often considered as an affordable and effective way to harness human resources for performing various types of work (Doan et al., 2011; Geiger and Schader, 2014; Nakatsu et al., 2014), including the creation of products and services (Brabham, 2008; Levina and Arriaga, 2014), the rating of content (Geiger and Schader, 2014), the solving of complex problems (Cooper et al., 2010; Sørensen et al., 2016), the development of ideas (Leimeister, 2010), the collecting of funds (Agrawal et al., 2014), and the processing of repetitive homogeneous tasks (Geiger and Schader, 2014; Law and Ahn, 2011). Crowdsourcing is a multifaceted phenomenon and appears in many different forms. While in the origins, crowdsourcing was realized by using website-based platforms accessible via the Internet, the recent rise of mobile technologies and the connection of everybody and everything enabled new forms of crowdsourcing, such as *mobile*, *wearable-based* or *situated crowdsourcing* (Prpić, 2016). The application of crowdsourcing can be found in most industries and has strongly influenced the ways in which products and services are invented, produced, funded, marketed, distributed, and used (Tapscott and Williams, 2011, 2010).

While there are various forms of crowdsourcing, explicit cooperation of the crowdsourcees is a key characteristic of most crowdsourcing initiatives (Doan et al., 2011; Geiger and Schader, 2014; Prpić, 2015a; 2016; Zhao and Zhu, 2014a). Crowdsourcing approaches where large groups of crowdsourcees explicitly work together to create emerging solutions have gained considerable interest in recent years, since examples such as Wikipedia, Yelp, Open Street Map, Waze, or TripAdvisor have demonstrated that cooperating crowdsourcees can create impressive outcomes, such as extensive knowledge repositories or databases. In the academic literature, these approaches are known by different designations such as *crowdcreating* (Geiger and Schader, 2014), *open collaboration* (Prpić et al., 2015b) or *mass collaboration* (Doan et al., 2011; Tapscott and Williams, 2010). However, since an active crowd with many participants is crucial for any crowdsourcing initiative, we need to understand the design aspects and incentives that are capable to sustainably engage large groups of people (Brabham, 2013; Doan et al., 2011; Law and Ahn, 2011; Zhao and Zhu, 2014a).

In incentive design, *gamification* has become a dominant approach across domains (see Hamari et al., 2014) and has been especially prominent in crowdsourcing (see Morschheuser et al., 2017a). Gamification refers to the use of *game design features* outside traditional video game environments with the aim to induce similar experiences as in games and to affect behaviors (Hamari et al., 2014; Huotari and Hamari, 2017; Vesa et al., 2017). Gamification's popularity stems from the notion that games are seen as particularly effective in addressing intrinsic needs such as the need to feel competent, autonomous and being meaningfully related to others (Przybylski et al., 2010; Rigby, 2015; Ryan et al., 2006), and experimental states such as flow experience (Csikszentmihalyi, 1990) and enjoyment (Hamari and Koivisto, 2015a; Rigby, 2015), and are therefore believed to positive encourage people to carry out given sought after behaviors outside of typical video game environments (Huotari and Hamari, 2017). Various studies reveal that gamification can indeed be an effective approach for positively affecting *motivations* and influencing *behaviors* (Hamari et al., 2014), for instance, the usage of information systems (Hamari, 2013; Morschheuser et al., 2015; Thom et al., 2012), learning outcomes (Denny, 2013; Hamari et al., 2016a; Morschheuser et al., 2014), participation in online communities or government services (Hamari, 2017; Tolmie et al., 2013; Vasilescu et al., 2014), exercise (Chen and Pu, 2014; Hamari and Koivisto, 2015b), creativity and innovation (Barata et al., 2013; Roth et al., 2015), consumer behaviors (Bittner and Schipper, 2014; Harwood and Garry, 2015).

Crowdsourcing systems are among the most popular application areas of gamification (Hamari et al., 2014; Morschheuser et al., 2017a, 2016; Seaborn and Fels, 2015). Considering gamification in the context of crowdsourcing systems, gamification is typically applied to increase crowdsourcees' *autotelic participation* (Morschheuser et al., 2017a, 2016). Previous research has shown that applying game design features in crowdsourcing can influence crowdsourcees' *motivations* (Runge et al., 2015; Tinati et al., 2016), quantitative *participation* (Eickhoff et al., 2012; Lee et al., 2013), *long-term engagement* (Lee et al., 2013; Prestopnik and Tang, 2015), and *output quality* (Eickhoff et al., 2012; Prestopnik and Tang, 2015) in various forms of crowdsourcing (Morschheuser et al., 2017a, 2016). However, several gaps prevent us from harnessing the full potential of gamification in crowdsourcing and similar contexts. According to a recent literature review on the use of gamification in crowdsourcing (Morschheuser et al., 2017a), the comparison of different gamification designs and particularly the comparison of competitive, cooperative, and inter-team-competitive gamification features have been largely ignored by previous research. Further, using gamification to engage explicit cooperation between crowdsourcees has been less researched, even though cooperative value creation is a key aspect of crowdsourcing, especially in crowdcreating (Doan et al., 2011; Geiger and Schader, 2014; Morschheuser et al., 2017a). Table 1 provides an overview of studies on the gamification of crowdsourcing systems that seek to collectively create emerging outcomes such as in crowdcreating, based on Morschheuser et al. (2017a). Since the implemented game designs differ greatly across individual studies, the extant studies' results are hardly comparable. Thus, we lack a comprehensive understanding which gamification feature types (e.g. cooperative vs. competitive features) are most effective to influence crowdsourcees' motivations and behaviors in crowdsourcing, particularly in crowdcreating with emergent outcomes.

Name of the example (source)	Purpose of the example	Type of implemented gamification features	Results of the study on gamification
Biotracker (Bowser et al., 2013)	Generating a database with plant phenology data	Competitive (leaderboard with the most active users) and individualistic (individual badges that could be unlocked)	Quantitative study: Significant correlations between perceptions of the gamification features and continued uses and participation intentions.
CampusMapper (Martella et al., 2015)	Creating a database/map with geospatial data	Competitive (conquer virtual territories; a leaderboard) and individualistic (individual points, badges, and levels)	Qualitative study: Participants preferred gamified version over a non-gamified version.
Close the door (Massung et al., 2013; Preist et al., 2014)	Generating a map with shops that close their doors during cold weather to reduce energy waste	Competitive (leaderboard with most active users) and individualistic (individual badges)	Mixed-method study: Gamification increases performance but not significantly compared to a non-gamified version. Competitions can be demotivating when poorly designed.
Geo-Zombies (Prandi et al., 2016)	Creating an interactive map with urban impediments for people with disabilities	Individualistic (collecting ammunitions to stay alive while fighting zombies on a map)	Mixed-method study: The gamified version led to a significant higher participation than the non-gamified version. Users perceived the app as more engaging than HINT! and were more willing to change their normal behaviors.
HINT! (Prandi et al., 2016)	Creating an interactive map with urban impediments for people with disabilities	Individualistic (collecting image parts of a puzzle; when completed, the image can be used as a voucher)	Mixed-method study: The gamified version led to a significant higher participation than the non-gamified version.
Ingress (Morschheuser et al., 2017c; Sheng, 2013)	Creating an interactive map with landmarks and locations of public art	Inter-team competitive (two factions that fight each other; conquer virtual territories for your team) and individualistic (individual badges)	Preliminary (poor or no empirical results).
Knome (Pothineni et al., 2014)	Creating a corporate knowledge database	Individualistic (performance points) and cooperative (karma / reputation points)	Quantitative study: Gamification can influence contributions and user behaviors.
REfine (Snijders et al., 2015)	Collaborative requirement elicitation and refinement	Mainly competitive (several leaderboards on which users can compete; limited coins/resources that can be	Qualitative study: Gamification seems to be effective for increasing engagement compared to traditional approaches.

		spent to perform actions and earn points)	
Urbama (De Franga et al., 2015)	Generating an interactive map with real-time traffic events, restaurant ratings, and weather information	Competitive (leaderboards) and individualistic (self-representation with avatars; points; levels; medals)	Quantitative study: Participation increased with gamification features compared to the period without the features.
WikiBus (Brito et al., 2015)	Creating an interactive map with real-time information about public transportation	Mainly individualistic (individual challenges; ownership of locations; individual points)	Preliminary (poor or no empirical results).

Table 1. Gamified Crowdsourcing Approaches with Emergent Outcomes (based on Morschheuser et al., 2017a)

2.2. Theoretical Underpinning

Research into why people participate in different initiatives and carry out given activities generally lean on the notion and theory that motivations can be chiefly categorized into *intrinsic* and *extrinsic*. Intrinsic motivation refers to a person's desire to take part in an activity for its own sake, while an extrinsic motivation refers to behavior driven by a person's expectation to receive external rewards, utilitarian benefits or to fulfil external regulations (Deci, 1975; Deci and Ryan, 1985; Ryan and Deci, 2000). This conceptualization mainly stems from self-determination theory (Deci and Ryan, 1985; Ryan and Deci, 2000), which is diversely applied in the technology adoption literature (Davis, 1989; Van der Heijden, 2004; Venkatesh et al., 2003), consumption theory (Hirschman and Holbrook, 1982), or media consumption research (e.g. Gan and Li, 2018; Luo et al., 2011). Therefore, the focus of what benefits people derive from the use of technology and what motivates them to use technology can be generally categorized into two broad main areas of 1) intrinsic/enjoyable and 2) extrinsic/useful (Van der Heijden, 2004). In the context of crowdsourcing systems, several studies found that both intrinsic and extrinsic factors determine users' *participation* in crowdsourcing systems (Kaufmann et al., 2011; Nov, 2007; Nov et al., 2010; Soliman and Tuunainen, 2015; Zhao and Zhu, 2014b), suggesting that while people may pursue extrinsic utility from participating in crowdsourcing, they also seem to participate in it because the crowdsourcing activity is enjoyable. Self-determination theory claims that we perform better when we are intrinsically motivated, i.e. when an activity is autotelic and we feel competent, autonomous, or connected to others. Games are seen as particularly effective in addressing such needs (Przybylski et al., 2010; Rigby, 2015; Ryan et al., 2006). Thus, the gamification of crowdsourcing has been considered a fruitful avenue to pursue in attempts to enrich crowdsourcing systems with the aim to positively influence crowdsourcees' intrinsic motivations and therefore their behaviors (Morschheuser et al., 2017a).

However, *gamification* is a manifold design direction (Deterding, 2015; Morschheuser et al., 2017d), and different kinds of implementation of gamification can lead to different motivational effects and behavioral outcomes (Hamari et al., 2014; Huotari and Hamari, 2017; Morschheuser et al., 2017a; Ryan et al., 2006). *Goals* have always been considered as a key design aspect of games and gamification with direct impact on the motivation and behavior of players (Deterding, 2015; Huotari and Hamari, 2017; Malone, 1982, 1981; Sweetser and Wyeth, 2005; Von Ahn and Dabbish, 2008). This is grounded in the goal-setting theory, which assumes that humans are goal-directed in their behaviors and that thus the setting of goals can influence a persons' motivations and behaviors (Locke and Latham, 1990; 2002). Games are known for their difficult challenges the players have to overcome, which mean that they typically set goals which are difficult to achieve due to specific rules and game mechanics the palyers have to follow (Deterding et al., 2015; Malone, 1982, 1981; Von Ahn and Dabbish, 2008). According to the goal-setting theory, the overcoming of such challenging goals can induce high levels of intrinsic motivation and performance (Hamari, 2013; Jung et al., 2010; Landers et al., 2017; Locke and Latham, 1990). Further, it has been shown that explicit performance feedback provided by game elements such as points or leaderboards, can increase the performance of people in achieving goals compared to those without such gamification elements (Jung et al., 2010). Various types of goals can be found in games that provide player engaging challenges and little research has focused on their classification and difference in influencing motivations and behaviors. One classification that can be applied is whether a game is cooperative or competitive (Arnab et al., 2016; Chen and Pu, 2014; Liu et al., 2013; Morschheuser et al., 2017b; Plass et al., 2013; Siu et al., 2014), i.e. how players are interdependent of one another and interact with each other in a game or a gamified environment. In social science, social interdependence theory (Johnson, 2003; Johnson and Johnson, 1989) is widely used to explain how an environment's goal structures influence the interaction of individuals, such as whether they act individualistically and/or whether they cooperate or compete. This theory has also applied to the context of video games to distinguish between *individualistic*, *cooperative*, *competitive*, and *inter-team competitive* game designs (Liu et al., 2013; Plass et al., 2013; Morschheuser et al., 2017c). Following Liu et al. (2013), game designs can be classified as (1) *individualistic* when the goals of players are independent and individual actions have no effect on other players (no interdependence; e.g. single-player game designs); (2) *competitive* when goals are negative correlated and individual actions obstruct the goals and actions of others (negative interdependence; e.g. competitions in which player compete with each other); (3) *cooperative* when several players have a shared goal and individual actions promote the goals and actions of others (positive interdependence; e.g. shared challenges for a team of players); and (4) *inter-team competitive* when groups of players compete with other groups and thus several players share the goal to jointly obstruct the goals and actions of others (mixed; e.g. team competitions) (Liu et al., 2013; Peng and Hsieh, 2012; Tauer and Harackiewicz, 2004). Since gamification approaches apply the same goal structures as games (Deterding, 2015), this conceptualization has been also applied to classify gamification designs and their features (Morschheuser et al., 2017b; Star, 2015).

According to prior research, gamified crowdsourcing systems commonly apply game design features such as leaderboards or rankings to invoke competitions between crowdsourcees, combined with individualistic game design features such as private badges, points, or levels to provide additional motivational affordances (Morschheuser et al., 2017a). This seems to also be the case in crowdsourcing types where people are supposed to explicitly work together (Table 1) (Morschheuser et al., 2017a). However, inter-team competitions (4) or cooperative gamification (3) may be also fruitful gamification avenues for such crowdsourcing initiatives (Table 1). Thus, there is a clear research gap in investigating which type of interdependence between crowdsourcees prompted by goals set by gamification are optimal for crowdsourcing performance. While the implementation of all four different goal structures have been used in crowdsourcing initiatives (Table 1) (Morschheuser et al., 2017a; Seaborn and Fels, 2015), we still lack empirical research into their effects and differences.

Social interdependence theory indicates that competition or cooperation between people can influence people's enjoyment in an activity and behaviors in several ways (see Johnson and Johnson, 1989 for a review; Tauer and Harackiewicz, 2004). Research conducted on the psychological effects of competitions stressed that competitions are enjoyed by individuals owing to their great potential to 1) transform an activity into an engaging challenge and 2) assess a person's competence in performing a task (Liu et al., 2013; Tauer and Harackiewicz, 2004; Zhang, 2008). Competitions provide difficult and interesting challenges whose mastery can convey a strong sense of competence (Reeve and Deci, 1996; Jung et al., 2010; Zhang, 2008). Further, competitions commonly afford instant performance feedback for direct competence valuation (Jung et al., 2010). Together, these aspects of competitions can give rise to intrinsic motivations and feelings, such as enjoyment (Epstein and Harackiewicz, 1992; Tauer and Harackiewicz, 2004) and flow (Csikszentmihalyi, 1990), as has often been shown in research on competition in games (Liu et al., 2013; Ryan et al., 2006). However, competitions can also thwart intrinsic motivation when users focus on winning rather than on the activity itself or when the competition is perceived as controlling and external consistency (Ames and Felker, 1979; Deci et al., 1981). Further, competitions can have demotivating effects when opponents are unbalanced (e.g. skilled players compete against novices with little experience of a game) (Ipeirotis and Gabrilovich, 2014; Liu et al., 2013). Particularly in the context of gamified crowdsourcing previous research indicates that pure competitive structures can demotivate users with medium and low contributions when they directly compete with a small group of high-performing crowdsourcees (Massung et al., 2013; Preist et al., 2014).

Cooperative goal structures also provide opportunities to invoke intrinsic motivations (Roseth et al., 2008; Tauer and Harackiewicz, 2004). Being part of a team that works together towards a shared goal has been identified as motivational gratification for players of online games with cooperative features (Rigby and Ryan, 2011; Scharkow et al., 2015; Yee, 2006). Cooperative play allows players to overcome challenges that would be impossible to reach when playing alone. Mastering such challenges in a team may invoke the experience of deep competence satisfaction (Rigby and Ryan, 2011; Ryan et al., 2006). Cooperative situations also provide opportunities for socializing and the experience of social relatedness and can thus satisfy the innate need for having meaningful connections with others (Deci and Ryan, 2000; Roseth et al., 2008; Zhang, 2008). The experience of being related to others and being of relevance for others have been shown to be a crucial mediator for intrinsic motivation processes (Ryan and Deci, 2000). Thus, cooperative structures that provide an individual the sense of social relatedness and the possibility of experience competence satisfaction when working with others towards a common goal may positively influence a user's intrinsic motivation and enjoyment in an activity (Rigby and Ryan, 2011; Ryan et al., 2006). While a great range of literature on the self-determination theory indicates that cooperative structures promote intrinsic motivation (for reviews see Ryan and Deci, 2000; Tauer and Harackiewicz, 2004), research also reported that cooperative structures can negatively affect the intrinsic need satisfaction. For instance, cooperative may thwart intrinsic motivation, when the cooperative structures are perceived as controlling or impose restrictions towards the autonomy of an individual (Chirkov et al., 2003; Deci and Ryan, 2000; Tauer and Harackiewicz, 2004).

According to Tauer and Harackiewicz (2004), the motivational benefits of cooperation can be even greater when combined with competition, for instance in the form of team structures where individuals cooperate in a team but compete as a team against other teams. Competition between groups can provide an additional incentive for the members of a group, motivating them to raise their individual performance compared to pure cooperation (Johnson and Johnson, 1989; Tauer and Harackiewicz, 2004). Further, combinations of cooperation and competition provide additional opportunities for competence satisfaction, which – in turn – can increase people's levels of enjoyment and performance in such situations (Erev et al., 1993; Okebukola, 1986; Tauer and Harackiewicz, 2004). Inter-team competitions provide clear goals in groups and create clear barriers between groups; taken together, these can invoke strong tribal instincts (Vugt and Park, 2010), social identification processes (Turner, 1975) and *we-intentions* (Tuomela, 2000) with positive influences on the group members' individual performances (Julian and Perry, 1967; Tuomela, 2000).

While research indicates that both cooperative and competitive goal structures positively influence intrinsic motivation, enjoyment, and performance of people in an activity (Epstein and Harackiewicz, 1992; Johnson, 2003; Johnson and Johnson, 1989; Roseth et al., 2008; Tauer and Harackiewicz, 2004), it has been shown that the combination of both goal structures, as in inter-team competitions, can lead to the highest enjoyment and performance levels (Johnson and Johnson, 1989) in sports (Tauer and Harackiewicz, 2004), at work (Erev et al., 1993), or in education (Okebukola, 1986). Thus, applying gamification designs that invoke inter-team competitions in crowdsourcing systems may be most effective for enhancing crowdsourcees' intrinsic motivations and enjoyment. Supported by the self-determination theory (Deci and Ryan, 1985; Ryan and Deci, 2000) and a broad body of literature relating to technology use (Davis, 1989; Van der Heijden, 2004; Venkatesh et al., 2003), it can be assumed that greater intrinsic motivation of crowdsourcees positively influence their *behaviors*, such as their *system* *usage* and/or the amount and quality of *participation*, depending on which specific behaviors the gamification rewards (Morschheuser et al., 2017a). Thus, inter-group competitions may be particular effective for supporting intrinsic motivation and behaviors in crowdsourcing, compared to pure cooperative or competitive gamification designs.

Besides a motivated and active crowd (Doan et al., 2011; Morschheuser et al., 2017a) operators of crowdsourcing approaches must also continually attract new participants to compensate for crowdsourcee churn. Thus, it is important that active users who enjoy voluntary participation in a crowdsourcing approach invite others to also participate in the initiative and thus recommend the system. In crowdcreating systems, crowdsourcees commonly benefit from an increasing number of supporters, since the overall usefulness of cooperatively created outcomes typically increases with a larger group of active crowdsourcees (Geiger and Schader, 2014). These reciprocal benefits may motivate people to invite others to participate in crowdsourcing. Cooperative gamification designs that further enhance these benefits by motivating working together instead of competing may encourage crowdsourcees to invite others for achieving the shared goals (Hamari and Koivisto, 2015b). Therefore, cooperative gamification may lead to higher word-of-mouth compared to competitive gamification, where the general incentive for inviting further people to participate is undermined by the fact that more users increases competition between users. Further, a person's willingness to recommend a system via word-of-mouth is strongly related to their satisfaction with a system (Kim and Son, 2009; Richins, 1983). Thus, gamification features with goal structures that invoke high levels of intrinsic motivation and enjoyment may also relate to a higher intention to recommend crowdsourcing approach (Hamari and Koivisto, 2015b; Plass et al., 2013).

3. Method and Data

We conducted a large field experiment to shed light on the research question and to investigate the motivational and behavioral effects of cooperative, competitive, and inter-team competitive gamification in crowdsourcing. With the intention to provide a high external validity, we performed the experiment in the field with a crowdsourcing app called ParKing, which we developed as an experimental platform for performing this research.

ParKing is a gamified crowdcreating system designed to create an interactive map of on-street parking spaces, including the location of parking spaces and their conditions (e.g. prices; restrictions such as residents' parking; time and day restrictions; free parking). Thus, ParKing seeks to effectively provide parking information to people looking to park. The gamification component of ParKing attempts to motivate people to participate in the collective data collection by sharing location-based parking information. ParKing directly visualizes the user-generated and aggregated data on a map, so that users who are unfamiliar with a city's parking situation can easily see where (free) parking is possible and where not (Figure 1). A button enables users to switch between the *visualization of the data* and the *game mode*, in which parking information can be shared and users can interact with the app's gamification features (Figure 1).

We chose this context since the search for on-street parking is a problem that affects many people, and we lack comprehensive digital solutions that holistically focus on this problem. Current digital maps, including crowdsourcing approaches such as OpenStreetMap and Waze don't as yet provide detailed on-street parking information. Further, simplifying parking could have great economic and ecological consequences, since searching for parking in urban areas is a primary cause of traffic congestions in large cities (Arnott et al., 2005; Axhausen et al., 1994; Shoup, 2006, 2005). Studies conducted in different cities around the world revealed that around 30% of prevailing traffic is due to cruising for parking (Shoup, 2006, 2005). Searching for parking is responsible for tons of carbon dioxide emissions every day, and strongly influences other drivers' time and fuel consumption (Shoup, 2006, 2005). With ParKing, we sought to generate a comprehensive information platform that allows drivers to easily get an overview of parking and non-parking areas. In our view, such a platform can reduce cruising for parking by drivers unfamiliar with a city's parking situation, such as tourists or business travelers. Further, current efforts in the context of autonomous driving, shared mobility, and smart cities will need highly qualitative maps, in particular in the parking context (Coric and Gruteser, 2013; Margreiter et al., 2015).

The design followed the conceptual framework for gamified crowdsourcing systems by Morschheuser et al. (2017a). The app gives users the functionality to jointly generate an emergent map with parking information (solution) by sharing street-based parking information (task) on a digital map in a smartphone app. The user interface is comparable with other crowdsourcing apps that seek to collect geographical data (Brito et al., 2015; De Franga et al., 2015; Liu et al., 2011; Martella et al., 2015; Massung et al., 2013; Prandi et al., 2016; Sheng, 2013) and consists mainly of a map on which users can select street segments in their near vicinity (approximately a 130m radius) to share parking information (Figure 1, top middle).

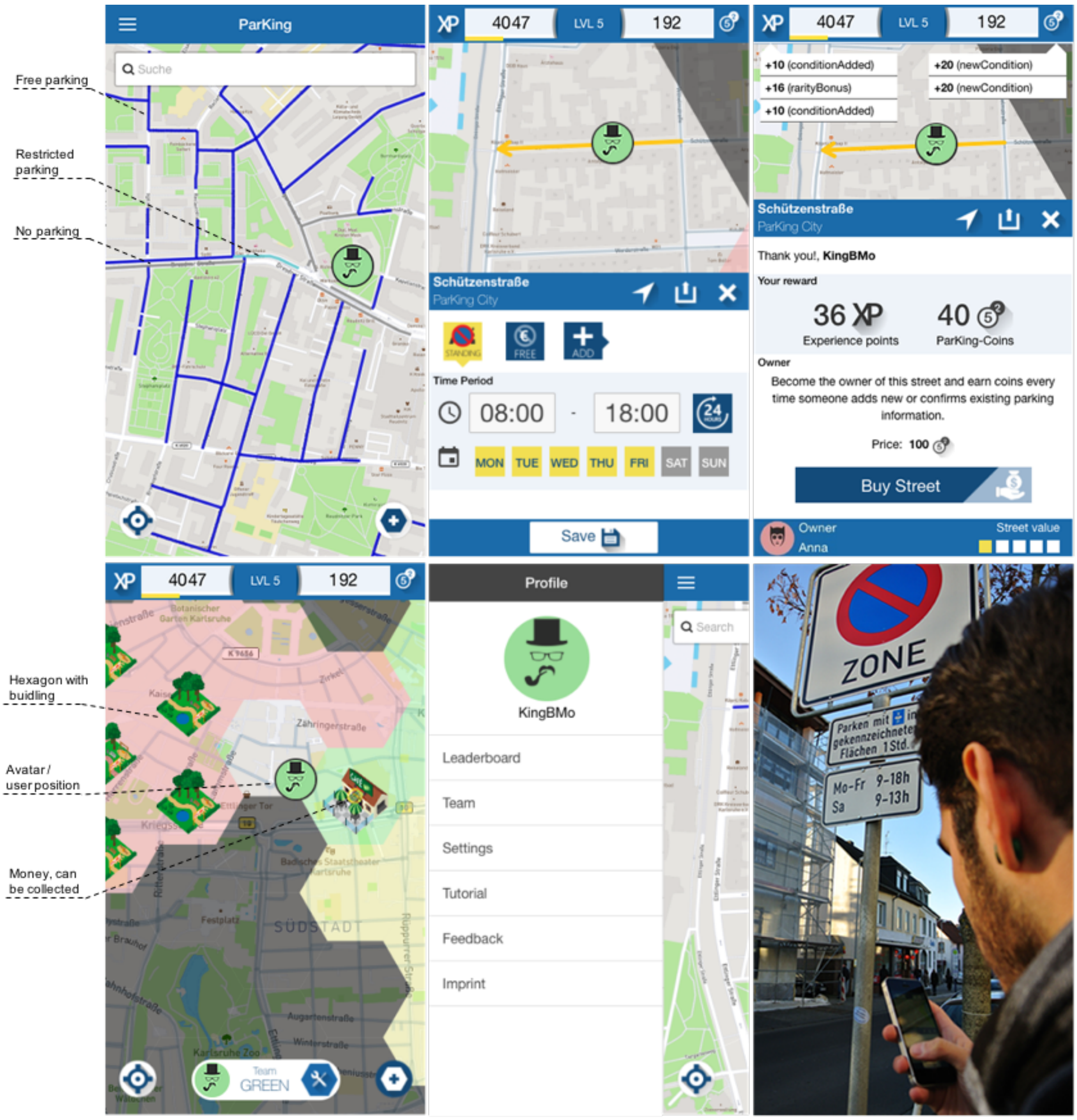

Figure 1. The ParKing App

Notes: Top left: A map with collected parking information. Top middle: Sharing parking information. Top right: Rewards for sharing parking information. Bottom left: The game mode (the screenshot shows the inter-team competition). Bottom middle: Menu. Bottom right: A user playing ParKing.

To gamify ParKing, we followed the method of Morschheuser et al. (2017d), the latest gamification design framework developed as a synthesis of 17 previous gamification design frameworks. We developed the game design features in several iterations and with an interdisciplinary team of six M.Sc. students and a PhD student. Inspired by popular games such as Monopoly, SimCity, Pokémon Go, and Ingress, as well as other gamified crowdsourcing apps (Table 1), ParKing's core game mechanism is the conquering of virtual territories (*hexagons*) on a map and the constructing of buildings in these territories, visible to the other users of the app (Figure 1). The gameplay is simple; users can earn virtual coins by sharing parking information. These coins can be spent to purchase street segments or construct buildings. Buildings can only be constructed on virtual hexagons, which have been generated and mapped on the real map. The user who owns the most streets in the area of a hexagon automatically owns the overlying hexagon and can construct one building on it. We created a set of different building types from which the users can choose. Some of these buildings have effects on their environment (e.g. increased income from other users' inputs, increased value of the streets, additional regular income from the building), so that the users have to make strategic decisions when choosing a building. Further, these buildings' prices differ and some can be further upgraded to increase their influence.

To motivate users to share correct information, we followed Von Ahn and Dabbish's (2008) design principles and implemented an output-agreement mechanism: a user can receive bonus coins if they confirm the data previously shared by other users. Further, a street owner can receive bonus coins if other users confirm their street's data (Table 2). Thus, to think and act like others is the winning strategy and can motivate people to share qualitative data instead of wrong data (Von Ahn and Dabbish, 2008).

The current geographical position of a user and those of other users in the vicinity are visualized by small customizable avatars that are also used to represent the user in the app, for instance, as the owner of a street or a hexagon. We implemented several personal challenges (Hamari, 2017) connected with clear goals (e.g. conquer five related hexagons, buy a first street, use the app for several days) that allow one to unlock new costumes for the avatars, such as a special hat or glasses.

Interaction	**User reward**	**Street owner reward**

User adds parking conditions	$coins += 20 + c$ $xp += 10 + r$	If street has an owner, the owner receives: $coins = 5 + v + r + b$

$c = confirmation\ bonus = Min(x \cdot 2\ ;\ 10)$
$r = rarity\ bonus = Max(20 - p\ \cdot 2\ ;\ 0)$
$x = number\ of\ conditions\ that\ match\ conditions\ of\ previous\ posts\ from\ other\ users$
$p = overall\ number\ of\ posts\ per\ street\ segment$
$v\ =\ value\ of\ the\ street\ segment;\ between\ 1\ and\ 5$
$b\ =\ influence\ of\ buildings\ in\ the\ vicinity\ \ e.g. = \ 50\ *\ marketlevel$

Table 2. Rewards Rules in ParKing

3.1. Experimental Conditions

Based on the above described game mechanics of ParKing, we developed three different versions, with three different primary goal structures. According to the framework of Morschheuser et al. (2017b) and the social interdependence theory (Johnson, 2003; Johnson and Johnson, 1989), we created (1) a *cooperative* version where users' primarily goal was to enlarge the joint 'ParKing realm' by conquering as many hexagons together as possible; (2) a *competitive* version where the overall goal was to become the 'ParKing' (the user with the most conquered hexagons); and (3) an *inter-team competition* where the users could join one of three competing teams (cf. Tauer and Harackiewicz 2004), with the overall goal to jointly conquer and defend the largest 'ParKing realm' with the most hexagons. In each version, users had to click through a short onboarding tutorial explaining the gamification features and the overall goal of the gamification version a user was playing. In the inter-team competition, the users were asked to join one of the three teams (team green, team red and team yellow) as part of the onboarding tutorial. Further, we applied different rules and color schemes to realize these three gamification approaches (Table 3). In the *cooperative* version, all conquered hexagons by players were colored in green and users were unable to buy streets already owned by other users. In the *competitive* version, own hexagons were colored in green and other users' hexagons in red. In the *inter-team competition*, the hexagons were colored in the team colors: red, green, and yellow (Figure 1, bottom left). In *competitive* and the *inter-team competitive* versions, users were able to buy streets from their opponents by paying a coin price related to the value of the streets. On the other hand, by paying virtual coins, users of these two versions could increase their own street's values in order to protect them against opponents. The three variants were completely separate from one another so that, in a version, only players of that version could interact with one another and could perceive each other.

Game features	Competition	Inter-team competition	Cooperation
Goal	Become the 'ParKing' by conquering the largest realm	Conquer the largest 'ParKing realm' jointly with your team	Enlarge the joint 'ParKing realm'
Goal measurement	Number hexagons conquered by a player	Number hexagons conquered by all players of a team	Number hexagons conquered by all players
Core activity needed for goal achievement	Players share parking information to earn virtual coins that can be spend to purchase street segments. The player who has the most street segments in a hexagon becomes the owner of the hexagon.		
Additional activities related to the goal achievement	Players can build buildings on hexagons they own in order to increase their incomes of virtual coins. This allows them to accelerate the purchasing of street segments and thus to conquer hexagons more quickly. However, if a player loses a hexagon constructed buildings are destroyed.		
Buying other players' street segments is possible?	Yes	Yes, from players of opposing teams	No
Visualization	Hexagons of the player: green; Hexagons of other players: red; Other hexagons: grey	Hexagons were colored in the team color of the player who owns the hexagon; Other hexagons: grey	All hexagons conquered by the players were green; other hexagons: grey
Feedback on goal achievement (Figure 2)	Performance of the 10 most successful players and the individual performance	Team performance, performance of the 10 most successful players of each team and the individual performance	Community performance and the individual performance

Table 3. Game features and their differences in the three experimental conditions

According to goal-setting theory (Locke and Latham, 1990) and as a common practice in gamification (Hamari et al., 2014; Morschheuser et al., 2017a, 2016), we implemented different types of leaderboards/statistics so as to give users immediate feedback on their performance. In the inter-team competition, users could see their team's overall performance and the performance of the top 10 players of each team; in the competitive version, we listed the top 10 users according to their individual performance; in the cooperative version, we showed joint success and individual contributions (Figure 2). In all groups, users could view these statistics and rankings for different time intervals: the last week, the last month and all-time (i.e. since the rollout of the app).

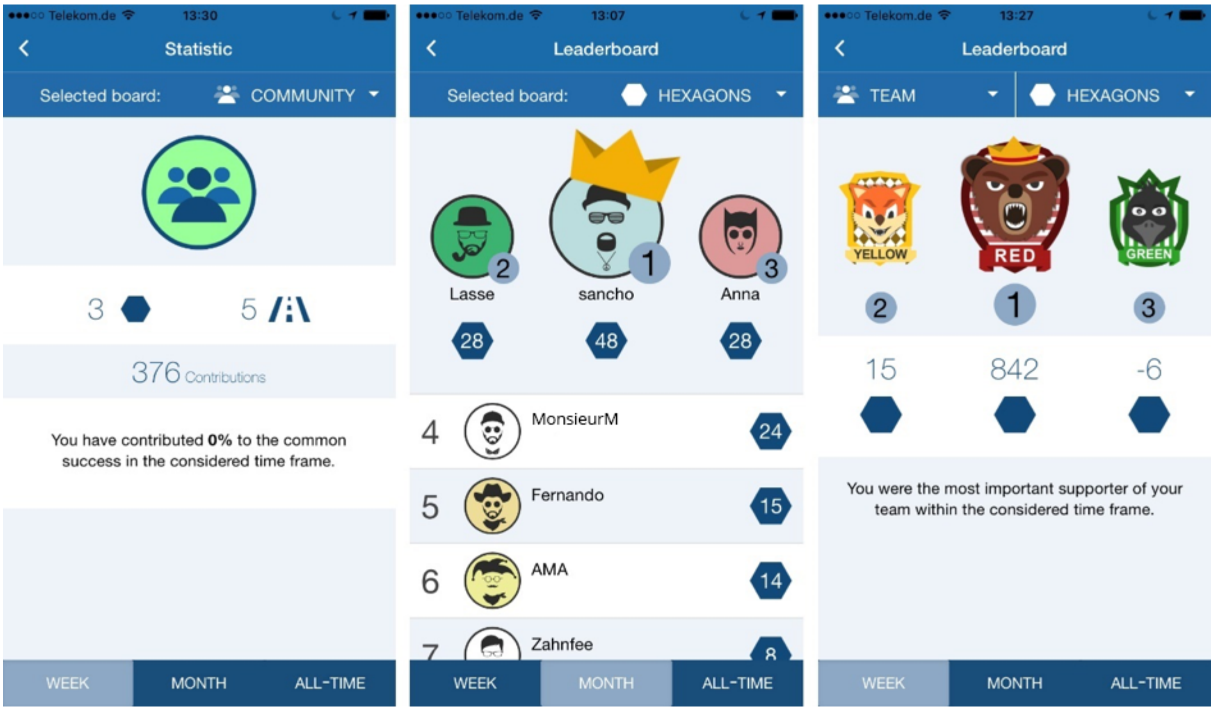

Figure 2. The Three Different Leaderboards

Notes: Left: the cooperative version, which showed the joint community progress. Users could further select another view to analyze their individual contribution to the joint success. Middle: the competitive version, which showed the current 'ParKing' with the most hexagons and their opponents, ranked by their performance. Right: the leaderboard of the inter-team competition, which showed an overview of the team success. Users could further select another view that showed the top 10 contributors of each team and could analyze the individual contribution of the team members.

3.2. Participants and Procedure

The experiment was conducted between January and April 2017 across Germany. Participants were recruited in forums on various mobility-related platforms and by using the service of two large Germany experiment databases with more than 6000 registered persons. The experiment was described as a field experiment with the aim of testing a novel mobility app. Interested people were asked to sign up for the field study on our website (http://parking-app.de) by providing their e-mail address, place of residence, and smartphone type. When starting the field experiment, we have sent everyone who had signed up to participate a tutorial for installing the app via Apple TestFlight or the Google Play Store and one of three pre-defined registration codes that assigned the participants into one of the three experimental groups. Instead of a complete randomized assignment of the participants into the three experimental groups, we manually blocked the participants based on their place of residence. Blocking is the non-random arrangement of experimental units into groups (blocks) consisting of units that are similar to one another (Mason et al., 2003, p. 316). This reduces known but irrelevant sources of variation and interferences between subjects and thus allows greater precision in the estimation of the source of variation under study. In our case, we assumed that large differences in the geographical proximity of the participants in the three groups could heavily influence the results of the field experiment. Because our gamification approach was played on a map of the real world and within the experimental groups all participants were able to interact (cooperate or compete) with each other by using location-based elements in their geographical vicinity such as streets, virtual areas (hexagons) and virtual buildings, we decided to blocked the participants based on their place of residence and thus to manually ensure that the experimental groups were homogeneous with respect to the geographical proximity of the participants. Technically, the blocking was performed in the following steps: First, we clustered the people who signed up at our website according to their reported place of residence and divided these clusters into three homogenous groups, paying particular attention to geographical and numerical sizes of these clusters. Second, we randomly assigned these groups to the three experimental conditions and generated an individual registration code for each group. Third, we have sent the participants these codes together with a tutorial how to install the app. Fourth, after a participant downloaded and installed the app, they were asked for the registration code. When entering the code, the app was automatically configured to include only the features of the corresponding experiment group. Based on our blocking, the competitive version was used by participants in Stuttgart and Düsseldorf area, the inter-team version by participants in Leipzig, Berlin, and Karlsruhe area, and the cooperative version by participants in Munich and Hannover area. Figure 3 provides an overview of the entire experimental procedure. The approach ensured that the features of the app were equal for all participants within one experimental group, while between the groups the variants were completely separated from one another (Table 3). Thus, all members of an experimental group were able to perceive and interact with each another without recognizing that different versions of this app were available and used in parallel in different experimental groups. Further, the implementation ensured that all participants, even if they were geographically clustered from the beginning of the experiment, were able to use the app in their groups all over Germany. Thus, all participants that played the pure competitive version were able to compete against each other even they used the app in different cities. The same applied to the cooperative and inter-team competitive version.

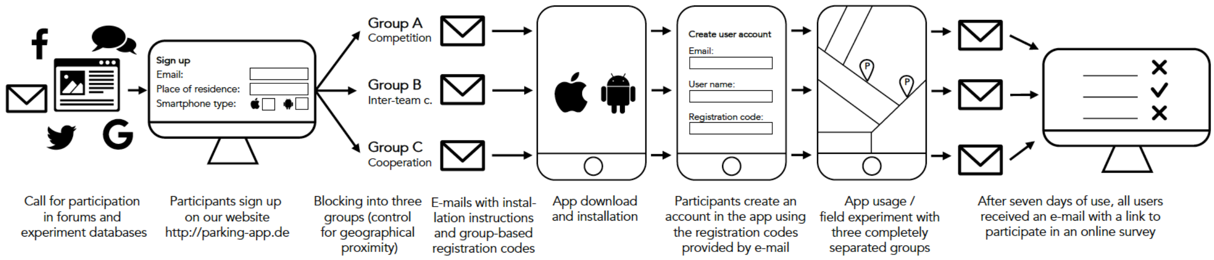

Figure 3. Experimental procedure

During the three-month period, 459 persons downloaded the ParKing app, 214 on iOS and 245 on Android. Of these, 372 installed the app and created a user account in the app (*app users*); they all used the app (e.g. to find parking places). A subsample of 203 app users added at least one parking condition and can therefore be seen as *crowdsourcees*, since they participated in the app's crowdsourcing aspect. After a user has installed and used the app, they automatically received an e-mail after seven days with a request to participate in an online survey to measure motivations to use the app and willingness to recommend the app, as well as to gather demographic information, information related to the app's relevance, and feedback. In total, 170 users of all the *app users* took part in the survey; these *survey participants* formed another subsample of the app users. Depending on what is analyzed in the following, the data were based on one of these related samples. Table 4 provides an overview. All users with a user account were entered into a prize draw for one of 10 electric screwdrivers.

	Competition		**Inter-team competition**		**Cooperation**	
	N	%	N	%	N	%
App users	123	33.1	119*	32.0	130	35.0

Crowdsourcees: app users with at least one crowdsourcing contribution	58	28.6	72*	35.5	73	36.0
Survey participants:	50	29.4	61*	35.9	59	34.7
Gender						
Female	14	28.0	11	18.0	8	13.6
Male	36	72.0	50	82.0	51	86.4
	Mean	SD	Mean	SD	Mean	SD
Age	32.7	9.90	28.1	10.7	32.2	12.3
Frequency of using mobile apps for driving assistance						
	2.8	1.2	2.7	1.1	2.6	1.1
Perceived difficulty of finding a parking spot						
In familiar cities	2.9	0.9	2.9	0.8	2.9	0.9
In unfamiliar cities	4.1	0.8	4.1	0.7	3.9	0.8
Average time to find a parking space	11.6 min	7.5 min	11.9 min	6.1 min	12.5 min	7.4 min

* Team sizes in the inter-team competition: Team green = 41 app users, 27 crowdsourcees, 21 survey participants; Team red = 38, app users, 19 crowdsourcees, 18 survey participants; Team yellow = 40, app users, 26 crowdsourcees, 22 survey participants.

Table 4. Overview of the Samples

3.3. Measures

The self-determination theory (Deci and Ryan, 1985; Ryan and Deci, 2000) distinguishes "between different types of motivation based on the different reasons or goals that give rise to an action. The most basic distinction is between intrinsic motivation, which refers to doing something because it is inherently interesting or enjoyable, and extrinsic motivation, which refers to doing something because it leads to a separable outcome" (Ryan and Deci, 2000, p.55). In the information systems research it is commonplace to discuss intrinsic and extrinsic motivation to use information systems (Davis, 1989; Van der Heijden, 2004; Venkatesh et al., 2003), which also have been used as such in several studies in gamification (Deterding, 2015; Hamari and Koivisto, 2015a; Huotari and Hamari, 2017; Mekler et al., 2013). However, it should be noted that this conceptualization is not completely analogous with the self-determination theory (Deci and Ryan, 1985; Ryan and Deci, 2000) where intrinsic and extrinsic needs and motivation are more particularly and specifically defined. In this study, we specifically attach ourselves to the understanding of intrinsic and extrinsic motivation in information systems area, and therefore, on a general level measure intrinsic motivations as general *perceived enjoyment* of system use and extrinsic motivation as general *perceived usefulness* of system use (e.g. Davis, 1989; Van der Heijden, 2004; Venkatesh et al., 2003).

To investigate the different gamification conditions' effects on users' behaviors, we measured how they interacted with the system and its gamification and crowdsourcing features. First, we measured the overall *system usage* in the three alternative gamification conditions, which we operationalized as overall time of using the app per user. Second, as part of the system usage, we measured users' *crowdsourcing participation* and their *engagement with the gamification feature*. Thus, we collected the numbers of quantitative contributions (parking conditions) a user provided, as well as how many hexagons a user has conquered, since this activity represented the user engagement with the gamification feature's goal in all three conditions. Third, we collected users' *willingness to recommend* the app, operationalized as survey construct, following Kim and Son (2009).

Table 5 provides a detailed overview of the constructs and their operationalizations. We adapted all survey items from previously published sources (Table 5; Appendix A) and measured them along a 7-point Likert scale (from *strongly disagree* to *strongly agree*).

Construct	Definition	Operationalization
Perceived usefulness	The extent to which a user perceived the use of the system to be useful	Survey construct according to Hamari and Koivisto (2015a) and Davis (1989)
Perceived enjoyment	The extent to which a user perceived the use of the system to be enjoyable	Survey construct according to Hamari and Koivisto (2015a) and Van der Heijden (2004)
System usage	Overall usage of the gamified crowdsourcing app	Overall time of using the app per user in seconds (cumulative)
Crowdsourcing participation	Contribution level in the crowdsourcing aspect of the gamified crowdsourcing app	Number of parking conditions shared by a user in the app
Engagement with the gamification feature	Engagement level with the gamification feature of the gamified crowdsourcing app	Number of hexagons conquered by a user in the app
Willingness to recommend	Users' willingness to recommend the gamified crowdsourcing app to others	Willingness to recommend, survey construct according to (Kim and Son, 2009)

Table 5. List of Constructs, Definitions, and Operationalization

Besides the motivational and behavioral aspects, we also used the survey to collect control variables to check possible heterogeneities between the three independent groups, which could arise form *demographic differences* or *differences in the app's relevance* for participants. Thus, we collected age and gender of the participants, as well as the *frequency of using mobile apps* *for driving assistance* (5-point scale from 1 = *always* to 5 = *never*), the *perceived difficulty of finding a parking spot in familiar and unfamiliar cities* (1 = *very easy* to 5 = *very difficult*), and the *average time spent by users to find a parking space* (*in minutes*).

3.4. Validity and Reliability

We assessed convergent validity (see Appendix A) via three metrics: Cronbach's α, average variance extracted (AVE), and composite reliability (CR). All the convergent validity metrics were met and were clearly greater than thresholds in the literature (each construct's Cronbach's $\alpha > 0.7$, AVE > 0.5, CR > 0.7) (Fornell and Larcker, 1981; Nunnally, 1978). First, we examined the discriminant validity by comparing of the square root of each construct's AVE to all the correlations between it and other constructs, where, according to Fornell and Larcker (1981), all of the square roots of the AVEs should be greater than the correlations between the corresponding construct and any other construct. Second, we assessed discriminant validity by confirming that each item had the highest loading with its corresponding construct.

The application of Pearson's Chi-square test revealed no significant associations between the groups and gender. Further, we found no significant differences between the three groups by conducting one-way ANOVA tests regarding the age of the participants $F(2,167) = 3.028$, $p = 0.051$; the frequency of using mobile apps for driving assistance $F(2,167) = 0.462$, $p = 0.631$; the perceived difficulty of finding a parking spot in familiar cities $F(2,167) = 0.029$, $p = 0.971$ and unfamiliar cities $F(2,167) = 2.648$, $p = 0.074$ and the average time spent by the users to find a parking space $F(2,167) = 0.135$, $p = 0.874$.

4. Results

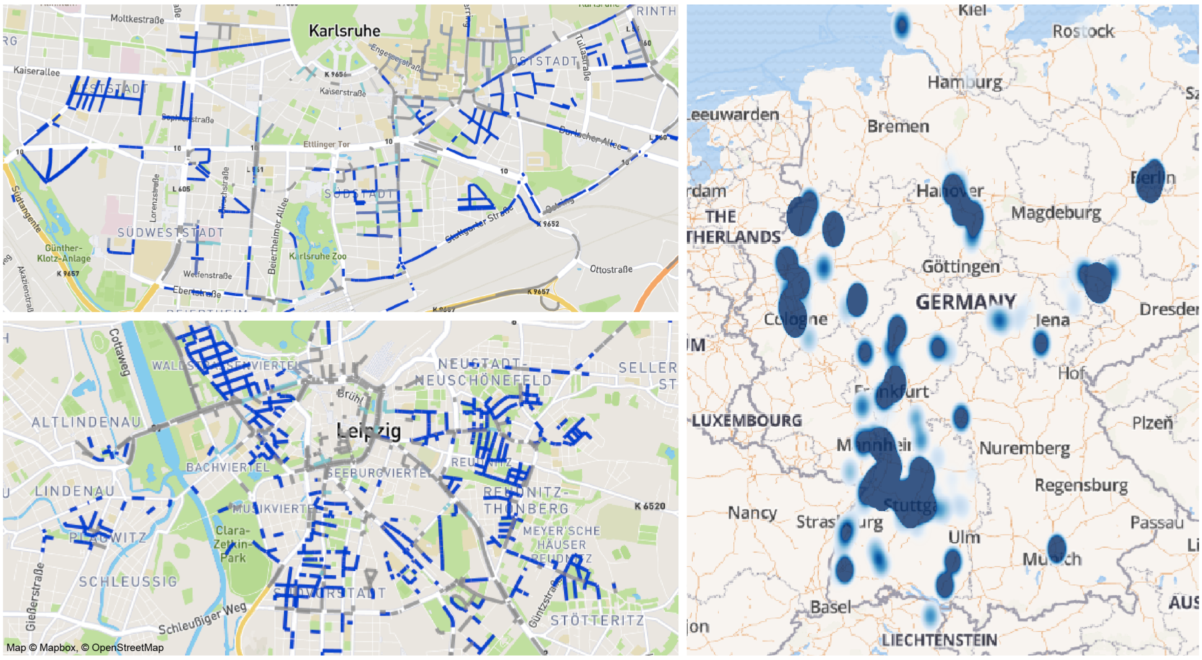

Figure 4. Overview of the Collected Parking Data in All Groups by Gamified Crowdsourcing

In total, the ParKing users collected 6,970 parking conditions all over Germany during the field study. Main activities were in Stuttgart, Karlsruhe, Leipzig, Mannheim, Cologne, and Dusseldorf (Figure 4).

4.1. Motivational Outcomes

First, we analyzed the users' perceived enjoyment and usefulness of the system in the three gamification conditions. Table 6 provides an overview of the descriptive results. We conducted a one-way MANOVA test to determine possible differences between the experimental conditions regarding users' perceived enjoyment and perceived usefulness when using the app.

Overall, the analysis revealed no significant difference when comparing the motivational outcomes between the gamification conditions: F(4,332) = 2.163, p = 0.073, Wilk's = 0.025. We then tested the effects of the gamification conditions on different dependent variables separately using one-way ANOVA analyses. The tests revealed significant differences in the *perceived enjoyment* between the gamification conditions: F(2,167) = 3.769, p = 0.025**, partial η^2 = 0.043, but no significant differences when analyzing the *perceived usefulness* F(2,167) = 1.873, p = 0.157.

Next, pairwise comparisons were run between the individual gamification conditions using the Tukey-HSD test (Table 7). We found that users of the inter-team competitive design reported a significantly higher enjoyment level compared to users of the competitive design (p = 0.030**, diff = 0.629) and a weakly significant, higher enjoyment level compared to the users of the pure cooperative design (p = 0.099*, diff = 0.485).

Levene's tests revealed that in all cases, homogeneity of variance could be assumed (p > 0.1).

	Competition		**Inter-team competition**		**Cooperation**	
Dependent variable	Mean	SD	Mean	SD	Mean	SD
Perceived enjoyment	4.06	1.35	4.69	1.14	4.20	1.36
Perceived usefulness	4.10	1.53	4.60	1.21	4.41	1.36

Table 6. Means and Standard Deviations for Users' Perceived Enjoyment and Perceived Usefulness

	Comparison		**Difference**	
Dependent variable	I	II	Mean (I to II)	p
Perceived enjoyment	Competition	Inter-team competition	-0.629	0.030**
	Cooperation	Inter-team competition	-0.485	0.099*
	Cooperation	Competition	0.144	0.829
Perceived usefulness	Competition	Inter-team competition	-0.503	0.133
	Cooperation	Inter-team competition	-0.196	0.713
	Cooperation	Competition	0.307	0.473

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Table 7. Tukey-HSD Test Results on Differences in Users' Perceived Enjoyment and Perceived Usefulness between the Groups

In order to identify and avoid possible confounds in the MANOVA results that may have caused by the fact that the participants in the competitive and inter-team competitive version had very specific goals (do better than other the players or do better than the other teams), but in the purely cooperative version the goal was vaguer (do your best jointly), we conducted the MANOVA again without the cooperative version: F(2,108) = 3.540, p = 0.032, Wilk's = 0.062. Without the cooperative condition the tests revealed an even more significant difference in the perceived enjoyment between the gamification conditions: F(1,109) = 7.014, p = 0.009, partial

$\eta^2 = 0.0630$ and again no significant differences when analyzing the perceived usefulness $F(1,109) = 3.726$, $p = 0.056$ at $\alpha = 0.05$.

4.2. Behavioral Outcomes

Second, we studied the differences in the behavioral outcomes of the gamification conditions. Using Kolmogorov-Smirnov (KS) tests, we found that the overall *system usage*, *crowdsourcing participation*, and *engagement with the gamification feature* followed heavy-tailed power-law and log-normal distributions (Clauset et al., 2009). Owing to the implementation of an onboarding tutorial that explained to users how to perform their first crowdsourcing contribution, around 55% of users shared at least one parking condition (Table 4). However, the overall crowdsourcing participation of users who shared one or more parking conditions also followed heavy-tailed distributions in the three groups. The literature indicates that this phenomenon is usual for crowdsourcing approaches (Ortega et al., 2008; Varshney, 2012). Commonly, Nielsen's participation inequality rule can be applied, which states that "90% of users are lurkers who never contribute, 9% of users contribute a little and 1% of users account for almost all the actions" (Nielsen, 2006). When considering the medians, the data showed that half of the users used the app for less than 22 minutes and shared around six parking conditions during the study period. However, when considering 10% of the most active users, we found that, on average, they had contributed 258 parking conditions and had used the app for more than 34 hours.

Due to the large variability in the data, standard descriptive methods or parametric tests are not effective for comparing differences between the groups. The standard deviation (SD) of heavy-tailed distributions can be very high, and medians as well as means underrepresent the tail of the distribution, which contained most of the relevant data (Alstott et al., 2013) (see Table 8).

Thus, following Clauset et al. (2009), we considered the complementary cumulative distribution functions and employed log-log plots, where both axes were on log scales, to investigate the effect of the three gamification conditions and to compare possible differences between the groups. Figure 5 shows our results generated with Powerlaw for Python (Alstott et al., 2013). In the first graph, the x-axis represents the total usage of the app in log scale; the y-axis represents the probability that a user would use the app for at least x seconds in log scale. In other words, a curve that extends further to the top and the right is likely to get more usage than a curve that near the lower left corner. The same applies to the other graphs, where the x-axis represents the crowdsourcing participation (number of parking conditions contributed to the community) and the engagement with the app's gamification feature (number of hexagons conquered by users) during the evaluation period.

At a glance, the results allow a comparison between the three experimental conditions. The probability that a user used one of the three versions for at least 22 minutes was fairly independent of the gamification design (Figure 5). However, the analysis indicated that the probability of a long-term engagement was higher with the competitive and the inter-team competitive designs compared to the cooperative design. The crowdsourcing participation and the interaction with the gamification feature differed greatly between the three groups. The data revealed that the probability for a specific crowdsourcing participation was nearly always higher in the inter-team competition than in the pure cooperative mode and the pure competitive mode. Further, the plotting of the gamification data indicates that all three versions motivated users to use the gamification features. However, the two competitive designs were more likely to engage users in interacting with the gamification features than the cooperative version. When comparing the user engagement with the gamification feature in the three groups, it became evident that around 10% of the users in the inter-team competition conquered many more hexagons than in the cooperative and competitive mode and were therefore much more committed to reach the goal of the gamification approach than other players in all three groups (Figure 5).

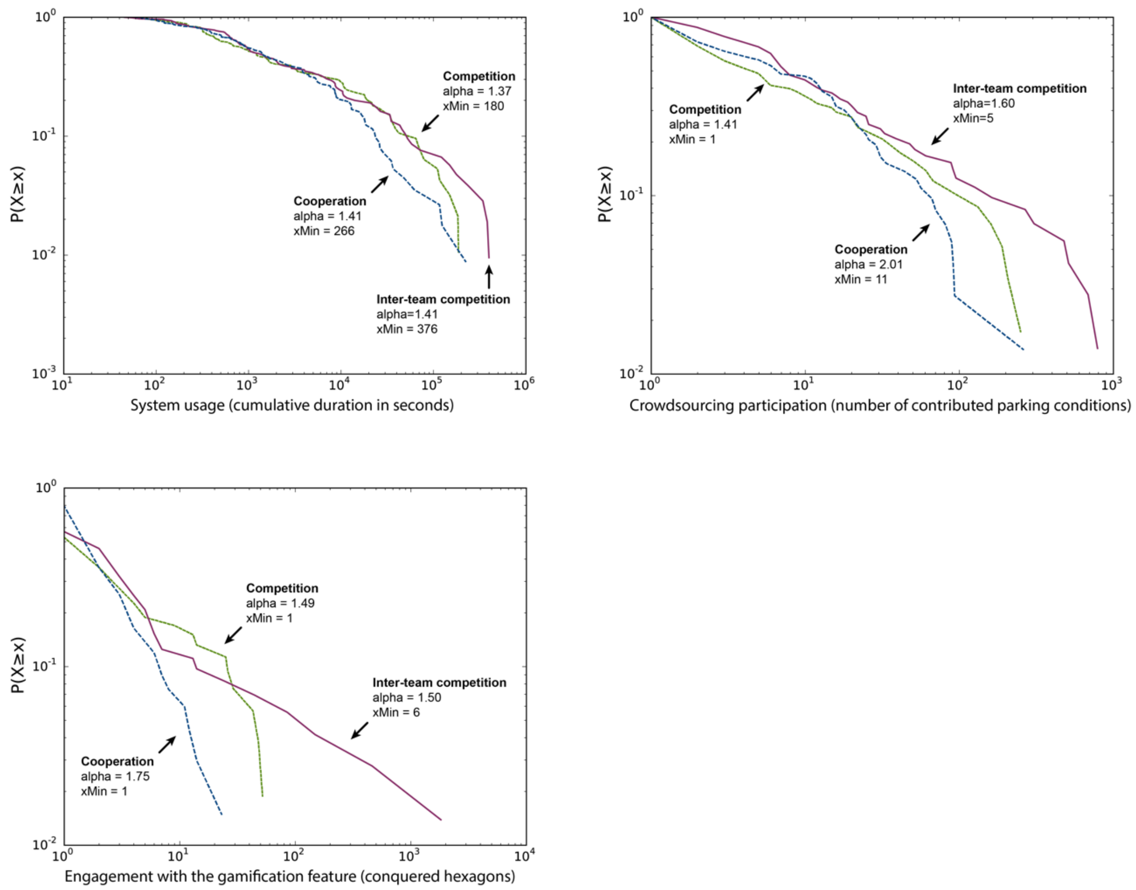

Figure 5. Log-log Plots of System Usage, Crowdsourcing Participation, and Engagement with the Gamification Feature

Notes: *Alpha* and x_{min} describe the calculated power law fits (Alstott et al., 2013). In the first graph, the x-axis represents the total usage of the app in log scale, and the y-axis the probability that a user would use the app for at least x seconds in log scale. In the second graph, the x-axis represents the crowdsourcing participation as number of contributed parking conditions in log scale, and the y-axis the probability that a user would at least contribute x parking conditions in log scale. In the third graph, the x-axis represents the user engagement with the gamification feature as the number of conquered hexagons in log scale, and the y-axis the probability that a user would at least conquer x hexagons in log scale.

To investigate whether the identified differences were significant, we conducted k-sample Anderson-Darling (AD) tests (Scholz and Stephens, 1987). According to Engmann and Cousineau (2011), k-sample Anderson-Darling tests are preferable compared to the commonly used Kolmogorov-Smirnoff tests when analyzing heavy-tailed distributed data with differences in the tail ends. The k-sample Anderson-Darling tests revealed no significant differences in the overall system usage. Thus, it could not be rejected that the system usage was homogeneous in all three groups, and the data were drawn from the same distribution (all $p > 0.1$). However, we found that the crowdsourcing participation differed significantly between the inter-team competition and the competitive version, as well between the inter-team competition and the cooperative version (Table 9). Comparing the crowdsourcing participation in the cooperative and competitive versions, it could not be rejected that the data were drawn from the same distribution ($p > 0.1$). The engagement with the gamification feature also differed significantly between the three groups. The analysis showed that the inter-team competition led to a significantly higher adoption of the gamification features compared to the cooperative version; users of the inter-team competition conquered more hexagons. Further, the competitive design led to a significant higher engagement with gamification features than the cooperative design.

When analyzing the gamification data in detail, we identified that, in the inter-team competition, users more actively sought to conquer territories owned by other users (37.5% more hexagons changed the teams in the inter-team competition compared to hexagons that changed the owner in the competitive version). This may indicate that players of the inter-team competition had a higher commitment to achieve the goal defined by the gamification approach, compared to players of the pure competitive version.

	Competition			**Inter-team competition**			**Cooperation**		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
System usage (in hours)	4:19 h	0:19 h	9:55 h	6:41 h	0:19 h	19:24 h	2:54 h	0:23 h	7:36 h
Crowdsourcing participation	26.96	4	54.34	59.85	7	149.36	19.97	6	36.86
Engagement with the gamification feature	5.56	1	12.20	37.54	1	219.00	2.39	1	3.77
Willingness to recommend	3.89	4	1.71	4.64	4.67	1.37	4.21	4.33	1.51

Table 8. Means, Medians, and Standard Deviations (SD) for the Behavioral Outcomes in All Three Groups

	Comparison		**Difference**	
Anderson-Darling test results	I	II	AD (I vs. II)	p
System usage	Competition	Inter-team competition	< 0	0.611
	Cooperation	Inter-team competition	< 0	0.580
	Cooperation	Competition	< 0	0.406
Crowdsourcing participation	Competition	Inter-team competition	3.675	0.011**

	Cooperation	Inter-team competition	1.854	0.055*
	Cooperation	Competition	< 0	0.600
Engagement with the gamification feature	Competition	Inter-team competition	< 0	0.675
	Cooperation	Inter-team competition	3.105	0.018**
	Cooperation	Competition	4.737	0.004***
Tukey-HSD test results	I	II	Mean (I - II)	p
Willingness to recommend	Competition	Inter-team competition	-0.753	0.028**
	Cooperation	Inter-team competition	-0.425	0.282
	Cooperation	Competition	0.328	0.504

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Table 9. K-sample Anderson-Darling and Tukey-HSD Test Results on the Differences in Users' Behaviors in the Different Groups

Based on the survey data, we further analyzed users' willingness to recommend the app. Overall, users of the cooperative versions reported a positive willingness to recommend the app, while users of the competitive version on average rather disagreed to recommend the app. A one-way ANOVA analysis revealed significant differences between the gamification conditions: $F(2,167) = 3.406$, $p = 0.036$**, partial $\eta^2 = 0.039$.

Thus, we ran pairwise comparisons using the Tukey-HSD test (Table 9) and found that users of the competitive design had a significantly lower willingness to recommend the app compared to users of the inter-team competition ($p = 0.028$**, diff = -0.753). A Levene's test revealed that homogeneity of variance could be assumed ($p > 0.1$).

5. Discussion

We investigated how competitive, cooperative, and inter-team competitive gamification affect motivations, user behavior, and the willingness to recommend crowdsourcing systems. By conducting a field experiment with three independent groups, which had used different gamified versions of a crowdcreating app, we found that inter-team competitions are particular effective in invoking enjoyment and can engage the highest levels of crowdsourcing participation, compared to pure competitive or pure cooperative gamification. Further, the comparison of the three gamification conditions showed that users were more likely to recommend crowdsourcing approaches when the gamification included cooperation. While the participation, engagement with the gamification feature and perceived enjoyment differed significantly between the groups, the system usage was similarly distributed in all three groups. Further, the different gamification conditions did not lead to any significant difference in the perceived usefulness of the app.

These findings might be explained in several ways: First, the identified positive effect of inter-team competitions on enjoyment and crowdsourcing participation are in line with previous research into the social interdependence theory conducted in education, economics, and sports (Bornstein et al., 2002; Erev et al., 1993; Johnson and Johnson, 1989; Tauer and Harackiewicz, 2004). In particular, the results of this study are consistent with the findings of Tauer and Harackiewicz (2004), who showed that the enjoyment and performance of people in inter-team competitions can surpass the enjoyment and performance of those in pure competition or pure cooperation. On the basis of the broad consensus, our findings indicate that the social interdependence theory (Johnson and Johnson, 1989) can serve as an effective theoretical framework for explaining the differences and effects of cooperative, competitive and inter-team competitive gamification. According to the theory, "promotive interaction resulting from a cooperative goal structure tends to result in intrinsic motivation based on the joy of increasing one's understanding and competence, benefiting others, and meaningful feedback from peers" (Johnson and Johnson, 1989, p.78). On the other hand, research highlighted that competitive contexts offer individuals interesting challenges and opportunities for evaluating the own performance, thereby affording possibilities for the satisfaction of needs such as competence, mastery, and achievement (Epstein and Harackiewicz, 1992; Reeve and Deci, 1996; Tauer and Harackiewicz, 2004). According to Tauer and Harackiewicz (2004), inter-team competitions that combine both provide the richest set of affordances for satisfying innate human needs and can thus lead to the highest levels of enjoyment, intrinsic motivation, and finally performance, compared to the pure cooperation or pure competition.

Second, besides the pure motivational aspects that can explain the behavioral effects of inter-team competitions, the general social structures of the crowdsourcing context may have played a role (Morschheuser et al., 2017c; 2017d). Cooperation theories (Gilbert, 1999; Johnson and Johnson, 1989; Shen et al., 2014; Tuomela, 2000) emphasize that cooperative situations, such as crowdsourcing, can induce social commitment and obligations between cooperating individuals. Crowdsourcees who explicitly work together in a crowdsourcing approach share a commitment to working together to support a crowdsourcing initiative (Morschheuser et al., 2017c; Shen et al., 2014). Competitive gamification designs may undermine these dynamics (Johnson and Johnson, 1989, p.81). On the other hand, pure cooperative gamification may not be sufficient to invoke social commitments and obligations. Previous research found that, in the absence of some external contingency (e.g. competition or rewards), people in a cooperative setting will perform similarly than when working individually (Johnson and Johnson, 1989; Slavin, 1996). Thus, we theorize that inter-team competitive gamification, where users share the goal to win against other teams, may be most effective in invoking cooperative commitments and obligations between users. Although we have not directly measured the cooperative commitment in the experimental groups, the significant differences in engagement with the gamification features in the pure cooperative and inter-team competitive version indicate that the latter approach has led to a stronger user commitment to the cooperative goal, defined by the game approach. Cooperative contexts such as crowdcreating approaches may therefore particularly benefit from inter-team competitive gamification. Further, these notions add to the previous research that suggests that a context's social structures should be carefully considered when designing gamification features (Hamari and Koivisto, 2015b; Morschheuser et al., 2017d).

Third, considering users' willingness to recommend the app, users in the two gamification conditions that included cooperation (cooperation and inter-team competition) reported a higher willingness to recommend the crowdsourcing app. In particular, users of the inter-team competition were significantly more willing to recommend the app than users of the competitive version. We assume that these differences result from two aspects: First, user enjoyment of the competitive version was lower, which may negatively affect their loyalty and willingness to recommend the app (Plass et al., 2013; Teng and Chen, 2014). Second, it can be expected that users in competitive situations have no interest in inviting others, since an increasing number of participants in a competition reduces an individual's chance to win a competition. However, in cooperative scenarios, where the success of an individual depends on the support of others, people can benefit from convincing others to work together towards a common goal (Tuomela, 2000). This aspect may be particularly important in inter-team competitions, where the external competition gives the users of a team a clear, appealing shared goal (Erev et al., 1993; Johnson and Johnson, 1989; Tauer and Harackiewicz, 2004). When people are organized in cooperative manner, higher positive network effects exist (Shapiro and Varian, 1998).

Fourth, the results indicate that there was no significant difference between the gamification conditions concerning the perceived usefulness of the system. This finding suggests that even though, in different implementation of gamification, users may find participation more enjoyable and may participate more actively, they still equally seek to derive instrumental outcomes from system use or participation. It could be argued that higher participation in crowdsourcing would indirectly increase the instrumentality of crowdsourcing to its participants via the accumulation of the information generated by the platform from individual contributions (Geiger and Schader, 2014). However, in the experiment's short timeframe, this effect to instrumentality is likely to not have been detected, if it existed. Future research, particularly long-term studies, should investigate possible effects of different gamification designs on crowdsourcees' extrinsic motivations (Zhao and Zhu, 2014b).

Fifth, one of the questions regarding gamification has been whether it can actually positively affect de facto productive behavior beyond just increasing the extent of the system usage (Hamari, 2017, 2013; Mekler et al., 2013; Morschheuser et al., 2015). The findings of this study, in fact, seem to show that the different gamification conditions did not influence the system itself was used but rather it precisely affected the productive behavior in the system, i.e. how much users contributed. These findings are in line with the intentions the designers had in mind when designing the system and support the optimistic view of gamification, which assumes that gamification can applied to effect specific motivational and behavioral outcomes (Hamari et al., 2014; Morschheuser et al., 2017a). Similarly, the fact that the system usage did not differ between gamification conditions further strengthen the internal validity of the present study, since we are fairly confident that the heightened productive behavior on the platform was not caused by an overall higher system use in one of the three groups.

The study extends previous research in several ways: First, the results demonstrate that the implementation of cooperative, competitive or inter-team competitive gamification differ in the resulting motivational and behavioral outcomes. This extends prior gamification research that has mainly focused on the effects of specific gamification elements but omitted the comparison of different gamification designs and in particular the differences between cooperation-based and competition-based gamification (Bui et al., 2015; Liu et al., 2017; Morschheuser et al., 2017a; 2017c).

Second, the findings of this study indicate that the social interdependence theory (Johnson and Johnson, 1989) can serve as an effective theoretical framework for explaining the differences and effects of individualistic, cooperative, competitive and inter-team competitive gamification (Liu et al., 2013; 2017). In particular, the theory seems to be a suitable framework for explaining the effects of goal structures that different types of gamification invokes among their users (Morschheuser et al., 2017b; 2017c). Decades of research are available on the effects of cooperative and competitive goal structures on humans' motivation on which future gamification research can draw on (Johnson and Johnson, 1989). For instance, existing research conducted on the social interdependence theory could inform gamification research that effective cooperative gamification designs should induce positive correlations among individuals' goal attainments, enable mutual promotive interactions, allow peer-feedback, and provide members of a cooperating group periodically the opportunity to reflect on how their individual efforts contribute to achieving a joint goal (Johnson and Johnson, 1989; Johnson, 2003). Further, previous research from ths field could inform gamification research that in general competitions should be "used with simple, unitary, nondivisible, overlearned tasks" (Johnson and Johnson, 1989, p. 30), while cooperation seems more effective if the tasks are new, complex and divisible.

Third, the results of this study contribute to the ongoing discussion on the positive and negative consequences of competitions in gamification approaches (Ipeirotis and Gabrilovich, 2014; Koivisto and Hamari, 2014; Landers et al., 2017; Massung et al., 2013; Morschheuser et al., 2017a; Preist et al., 2014). Previous research has postulated that competition between unbalanced opponents with a high likelihood that one party will defeat another party can demotivate both parties (Chen and Pu, 2014; Epstein and Harackiewicz, 1992; Liu et al., 2013; Massung et al., 2013; Morschheuser et al., 2017a; Preist et al., 2014). In other words, people become demotivated in competitive scenarios where they see no chance of winning, as well as when they have a very high chance of winning because no suitable opponents are available. Our results suggest that inter-team competition can counter these demotivating aspects of mere competition – both the demotivating effect of individual loss/inability to fare well and lack of challenging competition. One reason seems to be that playing in competing teams may increase the balance of the competition, as winning and failing is the result of the collective rather than of a single individual (Erev et al., 1993; Tuomela, 2000). Further, team structure may relativize the demotivating aspects of pure competitions by motivating individual contributions towards a shared goal and shifting possible losses that arise from not achieving of the shared goal to the community. All in all, gamification design where teams compete each other cherry-pick the best aspects of competition and cooperation. Future research should continue to investigate the psychological effects of inter-team competitions compared to pure competitions, drawing on the results of this study.

Fourth, this study indicates that motivational and behavioral outcomes of gamification features, such as leaderboards can differ according to the specific design of a gamification feature. This highlights that gamification research should not be limited to the investigation of recurring gamification features such as points, badges, and leaderboards (Hamari et al., 2014; Morschheuser et al., 2017a), but should also be extended to key design characteristics of gamification features. In particular, goal structures should be considered as it became evident in this study (Deterding, 2015; Landers et al., 2017; Morschheuser et al., 2017b).

Besides these insights, this study suggests the following practical guidelines for implementing gamification:

Design implication 1: Practitioners looking to increase enjoyment and participation are advised to prefer cooperative rather than competitive gamification, but especially inter-team competition, according to our findings. Inter-team competitions seem to combine the beneficial aspects of both and may thus yield best results in gamification approaches (cf. Johnson and Johnson, 1989; Tauer and Harackiewicz, 2004).

Design implication 2: To increase users' willingness to recommend and invite new users to a platform, designers should prefer cooperative goal structures, but especially inter-team competitions, since people prefer to increase the number of individuals they cooperate with rather than compete against.

Design implication 3: The findings of this experiment showed that different gamification designs that incorporating different goal structures can lead to different motivational and behavioral outcomes. Further, the study showed that only specific behaviors (in this case crowdsourcing participation) has been effected by the gamification design, while the overall usage of the app was similar in all three groups. When designing gamification approaches, we thus recommend practitioners to carefully evaluate the goal structures of gamification features and their potential consequences (see also Landers et al., 2017; Liu et al., 2013; Malone, 1982; Morschheuser et al., 2017c; Jung et al., 2010).

5.1. Limitations and Future Research

The present study has limitations, which offer points of departure for future inquiry. First, since we gathered our findings as part of a large field experiment, the results may be biased by extraneous variables. In order to control for possible interferences which could have resulted from a possible inhomogeneous distribution of the geographical proximity of the participants in the experimental groups, we have assigned the participants to the three experimental conditions based on their residence. Although we have taken great care to ensure that the blocks formed were homogeneous, this decision carries the risk that location-based differences such as the weather, availability of mobile Internet access, cultural background and other local conditions may have influenced the results. For instance, the experiment could have been influenced by different communal orientations of participants from West and East Germany, which we did not control in this experiment (Khaled, 2015; Ockenfels, 1999). Future research could address these issues by replicating the experiment as a fully randomized experiment taking into account possible interferences that may occur (e.g. that participants feel unable to compete or cooperate with other players in their near vicinity). Second, the field experiment survey respondents were self-selected, and survey data were self-reported, as with all voluntary questionnaires. Although our analysis showed that the collected data followed the typical rules of crowdsourcing initiatives (Nielsen, 2006), the results may overemphasize the perceptions and intentions of users with a higher personal interest in the application. This could be addressed in future long-term studies. Third, we conducted this study in the specific context of crowdsourcing (in the domain of traffic information) through a specific gamification approach. The results may differ in another context or when gamified differently. Fourth, characteristics of the participants, such as demographic factors (Koivisto and Hamari, 2014), culture or the users' orientations towards games (Bartle, 1996; Hamari and Tuunanen, 2014; Yee, 2006) may have affected the results. Thus, we recommend that researchers further investigate the same research problem in different settings. Fifth, the type of goal setting in the three different gamification conditions may have influenced the motivational outcomes and the behavioral outcomes. While the leaderboard in the competitive and inter-team competitive version provided very clear and probably challenging goals (e.g. the goal to beat the scores of the other teams/individuals), the goal in the cooperative condition was more unspecific, although we implemented textual feedback that informed the player in detail about his contribution to the joint success. According to goal setting research, vague "do your best" goals can be challenging but often lead to lower levels of performance in most individuals than specific goals, since specific goals provide a consistent performance benchmark, whereas "do your best" goals allow personal doubts (Locke and Latham, 1990; Latham and Locke, 1991; Jung et al., 2010). Future research should focus on this aspect and possible interactions between goal specificity and goal interdependence in gamification, building upon the results of this study and related works (e.g. Landers et al., 2017).

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Appendix

A: Survey constructs, items, construct reliabilities and sources

Construct	Item	Construct reliability	Source
Perceived usefulness	Using the app makes it easier for me to get parking information (e.g. price, location, …) Using the app enables me to be more productive with regard to finding parking information (e.g. price, location, …) I feel more effective with regard to finding parking information (e.g. price, location, …) when using the app I find the app to be useful for getting parking information (e.g. price, location, …)	Cronbach's α = .940, CR = .957, AVE = .847	Hamari and Koivisto, 2015a; Davis, 1989
Perceived enjoyment	I find using the app interesting I find using the app not a waste of time I find using the app fun I find using the app not boring I find using the app enjoyable	Cronbach's α =.904, CR = .929, AVE = .880	Hamari and Koivisto, 2015a; Van der Heijden, 2004; Tauer and Harackiewicz, 2004
Willingness to recommend	I will say positive things about the app to others I will recommend the app to others who seek my advice I will refer my acquaintances to the app	Cronbach's α = .932, CR = .956, AVE = .880	Kim and Son, 2009