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Are stress and engagement in toxicity associated with sleep quality? A study with League of Legends players

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Today, millions of people worldwide play popular multiplayer online battle arena games (MOBAs) such as League of Legends. MOBAs are designed to require real-time teamwork to win games. A side effect of this is toxic behavior (an umbrella term for various negative in-game behaviors). Following Transactional Stress Theory, in this study, we consider toxicity as a coping mechanism to better deal with in-game stress that leads to anger and frustration, potentially leading to subsequent sleep problems. Therefore, we asked League of Legends players (N=212) about their experiences within the last 30 days in a retrospective survey study. Our results indicated that perceived stress was, indeed, a positive predictor of sleeping problems, and toxic behavior partially mediated this relationship. These results indicate that some of the toxicity is caused by stress in play and that it may increase the likelihood of the occurrence of subsequent sleeping problems. Therefore, further efforts are needed to help players to develop harmonious means and techniques for coping with experienced in-game stress.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**.

Additional Key Words and Phrases: Toxic behavior, multiplayer online battle arena games, multiplayer online games, League of Legends, transactional theory of stress, sleeping problems

1 INTRODUCTION

Multiplayer online battle arena games (MOBAs) are a contemporary blend of real-time strategy, role-playing, and action games that are characterized by a unique player experience combining the design elements of team competition, multiplayer exchange, and teamwork [2, 18, 38, 48]. Players typically engage in team vs team matches of roughly 30 min in length, where their performance is dependent on themselves, their teammates, and their opponents. MOBAs such as League of Legends can now be seen as spearheading the esports phenomenon in terms of player numbers (i.e., 180 million unique players in 2022) and revenue (1.8 billion dollars in total revenue in 2022) [73]. Continuing on the topic of League of Legends, it has now evolved into a cross-media franchise, although there is now a popular Netflix series, Arcane, and various merchandise products (such as toys, plush toys, accessories and clothing), all based on the game and demonstrating its relevance to game-related digital culture [1, 30, 72].

While MOBAs such as League of Legends remain popular and are played by millions daily, there are negative behaviors associated with them as well, including phenomena such as gaming addiction [16] and toxic behavior [8, 23, 37, 54]. Previous research has framed toxic behavior as an umbrella term for describing rather short-term both verbal and non-verbal negative in-game player behaviors such as grieving, resource stealing, or criticizing others that are predominantly directed towards players of the own team limiting the own team performance [7, 13, 14]. For the purposes of our work, we follow the definition provided by de Medeiros Neto et al. [13], who proposed that toxic behavior is a behavior encountered when a player comes across a negative event during a game that generates anger and frustration, leading to

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a harmful, contaminated, and disseminated toxic type of communication [14]. Prior research on the topic can be broadly divided into research on (a) the variables involved in the emergence of toxicity and the psychological mechanisms associated with it [40, 61, 77], (b) the negative consequences of toxicity on in-game performance and tilt [9, 66], (c) toxic gamer cultures, and how some forms of toxicity may become ingrained and normalized among gamers [7, 46, 50, 78, 81], and (d) coping strategies players use when confronted with toxicity and ways game developers use dealing with corresponding behaviors [2, 64, 71]. Previous work on the roles of toxicity involved has provided indicators that toxicity is always initiated by a perpetrator against a victim of corresponding behaviors. However, this distribution of roles is highly dynamic throughout situations and games, which is consistent with literature on the theoretical origins of toxicity in the context of cyberbullying [4, 20, 26, 44, 80]. Previous studies already showed high correlations between the roles involved (i.e., perpetrators, victims, bystanders) indicating that victims and bystanders sooner or later become perpetrators themselves [43].

In this study, we aim to provide empirical answers to two existing research gaps. First, in existing HCI research, toxicity is often treated as a more proactive-related entity [22, 52, 61], which is surprising because some studies have already assumed that toxic behavior can also arise as a consequence of stressful situations during game-play [40]. Although this relationship has not yet been empirically quantitatively tested. This is the first research gap that we want to close with our work. Secondly, although there are already some studies that have looked at the consequences of toxic behavior and have been able to show that it leads to player attrition [25, 82] or deteriorated performance [66], the picture of the consequences is still incomplete. As an answer to this, we want to show that toxic behavior experienced in the game has an influence on short-term physiological states. We argue that sleep is a particularly suitable construct to examine in this context for several reasons [19, 63]. Firstly, sleep is a fundamental physiological process that is highly sensitive to stress and emotional disturbances [31, 65]. Toxic behavior in games, which can include harassment, bullying, and other negative social interactions, is likely to induce negative emotions in players. These responses can disrupt sleep patterns by increasing arousal and anxiety, making it difficult for players to fall asleep or maintain restful sleep. This is particularly crucial because a significant proportion of gamers spend the majority of their playing time immediately before bedtime (e.g., peak gaming times are often between 8 p.m. and midnight, as gamers are generally free from work or school commitments) [83]. Second, sleep quality and duration are critical for cognitive and physical performance. Poor sleep can lead to impaired decision-making, slower reaction times, and decreased overall performance, which can further exacerbate the negative effects of toxic behavior on gaming performance leading to an intra-individual increasing cycle of toxic player behaviors over days [63]. Thirdly, previous research has already showed that stress can have an influence of sleep [5, 6, 85] and derived indicators that video games as a context can have an impact on players' sleep [68, 86]. However, without postulating concrete causal relationships involving toxicity. By examining sleep as a construct, we can gain insights into how toxic behavior affects not just immediate performance but also the player's ability to recover and perform in subsequent gaming sessions. Lastly, sleep disturbances are relatively easy to measure using both subjective (e.g., self-reported sleep quality) and objective (e.g., wearable sleep trackers) methods, making it feasible to conduct empirical research [15]. This accessibility allows for a comprehensive examination of the impact of toxic behavior on physiological states, providing a more complete picture of consequences of this class of negative player behaviors. Therefore, investigating the effects of toxic behavior on sleep can offer valuable insights into the broader physiological and psychological impacts of negative social interactions in gaming environments.

To address these two research gaps, we propose a retrospective survey study asking players of the currently most successful MOBA game League of Legends regarding their perceptions and behaviors regarding stress, toxic behavior, and sleeping problems during the last 30 days. As a theoretical framework, we use the transactional theory of stress

[56, 57] that provides us with the opportunity to derive hypotheses in a theory-guided manner but has received only sporadic attention in HCI research up to know [28]. However, we argue that this is a particularly promising approach because it allows us to theorize toxic behavior as attempted coping that influences the relationship between perceived stress and physiological consequences. In summary, our study is guided by the following research question (RQ):

RQ: *What are the relationships between perceived stress, toxic behavior, and sleeping problems in MOBA games?*

Several insights for HCI research can be derived from the empirical findings of our study. First, the results offer support for several streams of HCI research such as user experience design or ergonomics and human factors. Second, the results contribute to the existing toxicity literature by illuminating the relationship between perceived stress in play and toxic behavior. Third, we support research into the potential short-term consequences of toxic behavior in a theory-guided manner, particularly concerning physiological aspects, by investigating the relationship between players' experienced toxic behavior over the last 30 days and their sleeping problems.

The rest of this study is structured as follows. Next, we present the related work (Section 2) and hypotheses derivation 3. Then we illustrate the methodology of the empirical study (Section 4), before pointing out the results (Section 5). We conclude the work with a discussion of the results (Section 6), and a conclusion (Section 7).

2 RELATED WORK

In this section, we describe the work associated with our study, provide information about the context, and derive corresponding hypotheses. To this end, we first present information on MOBAs (Section 2.1) and our theoretical framework the transaction theory of stress (Section 2.2).

2.1 MOBA games

To make it easier to comprehend the procedure of our study and understand perceived stress, toxicity, and potential consequences, it is helpful to better understand the context of our study MOBA games and their specifics. MOBAs have been around since the turn of the millennium and the first MOBA was released in 2003 as a player-developed modification for the game Warcraft III. This modification later became known as Defense of the Ancients (DotA), and even today a further development, DotA 2, is one of the most relevant MOBAs [58, 84]. The MOBA genre experienced a huge surge in popularity with the launch of League of Legends in 2009 and has always gone hand in hand with the spread of the internet into private households. It is also worth mentioning the free-to-play business model used by many MOBAs, where the basic game content can be used for free and only goods with hedonic value (i.e. without utility value) can be purchased [27, 38, 59]. These events have also increased scientific interest in MOBAs in various disciplines over the last decade, e.g., in business informatics [32, 33] and HCI research [17, 32, 70].

In terms of content, MOBAs can be understood as a mixture of real-time strategy (RTS), role-playing and action games, which contain many elements of existing game genres but offer a unique gameplay of competition, cooperation, and communication in real time. The game philosophy of the MOBA genre has moved away from building structures, building armies and controlling additional units towards a hero-centered gameplay that follows a progression gameplay [84]. All players start from scratch at the beginning of a game (which usually lasts between 20 and 40 minutes) and can collect gold and experience through game events to become stronger. The key feature of the game is the cooperation between the five players. There are currently several commercially successful MOBAs, of which League of Legends and DOTA 2 are arguably the most popular [47]. The success and relevance of MOBA games can also be seen in esports. In

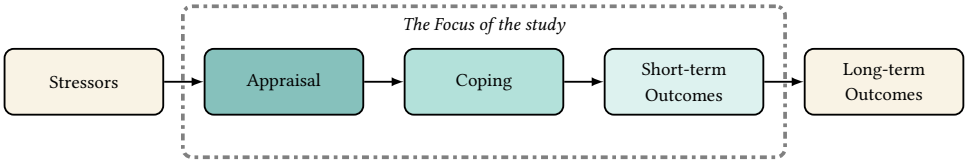

Fig. 1. Sequence and Building Blocks of Transactional Stress Theory

North America and Asia, for example, there are already scholarships at educational institutions [39]. For this reason, and to better compare our findings with existing HCI research, we chose League of Legends as the context for this study.

Based on the aforementioned unique mix of competition and real-time collaboration in teams in the MOBA game context, a significant amount of existing HCI research on toxicity has dealt with corresponding behaviors in games such as League of Legends and Dota 2. With regard to the emergence of toxic behavior, the Online Disinhibition effect (i.e., individuals exhibit less restraint and behave more aggressively online compared to their behavior in face-to-face interactions due to the perceived anonymity and lack of immediate consequences) [61] and the Unified Theory of Toxic Behavior [40], which showed that the constructs attitude, own experiences as a victim of toxicity, and behavioral control were relevant antecedents, should be mentioned in this context. Furthermore, studies have already been able to show intercultural differences between players from NA and India and that the roles involved in the occurrence of toxic behavior (i.e., perpetrators, bystanders, and victims) substantially overlap across situations [45] and games [43]. However, the relationship between toxicity and stress as well as potentially resulting sleep problems is still unclear.

2.2 Transactional Theory of Stress

Here, we explain the theoretical core of our work, an adapted version of transactional stress theory [56]. According to this theory, stress can be represented as a sequential process in a total of five phases. A sequence is postulated consisting of (1) the initial moment of a potential stressor, (2) the appraisal of this stressor, (3) the individual's attempt to cope with a stressor that is assessed as dangerous, (4) short-term outcomes, and (5) long-term outcomes [57, 60]. The theory emphasizes the person-environment interaction and assumes that a stress reaction is influenced to a large extent by individual evaluation processes. So far, it has only been used sporadically in the context of HCI research. Figure 1 illustrates the postulated sequence, whereby we will only focus on phases 2 to 4 in this study 2.2.1, 2.2.2 and 2.2.3.

2.2.1 Appraisal of Stress. After being confronted with a potential stressor, an individual evaluates (a) the relevance of the stressor as benign or potentially stressful as part of the primary appraisal (e.g., benign situations require no instrumental action on the part of the individual, while stressful situations require specific action) and (b) their own resources for potentially coping with stress as part of the secondary appraisal. In this study, we assume that there are a variety of potentially stressful situations during a ranked game for the individual player. If we now ask the players regarding perceived stress within the last 30 days, this can be understood as a query of the two forms of appraisal, since on the one hand only potentially stressful moments (primary appraisal) and on the other hand only those that require a specific measure (secondary appraisal) are queried.

2.2.2 Coping Attempts with Stress. The appraisal phase is followed by the possible coping phase, which represents the individual's efforts to overcome difficulties or, in other words, the way we try to deal with stress to evaluate the mediation process proposed by Lazarus and Folkman (1987) between individual resources, perceived stressors and the

stress response [57]. In the context of our study, we argue that one possible manifestation of coping with harmful stress during the play of competitive games is the display of toxic behaviors [8, 25].

2.2.3 Outcomes of Stress. The transactional model of stress posits that following attempts to cope with stress, certain short-term and long-term outcomes may occur, which can be divided into (a) biological (e.g., immune system, endocrine functions, sleep), (b) psychological (e.g., affective and cognitive responses), and behavioral forms (e.g., approach and avoidance tendencies). In this study, we propose that the short-term outcome sleep is a particularly relevant consequence of exciting play events, which is crucial not only for improving overall well-being but also for breaking the potentially harmful cycle between stress and disrupted sleep patterns.

3 HYPOTHESES DERIVATION

Based on the characteristics of the transactional stress model outlined in Section 2.2 and empirical knowledge from previous HCI research, we arrange a mediation model postulating the following hypotheses.

Initially, we hypothesize that a player's perception of stressful situations during the last 30 days in ranked games is associated with greater sleeping problems, as experiencing stress is also always associated with higher activation, which can potentially lead to increased sleeping problems the following night. We justify our selection of sleep with the aid of two arguments. First, on a theoretical level, sleep can be considered a relevant short-term consequence of coping based on the assumptions of the transactional theory of stress. Secondly, in practice, video games are most often played after work, school or university, so this will likely take place not too far from the point of falling asleep in the evening. Accordingly, we postulate:

Hypothesis 1: *Perceived stress is positively associated with sleeping problems in players.*

Following this, we understand toxic behavior as a form of exerted (i.e., toxic perpetration) emotion-oriented coping of other players. Due to the prevalence of toxic behavior in MOBA games, we assume that the negative experiences cannot be completely overcome and that the remaining parts exert outcomes on the individual. In the context of our study, we argue that experiencing toxic behavior leads to increased sleeping problems and specify the hypothesis:

Hypothesis 2: *Toxic behavior is positively associated with sleeping problems in players.*

Finally, we argue that the experience of stress while playing also has an impact on players' emotion-oriented coping attempts when there is more stress to cope with, which is one of the basic assumptions of transactional stress theory. Accordingly, we postulate the hypothesis:

Hypothesis 3: *Perceived stress is positively associated with toxic behavior.*

4 METHODOLOGY

In this section, we describe our data analysis and procedure, sample characteristics, employed metrics, as well as methods used to validate our instrument to investigate our research question.

4.1 Data Analysis and Procedure

To analyze the specified relationships in our Study, we used a cross-sectional retrospective survey collecting self-reported data from players of League of Legends using an online questionnaire and a web-based survey software platform (i.e., Unipark). Subsequently, we analyzed the data with covariance-based statistics (i.e., regression analyses) and widespread software applications (i.e., SPSS 28). For this, we applied two sequential steps:

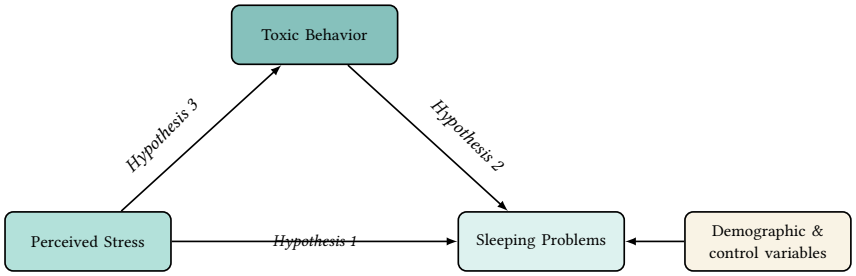

Fig. 2. Research model describing the relationships between perceived stress, toxic behavior, and sleeping problems.

(1) In the first step, we carried out some preliminary analysis, testing the influences of demographic (i.e., *age, gender, education*) and control variables (i.e., *frequency of play, experience of play*) concerning the dependent variable *sleeping problems* to identify potential confounds.
(2) Afterwards, in the second step, we used the information derived in Step 1 and analyzed the specified hypotheses using a simple mediation model, testing the relationships between *perceived stress* and *sleeping problems* (i.e., Hypothesis 1), *toxic behavior* and *sleeping problems* (i.e., Hypothesis 2), and *perceived stress* and *toxic behavior* (i.e., Hypothesis 3).

To determine the relationships between the *perceived stress* and the *toxicity* perpetrated in the game as antecedents of *sleeping problems*, we presented the participants with a frame of reference of their own experiences within the last 30 days. To ensure a valid procedure, we undertook several measures (a) we explained the aim of our study in detail on the starting page of our questionnaire, (b) then we asked participants how regularly they had played League of Legends ranked games within the last 30 days and excluded all participants without ranked games, (c) through the order in which the constructs (*perceived stress, toxicity, sleeping problems*) were asked, and (d) through semantic adjustments to the items.

4.2 Data Collection and Participants

To test the relationships in our Study, we used a digital questionnaire to collect data from 230 League of Legends players via the crowd-sourcing marketplace Prolific. After cleaning the data and excluding cases with missing data and nonsensical answers the final sample consisted of 212 participants. All participants received GBP 1.40 as a reward for participating in the study. On a level of characteristics, 82% of participants identified as male (173), followed by 17% who identified as female (35), and around 2% reported other as their identification (4). Additionally, 46% of participants were between 23 and 28 years old, 55% held (at least) a bachelor's degree, and were mostly Polish (23%). 66% reported playing the game between 2 and 4 days a week and 60% of participants had begun playing League of Legends in Season 5 (2015) or earlier. Concerning previous research, the sample appeared representative [40].

4.3 Measurements

Following the best practices of psychometric research, we build a digital questionnaire using empirically validated scales and items from previous research wherever available asking participants for their self-reported perceptions and behaviors regarding perceived stress [11], toxic behavior [43], and sleeping problems [67] during the last 30 days. Scales used either a five-point Likert scale ranging from 1 ("extremely unlikely") to 5 ("extremely likely") in case of *perceived*

stress and *sleeping problems* or a seven-point Likert scale in case of *toxic behavior* ranging from 1 ("strongly disagree") to 7 ("strongly agree"). All items used in our study are included in the appendix (see Table 3). Additionally, we collected demographic variables (i.e., age, sex, education, and country) and control variables (i.e., frequency and experience of play).

4.4 Instrument validation

To validate the measurement instrument of our study, we checked for various validity indicators. First, we tested our data for common method bias using Harman's single-factor test [3]. Inserting items for *perceived stress*, *toxic behavior*, and *sleeping problems* into a factor-analysis. Based on the results, no single factor dominated the total variance because the highest eigenvalue explained less than .50 percent of the variance, indicating that method bias was unlikely to be a concern in this study. Second, we assessed the convergent validity and the discriminant validity of all three constructs. For this, we used the composite reliability (CR) to test for convergent validity. To test for discriminant validity, we referred to the average variance extracted (AVE) and the Fornell-Larcker criterion, which postulates that a measurement model is supported when the square root of the AVE of each construct is greater than the correlations between each construct and the other constructs [21, 24]. Additionally, we checked for factor loadings and cross-loadings to have the chance to exclude non suitable items.

To test the validity of the measurement model, we inserted the items of *perceived stress*, *toxic behavior*, and *perceived stress* into a factor analysis, while specifying the extraction of three factors and varimax rotation. After inspecting the results of the initial factor analysis, we had to exclude four of the *perceived stress* items (i.e., PS_4, PS_5, PS_7, PS_8) because they showed either ambiguous or unclear loading patterns. Using the same settings as in the first iteration, we carried out another factor analysis. Based on the results, we had to exclude five of the items of *sleeping problems* (i.e., $SP_2, SP_3, SP_4, SP_6, SP_8$) since these items showed either ambiguous or unclear loading patterns. After the exclusion of these items, we rerun the factor analysis. Results showed that all composite reliabilities exceeded 0.7 ($CR \geq .81$), the AVE of each construct was greater than .5($AVE \geq 0.51$), and all items loaded on the intended factors ($j \geq 0.63$). Accordingly, all test results met the recommended thresholds, and the convergent validity of the constructs seemed satisfied. Additionally, the square root of the AVE of each construct (≥ 0.71) was greater than the correlations between each construct and the other constructs (≤ 0.27), and no meaningful cross-loadings were found ($j \leq 0.30$), satisfying the conditions for discriminant validity. The Table 1 illustrates all relevant indicators.

Table 1. Descriptive statistics and construct correlations

Variable	CR	AVE	*M*	*SD*	(1)	(2)	(3)
(1) Perceived stress	.87	.52	2.84	.83	.72		
(2) Toxic behavior	.81	.52	5.83	1.27	.22***	.72	
(3) Sleeping problems	.84	.51	2.93	.83	.27***	.26***	.71

Note(s): (a) CR: Composite reliability; (b) AVE: Average variance extracted; (c) Diagonal elements are the square root of the shared variance between the constructs and their measures; (d) Off-diagonal elements are correlations between constructs; ***p < 0.001.

5 RESULTS

To present our findings, we structured the derivation of our quantitative results into two consecutive parts: First, we controlled for potential confounds of our demographic (i.e., *age, gender, education*), and control variables (i.e., *frequency of play, experience of play*) on our dependent variable *sleeping problems* in Section 5.1. Following this, we tested the hypotheses of our study explaining our dependent variable *sleeping problems* in Section 5.2.

5.1 Preliminary Analysis

To test the influences of the potential confounds of our demographic (i.e., *age, gender, education*), and control variables (i.e., *experience of play, frequency of play*) as independent variables to explain the dependent variable *sleeping problems*, we carried out a multiple linear regression analysis. Checking the assumptions of linearity, auto-correlation, and multi-collinearity, neither the scatter plots, the *Durbin-Watson statistic* ($DW = 1.96$), nor the *Variance Inflation Factors* ($VIFs \leq 1.17$) seemed to be problematic [75]. Accordingly, we assumed that our data appeared suitable for regression analysis. The regression equation showed a significant result ($F(5; 206) = 2.28; p = .048$) that explained 5% of the variance of *sleeping problems*. However, after applying the Bonferroni correction, none of the regression weights illustrated in Table 2 indicated a significant relationship with the dependent variable ($\beta \geq .13$). Accordingly, we concluded that neither of the demographic nor the control variables had an influence more frequently than random on the dependent variable sleeping problems.

Table 2. Preliminary regression analysis explaining sleeping problems

Variable	*B*	*SE*	*β*	*T*	*p*
Constant	4.07	.33		9.02	=.006**
Age	-.02	.07	-.02	-.32	> .999
Gender	-.18	.14	-.09	-1.22	> .999
Education	-.14	.06	-.16	-2.30	=.132
Experience of play	.01	.02	.01	.17	> .999
Frequency of play	-.06	.03	-.14	-1.93	=.33

Note. B = unstandardized coefficient; SE = standard error; β = standardized coefficient; T = t-statistic; p = p-value; $^{***}p$ <.01.

5.2 Hypothesis Testing

To test the specified hypotheses of our study, we carried out a simple mediation analysis using the PROCESS tool in SPSS and included *perceived stress* as the independent variable, *toxic behavior* as the mediator variable in order to explain the dependent variable *sleeping problems*. Following recommendations from previous research [29], we checked the assumptions of linearity, auto-correlation, and multi-collinearity required for applying the analysis. Neither scatter plots, the *Durbin-Watson test* ($DW = 2.12$), nor the *Variance Inflation Factors* ($VIFs \leq 1.05$) indicated alarming values. Accordingly, we assumed that our data appeared suitable for testing the hypotheses.

A mediation analysis was conducted using the PROCESS macro for SPSS [29]. The independent variable was *perceived stress*, the dependent variable was *sleeping problems*, and the mediator variable was *toxic behavior*. The mediation model was tested with 5,000 bootstrap samples. After running the analysis, the model summary for sleeping

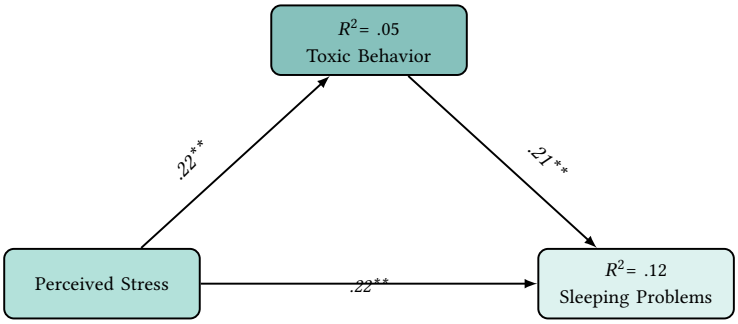

Fig. 3. Mediation model describing the relationships between perceived stress, toxic behavior, and sleeping problems.

problems indicated $R^2_{\text{adjusted}} = .116\%$, with *perceived stress*, controlling for *toxic behavior*, significantly predicting *sleeping problems* ($\beta = .223, p = .001, 95\%CI[.091, .351]$) supporting Hypothesis 1, which postulates a positive relationship between *perceived stress* and *sleeping problems*. Additionally, *toxic behavior* predicted *sleeping problems* ($\beta = .209, p = .002, 95\%CI[.051, .221]$), supporting Hypothesis 2, which posits that toxic behavior is positively associated with *sleeping problems*. The model summary for toxic behavior explained $R^2_{\text{adjusted}} = .049\%$, with *perceived stress* significantly predicting *toxic behavior* ($\beta = .220, p = .001, 95\%CI[.134, .540]$), supporting Hypothesis 3, which posits that *perceived stress* is positively associated with toxic behavior. In addition, the corrected $95\%CI$ for the completely standardized indirect effect of *perceived stress* on *sleeping problems* was [.008, .097] which excluded zero suggesting partial mediation. In summary, this analysis supports that *toxic behavior* partially mediates the relationship between *perceived stress* on *sleeping problems*, emphasizing the importance of considering the mediator to understand the dynamics of this relationship fully.

6 DISCUSSION

In this section, we discuss our results by highlighting the main takeaways and providing implications for both practice and theory. Finally, we address our limitations and propose recommendations for future work.

6.1 Key Findings

Based on the results of our study, we provide empirically-based answers to our research question (*What are the relationships between perceived stress, toxic behavior, and sleeping problems in MOBA games?*). We summarize the key findings from our study that extend current HCI research on *perceived stress*, *toxic behavior*, and *sleeping problems*.

- First, we showed that *perceived stress* had in deed a relevant positive influence on *sleeping problems* of players within a time window of the last 30 days.
- Second, with the aid of our mediation analysis, we derived empirical indicators that *toxic behavior* partially mediated the relationship between *perceived stress* and *sleeping problems*.
- Third, as part of our mediation analysis, we derived empirical indicators that *perceived stress* positively influences *toxic behavior* indicating that toxicity can be considered an attempt to cope with stress.

6.2 Implications for Practice

Several conclusions can be drawn from the results of our study that are relevant for HCI practitioners and designers. We will discuss three of these below.

First, identifying the relationship between perceived stress and sleep problems points to the added value of some promising potential interventions at the software design level that allow players to better cope with stress, especially in contrast to the currently widespread forms of punishment for an inadequate coping with stress and resulting bad behaviors [10, 42, 49, 51]. Specifically, stress reduction techniques could be implemented such as in-game support (e.g., relaxation activities, such as mini-games between the ranked games or during the loading screens) or tools related to performance support (e.g., implementing a constructive feedback system that highlights improvements, providing tips for better gameplay, and celebrating small victories) could be used in the game to ensure that players learn how to better deal with pressure and stress.

Second, our mediation analysis showed that toxic behavior can be understood as a partial mediator of the link between perceived stress and sleep problems, extending existing research on the cycle of toxicity to real-world consequences [43]. Our conclusion at the design level is that developers of MOBA games, such as Riot Games, could take steps to help players better manage emerging toxicity during gameplay. This could be achieved, for example, with the help of automated moderation tools nudging players to less toxic behaviors (e.g., using AI to detect and mitigate toxic behavior in real-time) and innovative tools to educate their player base (e.g., through additional tutorials addressing concrete forms of player behavior). Furthermore, previous findings related to exergames could add value to dealing with toxicity by leveraging insights into how physical activity and positive player engagement can mitigate negative behaviors and promote a healthier gaming environment [34, 35].

Third, our results have shown that stress can be considered as one of the causes of toxic behavior in MOBA games. Based on these empirical findings, stress management features could be integrated into the game building on insights from game experience and pervasive computing [12, 62, 74]. Accordingly, we suggest considering the implementation of real-time pop-ups or system messages after stressful events in the game (e.g., a lost Baron fight in League of Legends, which can be understood as one of the decisive moments in terms of the outcome of a game in League of Legends), which could remind players that it is important to stay calm now in order not to further jeopardize the success of their own team in this particular situation. Corresponding associations could be made available with tools from sports psychology that have been transferred to the digital world (e.g., techniques such as the Strength Circle, which is a tool for identifying, visualizing and maximizing the individual skills of athletes [76].

6.3 Implications for Theory

Several implications can also be derived from the results of our study that are important at the theoretical level of existing HCI research. In the following, we address some of them that seem particularly relevant to us.

First, we understand our findings regarding the direct relationship between perceived stress and the negative experience of sleep problems as an indicator of the suitability of applying transactional stress theory in the context of MOBA games [56, 57]. This seems promising for future work, as the theoretical framework of transactional stress theory allows to motivate a variety of interactions in a theory-driven way. For example, the next step could be to incorporate the first phase of transactional stress theory of concrete stressors into the game or the distinction between primary and secondary appraisal, which can then be used to extend our findings. In sum, we take this result as evidence that the stress response processes identified in traditional contexts are also applicable in contexts such as health [53], or

education [79], but may manifest differently in digital environments, which underscores the need to test the external validity of findings from neighboring disciplines. Based on our results, we can now infer that players evaluate certain in-game situations as stressors and that this leads to downstream substantial bio-physiological consequences in the form of sleep problems, providing a valuable innovative insight into the stress response process in the novel digital context of MOBA games.

Second, the partial mediation effect of toxic behavior on the relationship between perceived stress and sleep problems found in our mediation analysis suggests that toxic behavior can indeed be understood as a coping mechanism within the framework of transactional stress theory in the context of MOBA games [60]. Toxic behavior, traditionally viewed as a negative outcome, is thus seen as a maladaptive coping mechanism that players use in response to in-game stress. This theoretical conclusion extends conventional views of existing HCI research, which often understand toxicity more as an independent variable [55], and suggests that toxicity may play a role in players' coping with stress. This reconceptualization calls for a deeper exploration of the conditions and factors that lead to such coping strategies in digital environments. Furthermore, our study is one of the first within existing HCI research to highlight the consequences of toxicity outside of the gaming experience in the form of biophysical states (e.g., sleep disturbances), which have so far only been formulated as an assumption [60]. The next step could be to investigate possible long-term consequences of toxicity on a longitudinal basis.

Third, the study shows significant associations between perceived in-game stress, toxic behavior and subsequent sleep problems in gamers, suggesting that maladaptive coping mechanisms may have wider implications for mental health. This finding adds to the theoretical understanding of how digital gaming environments affect player wellbeing and suggests that stress and coping processes in these environments can have significant psychological effects outside of gaming in the real world. Thus, in summary, our study highlights the potential added value of integrating digital-specific stressors and outcomes (such as different game events) into holistic models of gamer mental health.

6.4 Limitations and Outlook

As with every empirical research, our work is not without limitations. Below we list some of them and explain how they can be used in future research to ensure the validity of our findings further.

First, participants self-reported their responses in our empirical study, which imposes some limitations. We note that the goal of our study was to gain initial insights into the relationships between perceived stress, toxic behavior, and sleeping patterns of players. Nonetheless, we encourage future research to test the relationships found in our study in future research by, for example, incorporating physiological data (e.g., heart rate variability, breath frequency, blood pressure) in a longitudinal approach related to League of Legends.

Second, we collected data using the Prolific service, a popular means by which researchers can efficiently obtain data [69]. However, crowdworking platforms (such as Prolific) have come under criticism for sometimes providing low-quality responses [36]. In our study, we addressed these challenges as best we could by introducing multiple questions to check for attentiveness and removing both outliers and ambiguous responses from the data. Despite that, we recommend that future research aims to replicate our study with samples from other sites by activating potential gatekeepers to share the study link to identify potential similarities and differences to our results.

Furthermore, we focused on a specific MOBA (League of Legends) as part of our study. This was intentional, as we did not want to introduce unwanted confounds into our data due to different games. Furthermore, League of Legends can be considered the MOBA game with the largest player base at the moment, and our study is only a first attempt to

investigate relationships between stress, toxic behavior, and sleep. Nevertheless, we encourage future research to apply our approach to other MOBAs (e.g., DOTA 2) testing the external validity of our findings.

Fourth, when constructing our research model, we followed the assumptions of the transactional theory of stress [56, 57]. On this basis, we assumed that perceived stress corresponds positively with *toxic behavior* and *sleeping problems* in our mediation analysis. However, our research model should not be interpreted as offering evidence of causality. Rather, it demonstrates the existence of significant positive correlations and invites further experimental research designs to explore the direction of the relationships.

Lastly, The instruments used also leave room for improvement for future studies. For example, we had to exclude several items from our operationalizations of perceived stress and sleeping problems as part of the construct validity check. We see this as an indication that we should prospectively develop context-specific measurement instruments in order to adequately do justice to the specifics of the novel context of human-computer interaction in moba games.

7 CONCLUSION

Within this study, we re-framed toxic behavior as an emotional coping mechanism for in-game stressors situated in a specific situation that potentially leads to sleeping problems of players. Our findings showed that perceived stress was a positive predictor of self-reported sleeping problems, and toxic behavior partially mediated this relationship. The results highlight the impact of in-game stress on toxicity and its potential connection to sleeping issues as an outcome, emphasizing the need for interventions to help players develop better stress management techniques and healthier coping strategies in the MOBA game environment.

REFERENCES

[1] Lucy A. Sparrow, Martin Gibbs, and Michael Arnold. 2021. The Ethics of Multiplayer Game Design and Community Management: Industry Perspectives and Challenges. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 325, 13 pages. https://doi.org/10.1145/3411764.3445363

[2] Sonam Adinolf and S. Turkay. 2018. Toxic Behaviors in Esports Games: Player Perceptions and Coping Strategies. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*. ACM, New York, NY, USA, 365–372. https://doi.org/10.1145/3270316.3271545

[3] Miguel I. Aguirre-Urreta and Jiang Hu. 2019. Detecting Common Method Bias: Performance of the Harman's Single-Factor Test. *DATA BASE for Advances in Information Systems* 50, 2 (2019), 45–70. https://researchr.org/publication/Aguirre-UrretaH19

[4] Cristina Alonso and Estrella Romero. 2017. Aggressors and victims in bullying and cyberbullying: A study of personality profiles using the five-factor model. *The Spanish journal of psychology* 20 (2017), E76. https://doi.org/10.1017/sjp.2017.73

[5] Rea Alonzo, Junayd Hussain, Saverio Stranges, and Kelly K Anderson. 2021. Interplay between social media use, sleep quality, and mental health in youth: A systematic review. *Sleep medicine reviews* 56 (2021), 101414. https://doi.org/10.1016/j.smrv.2020.101414

[6] Monira Alwhaibi and Noha A Al Aloola. 2023. Associations between stress, anxiety, depression and sleep quality among healthcare students. *Journal of Clinical Medicine* 12, 13 (2023), 4340. https://doi.org/10.3390/jcm12134340

[7] Nicole A. Beres, Julian Frommel, Elizabeth Reid, Regan L. Mandryk, and Madison Klarkowski. 2021. Don't You Know That You're Toxic: Normalization of Toxicity in Online Gaming. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 1–15. https://doi.org/10.1145/3411764.3445157

[8] Jeremy Blackburn and Haewoon Kwak. 2014. STFU NOOB! Predicting Crowdsourced Decisions on Toxic Behavior in Online Games. In *Proceedings of the 23rd International Conference on World Wide Web*. ACM, Seoul, Republic of Korea, 877–888. https://doi.org/10.1145/2566486.2567987

[9] Pablo Christian González Caino and Santiago Resett. 2024. Toxic Behavior and Tilt as Predictors of Mental Toughness in League of Legends Players of Argentina. In *Proceedings of the International Conference on Human-Computer Interaction*. Springer Nature Switzerland AG, Crete, Greece, 603–616. https://doi.org/10.1007/978-3-031-49215-0_55

[10] Alessandro Canossa, Dmitry Salimov, Ahmad Azadvar, Casper Harteveld, and Georgios Yannakakis. 2021. For Honor, for Toxicity: Detecting Toxic Behavior through Gameplay. *Proc. ACM Hum.-Comput. Interact.* 5, CHI PLAY, Article 253 (oct 2021), 29 pages. https://doi.org/10.1145/3474680

[11] Sheldon Cohen, Tom Kamarck, Robin Mermelstein, et al. 1983. Perceived stress scale. *Journal of Health and Social Behavior* 24(4), 2 (1983), 385–396. https://doi.org/10.2307/2136404

[12] Crystal Compton, Heidi Woelfle, Bolanle O. Dahunsi, Robert Pettys-Baker, Niharikha Subash, Miles Priebe, and Brad Holschuh. 2021. Dynamic, Discreet, Robotic Compression Garment for Real-Time Stress Assessment and Intervention. In *Proceedings of the 2021 ACM International Symposium on Wearable Computers*. ACM, New York, NY, USA, 170–174. https://doi.org/10.1145/3460421.3478837

[13] Anderson Macedo de Medeiros Neto, Matheus Araujo, Alexandre Diniz, Angelo Cardoso, Diego dos Santos, Jussara Almeida, Eduardo Almeida, and Matheus Gonçalves. 2017. Studying Toxic Behavior Influence and Player Chat in an Online Video Game. In *Proceedings of the 26th International Conference on World Wide Web Companion (WWW '17 Companion)*. International World Wide Web Conferences Steering Committee, Perth, Australia, 1577–1583. https://doi.org/10.1145/3041021.3055121

[14] Joaquim Alvino de Mesquita Neto and Karin Becker. 2018. Relating conversational topics and toxic behavior effects in a MOBA game. *Entertainment computing* 26 (2018), 10–29. https://doi.org/10.1016/j.entcom.2017.12.004

[15] Massimiliano de Zambotti, Leonardo Rosas, Ian M Colrain, and Fiona C Baker. 2019. The sleep of the ring: comparison of the ŌURA sleep tracker against polysomnography. *Behavioral sleep medicine* 17, 2 (2019), 124–136. https://doi.org/10.1080/15402002.2017.1300587

[16] Jory Deleuze, Jiang Long, Tie-Qiao Liu, Pierre Maurage, and Joël Billieux. 2018. Passion or addiction? Correlates of healthy versus problematic use of videogames in a sample of French-speaking regular players. *Addictive Behaviors* 82 (2018), 114–121. https://doi.org/10.1016/j.addbeh.2018.02.031

[17] Simon Peter Demediuk, Allan Murrin, David Bulger, Michael Hitchens, Anders Drachen, William L. Raffe, and Marco Tamassia. 2018. Player Retention in League of Legends: A Study Using Survival Analysis. In *Proceedings of the Australasian Computer Science Week Multiconference (ACSW '18)*. ACM, New York, NY, USA, 1–9. https://doi.org/10.1145/3167918.3167937

[18] Scott Donaldson. 2017. Mechanics and metagame: Exploring binary expertise in League of Legends. *Games and Culture* 12, 5 (2017), 426–444. https://doi.org/10.1177/15554120155900

[19] Catherine Dumas, Souvick Ghosh, Lingzi Hong, Amir Karami, and Priya Vaidya. 2023. Online Incivility and Contextual Factors: Data-Driven Detection and Analysis. *Proceedings of the Association for Information Science and Technology* 60, 1 (2023), 770–774. https://doi.org/10.1002/pra2.858

[20] Estefanía Estévez, Elizabeth Cañas, Jesús F Estévez, and Amapola Povedano. 2020. Continuity and overlap of roles in victims and aggressors of bullying and cyberbullying in adolescence: A systematic review. *International journal of environmental research and public health* 17, 20 (2020), 7452. https://doi.org/10.3390/ijerph17207452

[21] Claes Fornell and David F Larcker. 1981. Structural equation models with unobservable variables and measurement error: Algebra and statistics. https://doi.org/10.1177/002224378101800313

[22] Julian Frommel, Daniel Johnson, and Regan L Mandryk. 2023. How perceived toxicity of gaming communities is associated with social capital, satisfaction of relatedness, and loneliness. *Computers in Human Behavior Reports* 10 (2023), 100302. https://doi.org/10.1016/j.chbr.2023.100302

[23] Julian Frommel, Regan L Mandryk, and Madison Klarkowski. 2022. Challenges to Combating Toxicity and Harassment in Multiplayer Games: Involving the HCI Games Research Community. In *Extended Abstracts of the 2022 Annual Symposium on Computer-Human Interaction in Play*. ACM, Bremen, Germany, 263–265. https://doi.org/10.1145/3505270.3558359

[24] David Gefen, Detmar Straub, and Marie-Claude Boudreau. 2000. Structural equation modeling and regression: Guidelines for research practice. *Communications of the association for information systems* 4, 1 (2000), 7. https://doi.org/10.17705/1CAIS.00407

[25] Kate Grandprey-Shores, Yilin He, Kristina L Swanenburg, Robert Kraut, and John Riedl. 2014. The identification of deviance and its impact on retention in a multiplayer game. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. ACM, New York, NY, USA, 1356–1365. https://doi.org/10.1145/2531602.2531724

[26] Siying Guo, Jin Liu, and Jiandong Wang. 2021. Cyberbullying roles among adolescents: a social-ecological theory perspective. *Journal of School Violence* 20, 2 (2021), 167–181. https://doi.org/10.1080/15388220.2020.1862674

[27] Yue Guo and Stuart Barnes. 2009. Virtual item purchase behavior in virtual worlds: An exploratory investigation. *Electronic Commerce Research* 9 (2009), 77–96. https://doi.org/10.1007/s10660-009-9032-6

[28] Muhammad Fikri Haekal, Boy Nurtjahyo Moch, and Erlinda Muslim. 2020. Stress Emotion Evaluation in Battle Royale Game by Using Electroencephalogram. In *Proceedings of the 2020 International Conference on Engineering and Information Technology for Sustainable Industry* (Tangerang, Indonesia) *(ICONETSI '20)*. Association for Computing Machinery, New York, NY, USA, Article 5, 5 pages. https://doi.org/10.1145/3429789.3429795

[29] Andrew F Hayes. 2017. *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford publications, New York.

[30] Zorah Hilvert-Bruce and James T. Neill. 2020. I'm just trolling: The role of normative beliefs in aggressive behaviour in online gaming. *Computers in Human Behavior* 102 (2020), 303–311. https://doi.org/10.1016/j.chb.2019.09.003

[31] Camila Hirotsu, Sergio Tufik, and Monica Levy Andersen. 2015. Interactions between sleep, stress, and metabolism: From physiological to pathological conditions. *Sleep Science* 8, 3 (2015), 143–152. https://doi.org/10.1016/j.slsci.2015.09.002

[32] Xin Huang and Nan Chen. 2020. Can Social Ties Undermine Virtual Team Performance? Evidence from an Online Team-Based Game. In *Proceedings of the International Conference on Information Systems (ICIS 2020)*. Association for Information Systems, Online, 1–12. https://aisel.aisnet.org/icis2020/user_behaviors/user_behaviors/14/

[33] Chintha Dammi Kaluarachchi, Chandima Asith Wickramatunga, and Darshana Dewapriya. 2023. The Dark Side of E-sports: The Role of Player Emotions and Cyberbullying in MOBA. In *Proceedings of the 2023 International Conference on Information Systems (ICIS 2023)*. Association for Information Systems, Hyderabad, India, 1–9.

[34] Sukran Karaosmanoglu, Sebastian Cmentowski, Lennart E. Nacke, and Frank Steinicke. 2024. Born to Run, Programmed to Play: Mapping the Extended Reality Exergames Landscape. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*.

Association for Computing Machinery, New York, NY, USA, Article 309, 28 pages. https://doi.org/10.1145/3613904.3642124

[35] Sukran Karaosmanoglu, Katja Rogers, Dennis Wolf, Enrico Rukzio, Frank Steinicke, and Lennart E. Nacke. 2021. Feels like Team Spirit: Biometric and Strategic Interdependence in Asymmetric Multiplayer VR Games. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 443, 15 pages. https://doi.org/10.1145/3411764.3445492

[36] Ryan Kennedy, Scott Clifford, Tyler Burleigh, Philip D Waggoner, Ryan Jewell, and Nicholas JG Winter. 2020. The shape of and solutions to the MTurk quality crisis. *Political Science Research and Methods* 8, 4 (2020), 614–629. https://doi.org/10.1017/psrm.2020.6

[37] Bastian Kordyaka. 2018. Digital Poison " Approaching a Theory of Toxic Behavior in MOBA games. In *Proceedings of the International Conference on Information Systems - Bridging the Internet of People, Data, and Things, ICIS 2018, San Francisco, CA, USA, December 13-16, 2018*, Jan Pries-Heje, Sudha Ram, and Michael Rosemann (Eds.). Association for Information Systems, San Francisco, CA, USA. https://aisel.aisnet.org/icis2018/behavior/Presentations/18

[38] Bastian Kordyaka and Sidney Hribersek. 2019. Crafting identity in League of Legends: Purchases as a tool to achieve desired impressions. In *Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS-52)*. AIS, Maui, Hawaii, 1506–1515. https://doi.org/10.24251/HICSS.2019.182

[39] Bastian Kordyaka, Katharina Jahn, and Bjoern Niehaves. 2020. To diversify or not? Uncovering the effects of identification and media engagement on franchise loyalty in eSports. *International Journal on Media Management* 22, 1 (2020), 49–66. https://doi.org/10.1080/14241277.2020.1732982

[40] Bastian Kordyaka, Katharina Jahn, and Bjoern Niehaves. 2020. Towards a unified theory of toxic behavior in video games. *Internet Research* 30, 4 (2020), 1081–1102. https://doi.org/10.1108/INTR-12-2019-0514

[41] Bastian Kordyaka, Michael Klesel, and Katharina Jahn. 2019. Perpetrators in League of Legends: Scale Development and Validation of Toxic Behavior. In *Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS-52)*. AIS, Grand Wailea, Hawaii, 2486–2495. https://doi.org/10.24251/HICSS.2019.299

[42] Bastian Kordyaka and Björn Kruse. 2021. Curing toxicity–developing design principles to buffer toxic behaviour in massive multiplayer online games. *Safer communities* 20, 3 (2021), 133–149. https://doi.org/10.1108/SC-10-2020-0037

[43] Bastian Kordyaka, Samuli Laato, Katharina Jahn, Juho Hamari, and Bjoern Niehaves. 2023. The Cycle of Toxicity: Exploring Relationships between Personality and Player Roles in Toxic Behavior in Multiplayer Online Battle Arena Games. *Proc. ACM Hum.-Comput. Interact.* 7, CHI PLAY, Article 397 (oct 2023), 31 pages. https://doi.org/10.1145/3611043

[44] Bastian Kordyaka, Samuli Laato, Sebastian Weber, and Bjoern Niehaves. 2023. What constitutes victims of toxicity-identifying drivers of toxic victimhood in multiplayer online battle arena games. *Frontiers in Psychology* 14 (2023), 1193172. https://doi.org/10.3389/fpsyg.2023.1193172

[45] Bastian Kordyaka, Solip Park, Jeanine Krath, and Samuli Laato. 2023. Exploring the relationship between offline cultural environments and toxic behavior tendencies in multiplayer online games. *ACM Transactions on Social Computing* 6, 1-2 (2023), 1–20. https://doi.org/10.1145/3580346

[46] Bastian Kordyaka, Luisa Pumplun, Marlies Brunnhofer, Bjoern Kruse, and Samuli Laato. 2023. Gender disparities in esports–An explanatory mixed-methods approach. *Computers in Human Behavior* 149 (2023), 107956. https://doi.org/10.1016/j.chb.2023.107956

[47] Bastian Kordyaka, Aida Stelter, Samuli Laato, and Bjoern Niehaves. 2023. Dark Desires? Using the Theory of Basic Desires to Better Understand Toxic Behavior in Multiplayer Online Games. In *Proceedings of the 56th Hawaii International Conference on System Sciences (HICSS-56)*. AIS, Maui, Hawaii, 9. https://doi.org/10.24251/HICSS.2023.676

[48] Yubo Kou. 2020. Toxic Behaviors in Team-Based Competitive Gaming: The Case of League of Legends. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20)*. ACM, Virtual Event, Canada, 81–92. https://doi.org/10.1145/3410404.3414243

[49] Yubo Kou. 2021. Punishment and Its Discontents: An Analysis of Permanent Ban in an Online Game Community. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW2, Article 334 (oct 2021), 21 pages. https://doi.org/10.1145/3476075

[50] Yubo Kou and Xinning Gui. 2017. When Code Governs Community. In *Proceedings of the 50th Annual Hawaii International Conference on System Sciences*. AIS, New York, 2056–2064. https://doi.org/10.24251/HICSS.2017.250

[51] Yubo Kou and Xinning Gui. 2021. Flag and Flaggability in Automated Moderation: The Case of Reporting Toxic Behavior in an Online Game Community. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 437, 12 pages. https://doi.org/10.1145/3411764.3445279

[52] Rachel Kowert. 2020. Dark participation in games. *Frontiers in Psychology* 11 (2020), 2969–. https://doi.org/10.3389/fpsyg.2020.598947

[53] Maria L Kraimer, Margaret A Shaffer, Mark C Bolino, Steven D Charlier, and Olivier Wurtz. 2022. A transactional stress theory of global work demands: A challenge, hindrance, or both? *Journal of Applied Psychology* 107, 12 (2022), 2197. https://doi.org/10.1037/apl0001009

[54] Haewoon Kwak, Jeremy Blackburn, and Seungyeop Han. 2015. Exploring Cyberbullying and Other Toxic Behavior in Team Competition Online Games. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI'15)*. Association for Computing Machinery, New York, NY, USA, 3739–3748. https://doi.org/10.1145/2702123.2702529

[55] Samuli Laato, Bastian Kordyaka, and Juho Hamari. 2024. Traumatizing or Just Annoying? Unveiling the Spectrum of Gamer Toxicity in the StarCraft II Community. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*. ACM, Honolulu, HI, USA, 758:1–758:18. https://doi.org/10.1145/3613904.3642137

[56] Richard S. Lazarus and Susan Folkman. 1984. *Stress, Appraisal, and Coping*. Springer Publishing Company, New York, NY. xiii, 445 pages.

[57] Richard S Lazarus and Susan Folkman. 1987. Transactional theory and research on emotions and coping. *European Journal of personality* 1, 3 (1987), 141–169. https://doi.org/10.1002/per.2410010304

[58] Matthew Lee, Daniel Johnson, Porntida Tanjitpiyanond, and Winnifred R. Louis. 2022. It's habit, not toxicity, driving hours spent in DOTA 2. *Entertainment Computing* 41 (2022), 100472. https://doi.org/10.1016/j.entcom.2021.100472

[59] Vili Lehdonvirta. 2009. Virtual item sales as a revenue model: identifying attributes that drive purchase decisions. *Electronic commerce research* 9 (2009), 97–113. https://doi.org/10.1007/s10660-009-9028-2

[60] Tommy Lim, Jason Thompson, Leimin Tian, and Ben Beck. 2023. A transactional model of stress and coping applied to cyclist subjective experiences. *Transportation Research Part F: Traffic Psychology and Behaviour* 96 (2023), 155–170. https://doi.org/10.1016/j.trf.2023.05.013

[61] Yansheng Liu and Colin Agur. 2023. "After all, they don't know me" exploring the psychological mechanisms of toxic behavior in online games. *Games and Culture* 18, 5 (2023), 598–621. https://doi.org/10.1177/15554120221115

[62] K. Daniel MacLean, Asta Roseway, and Mary Czerwinski. 2013. MoodWings: A Wearable Biofeedback Device for Real-Time Stress Intervention. In *Proceedings of the 6th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA '13)*. ACM, Rhodes, Greece, 66. https://doi.org/10.1145/2504335.2504406

[63] Feng Mai, Zihan Chen, and Aron Lindberg. 2019. Does Sleep Deprivation Cause Online Incivility? Evidence from a Natural Experiment. In *Proceedings of the 40th International Conference on Information Systems (ICIS 2019)*. Association for Information Systems, Munich, Germany, 1–12. https://aisel.aisnet.org/icis2019/crowds_social/crowds_social/32/

[64] Regan L Mandryk, Julian Frommel, Nitesh Goyal, Guo Freeman, Cliff Lampe, Sarah Vieweg, and Donghee Yvette Wohn. 2023. Combating Toxicity, Harassment, and Abuse in Online Social Spaces: A Workshop at CHI 2023. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, Article 340, 7 pages. https://doi.org/10.1145/3544549.3573793

[65] Viviana Lo Martire, Danila Caruso, Laura Palagini, Giovanna Zoccoli, and Stefano Bastianini. 2020. Stress & sleep: A relationship lasting a lifetime. *Neuroscience & Biobehavioral Reviews* 117 (2020), 65–77. https://doi.org/10.1016/j.neubiorev.2019.08.024

[66] Charles K Monge and TC O'Brien. 2022. Effects of individual toxic behavior on team performance in League of Legends. *Media Psychology* 25, 1 (2022), 82–105. https://doi.org/10.1080/15213269.2020.1868322

[67] Vincenzo Natale, Marco Fabbri, Lorenzo Tonetti, and Monica Martoni. 2014. Psychometric goodness of the mini sleep questionnaire. *Psychiatry and clinical neurosciences* 68, 7 (2014), 568–573. https://doi.org/10.1111/pcn.12161

[68] Sai Prasad Ojha, Manika Shaikh, Meer mand Gupta, Arya Shinde, Sahil Waghmare, and Sarthak Shukla. 2023. Study the Effects of Online Gaming on Different Emotional Behavior of the Users. In *Design in the Era of Industry 4.0, Volume 1*, Amaresh Chakrabarti and Vishal Singh (Eds.). Springer Nature Singapore, Singapore, 445–457. https://doi.org/10.1007/978-981-99-0293-4_36

[69] Stefan Palan and Christian Schitter. 2018. Prolific. ac—A subject pool for online experiments. *Journal of Behavioral and Experimental Finance* 17 (2018), 22–27. https://doi.org/10.1016/j.jbef.2017.12.004

[70] Susanne Poeller, Martin Johannes Dechant, Madison Klarkowski, and Regan L. Mandryk. 2023. Suspecting Sarcasm: How League of Legends Players Dismiss Positive Communication in Toxic Environments. *Proc. ACM Hum.-Comput. Interact.* 7, CHI PLAY, Article 374 (oct 2023), 26 pages. https://doi.org/10.1145/3611020

[71] Elizabeth Reid, Regan L. Mandryk, Nicole A. Beres, Madison Klarkowski, and Julian Frommel. 2022. Feeling Good and In Control: In-game Tools to Support Targets of Toxicity. *Proc. ACM Hum.-Comput. Interact.* 6, CHI PLAY, Article 235 (oct 2022), 27 pages. https://doi.org/10.1145/3549498

[72] Sunghan Ryu. 2023. *Unlocking Intellectual Property Potential of Riot Games' League of Legends by Streaming an Adapted Animation Series Arcane: League of Legends*. SAGE Publications: SAGE Business Cases Originals, Thousand Oaks, CA. https://doi.org/10.4135/9781071915899

[73] Orvill Samanta. 2024. League Of Legends: Player Count and Stats 2024. https://prioridata.com/data/league-of-legends/

[74] Akane Sano, P. Johns, and Mary Czerwinski. 2017. Designing Opportune Stress Intervention Delivery Timing using Multi-modal Data. In *Proceedings of the 7th International Conference on Affective Computing and Intelligent Interaction (ACII)*. IEEE, San Antonio, Texas, 280–287.

[75] Nathan E Savin and Kenneth J White. 1977. The Durbin-Watson test for serial correlation with extreme sample sizes or many regressors. *Econometrica: Journal of the Econometric Society* 45, 8 (1977), 1989–1996. https://doi.org/10.2307/1914122

[76] Thomas Schack, Massimiliano Bertollo, Dirk Koester, Jonathan Maycock, and Kai Essig. 2014. Technological advancements in sport psychology. In *Routledge Companion to Sport and Exercise Psychology: Global Perspectives and Fundamental Concepts*, Athanasios G. Papaioannou and Dieter Hackfort (Eds.). Routledge, London, 953–965. https://pub.uni-bielefeld.de/record/2713938

[77] Sercan Şengün, Joao M Santos, Joni Salminen, Soon-gyo Jung, and Bernard J Jansen. 2022. Do players communicate differently depending on the champion played? Exploring the Proteus effect in League of Legends. *Technological Forecasting and Social Change* 177 (2022), 121556. https://doi.org/10.1016/j.techfore.2022.121556

[78] Sercan Sengün, Joni Salminen, Peter Mawhorter, Soon-Gyo Jung, and Bernard J. Jansen. 2019. Exploring the Relationship Between Game Content and Culture-based Toxicity: A Case Study of League of Legends and MENA Players. In *Proceedings of the 30th ACM Conference on Hypertext and Social Media*, Claus Atzenbeck, Jessica Rubart, and David E. Millard (Eds.). ACM, Hof, Germany, 87–95. https://doi.org/10.1145/3342220.3343652

[79] Shwadhin Sharma and Babita Gupta. 2023. Investigating the role of technostress, cognitive appraisal and coping strategies on students' learning performance in higher education: a multidimensional transactional theory of stress approach. *Information Technology & People* 36, 2 (2023), 626–660. https://doi.org/10.1108/ITP-06-2021-0505

[80] Cuihua Shen, Qiusi Sun, Taeyoung Kim, Grace Wolff, Rabindra A. Ratan, and Dmitri Williams. 2020. Viral vitriol: Predictors and contagion of online toxicity in World of Tanks. *Computers in Human Behavior* 108 (2020), 106343. https://doi.org/10.1016/j.chb.2020.106343

[81] Lucy A Sparrow, Martin Gibbs, and Michael Arnold. 2021. Ludic ethics: The ethical negotiations of players in online multiplayer games. *Games and Culture* 16, 6 (2021), 719–742. https://doi.org/10.1177/1555412020971534

[82] Jianrong Tao, Yu Xiong, Shiwei Zhao, Runze Wu, Xudong Shen, Tangjie Lyu, Changjie Fan, Zhipeng Hu, Sha Zhao, and Gang Pan. 2023. Explainable AI for Cheating Detection and Churn Prediction in Online Games. *IEEE Transactions on Games* 15, 2 (June 2023), 242–251. https://doi.org/10.1109/TG.2022.3173399

[83] Stefano Triberti, Luca Milani, Daniela Villani, Serena Grumi, Sara Peracchia, Giuseppe Curcio, and Giuseppe Riva. 2018. What matters is when you play: Investigating the relationship between online video games addiction and time spent playing over specific day phases. *Addictive Behaviors Reports* 8 (2018), 185–188. https://doi.org/10.1016/j.abrep.2018.06.003

[84] April Tyack, Peta Wyeth, and Daniel Johnson. 2016. The appeal of MOBA games: What makes people start, stay, and stop. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*, Paul Cairns and Regan L. Mandryk (Eds.). ACM, New York, NY, USA, 313–325. https://doi.org/10.1145/2967934.2968098

[85] Feifei Wang and Éva Bíró. 2021. Determinants of sleep quality in college students: A literature review. *Explore* 17, 2 (2021), 170–177. https://doi.org/10.1016/j.explore.2020.11.003

[86] Kimberly Young. 2009. Understanding online gaming addiction and treatment issues for adolescents. *The American journal of family therapy* 37, 5 (2009), 355–372. https://doi.org/10.1080/01926180902942191

APPENDIX

Table 3. Wording of the items of the questionnaire

Construct	ID	Wording	Ref.
Independent variable			
Perceived stress		During ranked games within the last 30 days…	[11]
	PS_1	...how often have you been upset because of something that happened unexpectedly?	
	PS_2	...how often have you felt that you were unable to control the important things?	
	PS_3	...how often have you felt nervous and stressed?	
	PS_4	...how often have you felt confident about your ability to handle problems*?	
	PS_5	...how often have you felt that things were going your way*?	
	PS_6	...how often have you found that you could not cope with all the things happening?	
	PS_7	...how often have you been able to control irritations*?	
	PS_8	...how often have you felt that you were on top of things*?	
	PS_9	...how often have you been angry because of things that happened that were outside of your control?	
	PS_10	...how often have you felt difficulties were piling up so high that you could not overcome them?	
Mediating variable			
Toxic perpetration		When you have been annoyed by others during a ranked game in the last 30 days, you...	[41]
	TBP_1	...intentionally interrupted others while they are writing.	
	TBP_2	...held others responsible for making own mistakes.	
	TBP_3	...took away resources belonging to others.	
	TBP_4	...insulted others.	
Dependent variable			
Sleeping problems		How likely is it that the following statements applied to you in the last 30 days?	[67]
	SP_1	Difficulty falling asleep.	
	SP_2	Waking up too early*.	
	SP_3	Hypnotic medication use*.	
	SP_4	Falling asleep during the day*.	
	SP_5	Feeling tired upon waking up in the morning.	
	SP_6	Snoring*.	
	SP_7	Mid-sleep awakenings.	
	SP_8	Headaches on awakening*.	
	SP_9	Excessive daytime sleepiness.	
	SP_10	Excessive movement during sleep.	

Note. * indicates items that were deleted during the test of the measurement model.

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