In Your Face(t)
Impact of Personality and Context on Gameplay Behavior

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ABSTRACT
Video games are now acknowledged as a prominent part of popular culture and played by an audience wider and more varied than ever before. Considerable recent research shows that people engage with games differently, and these variations may be attributable to individual differences. Understanding the impact of personality on behavior in games has several benefits: more inclusive design practices, accurate user models for adaptive applications and articulated toolsets to segment players for game user research. Nonetheless the work done so far to explore the interplay between personality and behavior in virtual environments does not always account for personality at a granular level, nor does it take into consideration the different contexts of the environment beyond pooling variables together. We hypothesize, first, that by considering the individual facets that compose broad personality traits we will be able to identify stronger links between them and gameplay behavior. Second, we expect that dividing the game environment into its component areas with different situational affordances will also improve correlations, as behavior modulation by personality is highly context-dependent. Using the Five-Factor personality model as an interpretive framework, we confirmed that the correlations between traits and behaviors were specific to game areas that carry different situational affordances, and were enhanced by inclusion of the facets. In the future, a verified database of game behavior correlations could have predictive value for inferring personality attitudes. This will help carve the way to more inclusive design, and the development of better adaptive strategies for games beyond what is currently in practice.

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1. INTRODUCTION
Digital games today are played by a more heterogeneous audience than ever before; EEDAR reports that 58% of all Americans play video games [34]. Catering for such a diverse audience is a craft better not left to chance. Accordingly, there has been a spate of recent studies [13, 14, 15, 28, 33] that attempt to understand the impact individual differences have on entertainment fruition and players' enjoyment, in order to design gameplay and environments able to elicit precise desired behaviors. Unraveling the complex relation between personality, context and behavior presents multiple potential benefits for designers and researchers: (a) more inclusive designs, especially for serious or educational games with a limited budget [17]; (b) a golden rule for adaptivity, in order to tailor user experience according to individual goals preferences and values [2, 24]; and (c) a framework to scaffold game user research with a precision that exceeds traditional demographics-based techniques [6].

Player personality may be parameterized using the Five Factor Model (FFM), originally developed by psychologists. The FFM was popularized in the game industry by Ubisoft Creative Director Jason Vandenberghe, who advocated mapping the choices afforded by games onto the traits and facets of the FFM [30]. Designers and researchers have attempted to incorporate the FFM and

other personality models into the design process [13, 14, 15, 28, 33], with several specifically studying personality and games [14, 15, 33]. However, two crucial questions almost always remain unanswered. First, the five traits of the FFM are broad, and not all of their facets apply in a virtual environment. For example, the trait Conscientiousness includes both the highly relevant Achievement facet and the more questionable Self-efficacy. An achievement-driven player is likely to behave quite differently from one who is self-efficacious, although both might have identical Conscientiousness scores. Thus, the first question is, "can a more fine-grained description of personality reveal previously hidden though consistent behavioral correlations?" The second unanswered question is arguably even more important: "How are people's personality traits and behavior influenced by the specific context and affordances of the designed situations in digital games?" It is self-evident that situation is a large determiner of behavior, but on a deeper level, situation also modulates the expression of different personality traits. For example, it is difficult for extroverts to express that aspect of their personality while waiting in an empty room. Translated to a game environment, a player's degree of extraversion is unlikely to influence their response to someone shooting at them, although their cautiousness probably would. Thus rather than averaging behavior over an entire game session, which almost all previous work on personality and games do [14, 15, 33], it is important to account for the different affordances offered by diverse game scenarios.

This paper attempts to extend previous work by utilizing FFM to account for players' individual characteristics and examine how behavior is affected by ludic and aesthetic affordances in each individual game situation. In particular, we use both the primary traits and their component facets to describe and interpret the observed relations between behavior and game context. We attempt a situational analysis by accounting for context intended as game environments: quantified as physical locations containing isomorphic ludic and aesthetic affordances. We acknowledge how this approach is still just a part of the whole context, yet it allowed us to gain significant correlation effects that would have otherwise been impossible to find. By examining personality, game situation, and behavior, we explicitly acknowledge social and personality theory stating that behavior is a function of a person's characteristics and situational influences [8, 9, 16, 19]. Our contribution is a new method for understanding the influence of player personality within games, extending previous work. This constitutes a step towards understanding individual differences exhibited in play behavior, which is useful for design, Game User Research and adaptive systems.

2. PREVIOUS WORK

Profiling players according to their in-game behavior has recently gained considerable momentum in game research. Bartle studied Multi User Dungeons and after observing that players exhibit different configurations of achievement, aggression, exploration, and social behaviors, concluded that individual differences in behavior reflect the unique goals and preferences that each player brings to the game [4]. This model has influenced design and game user research methods already. Bateman and Boon [3] carried out another seminal work in the area—they identified seven categories of players: Seeker, Survivor, Daredevil, Mastermind, Conqueror, Socializer and Achiever, loosely based on the Myers-Briggs personality model [22]. Further, Yee [32] expanded upon this research, developing game specific motivation factors that revealed ten subcomponents grouped into three overarching components of motivation in Massively Multiplayer Online Games: Achievement, Social, and Immersion. In addition, Rigby and Ryan developed an influential model explaining individual differences and player motivation called Player Experience of Need Satisfaction (PENS). This model is based on Self-Determination Theory [26], an influential theory that emphasizes personal growth through satisfaction of three primary motives: competence, autonomy and relatedness, which are tied to motivation and engagement in games [25]. The model has influenced the design of many entertainment games as well as non-entertainment games, such as EVE Online [31] and SpaPlay [27]. In parallel, Canossa et al. [7] investigated the motivations behind playing Minecraft. Committed players were asked to take the Reiss Motivation Profiler [23], a self-assessment questionnaire that gauges 16 basic motivations, from Vengeance to Romance, in terms of how important they are in driving life decisions. The difference between the mean scores of Minecraft players and the mean scores of the general population provided support for the notion that the act of selecting a game in itself is a strong expression of personality.

In addition to this work, researchers have also used the FFM to explain player behavior. Yee et al. [33] correlated gameplay behavior with the FFM personality model for the game World of Warcraft, finding significant correlations for each of the five traits although no coefficients exceeded ±0.17. Lankveld et al. [14, 15] investigated correlations between only one trait: Extraversion (and its facets) and behavior via a modification of an existing game, Neverwinter Nights (Atari, 2002). There were five significant correlations ($p < 0.05$) for the Extraversion trait in the range ±0.32, but the relations were stronger and more numerous when facets were examined. In a later study [13], the same researchers looked at all five traits but abandoned the facets, instead pooling game behaviors together to account for personality effects visible only across entire areas of the game. While not completely accounting for the individuality of locations, the results did confirm established knowledge in personality research: extraversion and openness are more observable traits than agreeableness or neuroticism. These initial results were confirmed through similar studies with two other games: Fallout 3 [29] and

Battlefield 3 [28], validating the knowledge that correlations exist between play behavior and the FFM traits. One study even developed an FFM-based classification of play style among Fallout: New Vegas players [18], though it relied on survey data rather than measuring game behavior directly.

Limitation of Previous work: One limitation of previous work is that none of the previous studies examined the role of facets and game situations in behaviors exhibited by players indicating individual differences. All previous studies pooled game behaviors together in large categories covering whole areas of the game. While this approach has proven fruitful, uncovering modest yet significant correlations, it is possible that other interesting correlations have been washed out by averaging. Given the importance of both personality facets and situational context, we incorporate them into our analysis. To compensate for the increased number of statistical comparisons and possibility of detecting spurious correlations, we establish an additional baseline with a Montecarlo approach also used by [33]. To conceptualize the importance of this limitation, we will now discuss the personality psychology theory addressing the role of situation and context.

3. PSYCHOLOGY OF PERSONALITY

As a formal academic discipline, personality psychology dates back to the 1930s, due in large part to the groundbreaking books by Allport [1] and Murray [21]. Despite significant theoretical differences, both writers agreed that three elements are required to fully describe and predict differences between individuals: personality characteristics, behavior, and situations. Lewin [16] formalized the relation between the elements in his classic equation B = *f*(P, E): behavior B is a function of a person P in his or her environment E. The three elements are central to the present article and will be described in turn.

3.1 Personality

The formal term 'personality' refers to different categories of psychological constructs used by researchers to characterize an individual's behavioral tendencies over time and across situations. These constructs include needs, motives, encoding strategies, traits, and others. The FFM is a set of psychological constructs whose members belong to the trait category. Although the terms FFM and Big Five Factor Model often are used interchangeably, their conceptual definitions and measures differ [10, 11]. In recent years, the FFM and related trait models have become increasingly popular. They have been shown to be reliable and valid, internationally and cross-culturally [11, 20, 35], and predictive of behavioral tendencies in the physical world [5]. The FFM, as measured by the NEO-PI-R, was developed to assess personality at two levels of abstraction. At the highest level, the FFM assesses five general factors of personality: **Extraversion**, **Agreeableness**, **Conscientiousness**, **Neuroticism**, and **Openness to Experience**. At the lowest level, each general factor is partitioned into six facets, or subscales. The five traits predict behavior broadly, while the facets predict more specific behaviors; looking at expression of facets in each situation enhances the prediction accuracy while narrowing the range of prediction. More details on the traits and their component facets may be found in Costa and McCrae [10].

3.2 Behavior

Whereas personality traits represent behavioral *tendencies* over time and across situations, behaviors themselves are actions that occur in a physical and social environment. Researchers often refer to the environment as "context" or a "situation." Behaviors can be characterized at both the micro level ("turns up corner of lips") and the molar level ("smiles frequently"). Micro behaviors are easier to measure; molar behaviors are easier to interpret but rely on larger samples and usually require human observers to filter and integrate information. In a gaming context, an example micro level behavior is choosing to speak or ignore a particular non-player character (NPC), while its molar analog might be whether the same player seeks a maximum or minimum of NPC interaction.

3.3 Situation and Context

Thus far, we have discussed personality traits and behavior. Previous gaming research has found a relation between the two. It would not be unreasonable to ask "If personality predicts gaming behavior, why bother with context?" The answer is that the FFM and related assessment tools measure general tendencies in behavior "over the long run" (i.e., over time and across situations) and are therefore most effective predicting behavior aggregated over time and situations. The trait of Extraversion, for example, should accurately predict the number of social events people attend each year but will be much less effective predicting their social participation next Saturday. Because trait measures implicitly aggregate over situations, the fluctuations due to contextual effects are controlled. Teachers give students several exams over the course of a semester for the very same reason, to eliminate contextual effects. This is fine when researchers want to predict behavior over the long run, but when it is desirable to predict behavior in a specific context, a different strategy is needed.

Lewin's [16] equation B = *f*(P, E) suggests that behavior is most predictable when information is available both about the person's general tendencies and the influence of the situation. Despite hundreds of measurement devices to assess traits and behavior, the number of situation assessment devices is limited. Nevertheless, researchers have offered important insights about situations. Murray [21] argued that situations affect behavior in two ways. First, situations possess objective properties, such as room color, temperature and people present, that he labeled "alpha press." Second, in addition to objective properties, people perceive and evaluate situations based on previous

experience and personality traits which he labeled "beta press." It appears that subjective interpretations of situations (i.e., beta press) have greater effect on behavior than objective characteristics. By understanding the "person by situation interaction" [12], researchers and designers will have the information necessary to better tailor each context within a game. The basic tenets of the FFM are that (a) people exhibit individual differences in situation perception, (b) unique perceptions elicit behavioral responses, and (c) behaviors correspond to underlying traits. This process is comprised of three elements – situations, traits, and behaviors—of which situations have received the least empirical scrutiny.

4. DESIGN AND METHODOLOGY

4.1 Game Environment

In order for players to express their personality in a virtual game world, they need numerous interaction possibilities and the opportunity to execute a wide range of behaviors in an immersive environment. We thus created a short, custom scenario (Figure 1) using the game Fallout: New Vegas (FNV) by Bethesda Softworks. The scenario takes place in a small town with a Western style. The town is beset by a biker gang and the player is asked to do something about the situation. The story is very generic: "lone hero saves town from evildoers". This was by design, so the players would recognize it as a trope and feel familiar with it, allowing them to freely fill the gaps in the story. The story encourages players to deal with the bikers, but it does not mandate it, leaving the selection of actions open. The setting was formed so that the game world was neither arbitrary nor completely open ended, but at the same time did not solely promote a constrained set of behaviors. In order to limit players to a defined game arena while at the same time providing a rich environment consistently offering multiple options, we developed the world as a large valley circumscribed by natural borders such as mesas, mountains and high slopes. Within this valley there are several locations with their own visual identity, NPCs, quests, collectible items and creatures. NPCs initiate formal quests, provide precise information about interesting locations in the world but no quest, or "flavor" the game world by offering details about themselves and their stories with no other implications. A few NPCs are non-interactive, but will join in combat against the player if provoked. The design aim was to provide a space easy to access for non-gamers but interesting enough for more experienced players.

Game locations serve as the context variable. Players begin in the *Intro House*, a small house with several rooms where they have an opportunity to learn the game controls. Besides exploring and picking up objects (as is the case with all game areas), players can interact with and do quests for up to three NPCs. Two of the quests simply entail conversing with their NPCs; the third is optional and involves engaging in combat with a large rodent. The *Sheriff's Office* is a small building in town, containing little more than some useful objects and a weapon. It does include containers such as a desk and filing cabinets, as well as a stack of money that can be used to solve the main quest. *The Bar* is also small and somewhat dark, but contains useful items as well as two NPCs with some generic dialogue ("Heard any rumors?" and "How are you?"). The dilapidated *Abandoned House* lies just outside of town and is indeed deserted, with only a few objects scattered among the debris. The *Silver Mine* lies at the end of one road leading out of town; it is a cave with several segments and contains items, a quest opportunity and potentially hostile NPCs. The quest involves rescuing a prisoner held by a group of rogue bikers, which can be solved either by finding some silver hidden in the mine or by killing the bikers. The *Hotel* also lies outside of town off the main road and serves as the biker gang headquarters, including the boss (immediately confronted upon entering) and the kidnapped sheriff (in a back room). Similar to the mine, the player can attempt to reason with the bikers (i.e., bribe them) or attack them; the sheriff will aid the player if he is rescued first. All these locations are connected by the spacious *Outside* area, which includes inaccessible buildings comprising the rest of the town, several NPCs (six generic, one that furthers the main quest and a second involved in the Mine quest) and an abandoned farm teeming with hostile rats.

Figure 1: Screenshot from the game featuring a conversational interaction with an NPC

4.2 Behavioral metrics

The mechanics offered by the game were enumerated and grouped in homogeneous categories of similar affordances. It was necessary to aggregate single affordances for behavior and individuate these categories, aligned to the previous work examined above [13, 29], to facilitate the analytical process and to provide a typology of behaviors on a higher level of abstraction. These categories are:

- *Navigation and Interaction with the world*. This class contains nine behaviors: number of areas entered, interactions with doors, speech choices inquiring about the world, total distance travelled, total head movement, interactions with dead creatures and NPCs,

interactions with containers, time spent looking in containers, and key 'E' pressed (activate objects).

- *Conversational Interactions.* This class contains six peaceful interaction behaviors: interactions with NPCs, speech choices making small talk, speech choices ending dialogue, time spent in dialogue, instances of dialogue, and time spent in the proximity of NPCs.
- *Narrative Compliance*: This class collects the eight behaviors that are directly aligned with completing tasks assigned to the players: creatures and NPCs attacked that were quest related, number of quests accepted or completed, speech choices inquiring about quests, and the total time spent on each of the five game quests. The quests are: complete the tutorial, kill the rat, talk to Mr. Johnson (Intro House), remove the bikers (Outside), and free the captive (Mine).
- *Combat Behaviors.* This class captures aggressive interactions and attitudes with the following two behaviors: creatures and NPCs attacked unmotivated, and left mouse button pressed (attack).

Note the similarities to the categories identified by Bartle [4], despite the differences in game genre.

4.3 Experiment Protocol

We recruited 41 participants for the study from IT University of Copenhagen. Participation was voluntary; participants were promised the results of the personality tests as compensation. We accepted everyone who volunteered.

All participants were asked to come to the lab to play the game for a 30 minute period, which was scheduled as a one-on-one session with the researcher. We randomly selected a specific number of participants (38%) to complete a personality test at the beginning of the study (seven days before their play session). The rest were prompted through email to finish the personality test 2-3 days after their session. Upon completion, participants were given the results of their personality test as compensation. An introductory questionnaire was used to probe demographic data, asking about gender, nationality, occupation and a series of questions aimed at assessing level of proficiency and experience at playing games. Gameplay experience was used as a control variable for the main correlation analysis (see section 4.4); the rest of the information was collected to assess the diversity of our participants.

We used our experimental lab for the play session. The lab was equipped with computers running the version of the game instrumented to collect behavioral data. Participants scheduled an appointment with the researcher who then showed them to the lab, started the game, and inserted a code indicating participant's ID, which allowed us anonymously to tag the behavioral data to the participants' personality test results. While we know that such a setting might impact ecological validity, it was necessary given that an operator had to manually enter each participant's ID. After 30 minutes of play, the experiment officially terminated and the participant was informed of the end of the session through a game popup window. We did, however, allow participants to continue if they wanted to. For the personality questionnaire, we asked participants to complete a 300-item IPIP NEO personality questionnaire [11]. Although personality researchers often use more in-depth approaches to personality assessment including informant ratings and social behavior evaluations, we chose only the self-report questionnaire in the interest of maximizing sample size.

4.4 Analysis Methods

We accumulated two types of data sets: (a) personality answers to the IPIP NEO questionnaire, and (b) gameplay data. The gameplay data was aggregated by location to enable analysis at the situational level. As stated previously, each location was designed with a different set of affordances and thus serves as a first-order approximation for context or situation. Behaviors over the course of the full game were also analyzed as a baseline for comparison.

Not every behavior was reliably performed by every subject in each location. In some cases this is obvious; e.g., conversational interactions are impossible in areas without NPCs. In other cases, not all subjects took advantage of all possible affordances; e.g., half of the subjects did not engage in combat in the Hotel. Therefore, we established the criterion that in order for a behavior to be subject to the location-specific analysis, it had to be exhibited by at least 90% of the players for that area. As a result, we were able to narrow the original list of behaviors down to the following six, in three categories:

- *Navigation and interactions with the world*: total distance traveled, total head movement, number of interactions with doors. These behaviors were valid for all locations.
- *Conversational interactions*: number of interactions with NPCs, total time spent in dialogue. These behaviors were valid in the locations Intro House, Outside, Bar, Mine and Hotel.
- *Narrative compliance*: total time spent on quests. Specifically, this measured the elapsed time between triggering the quest start and its completion. Quests were categorized according the location of their initiator; thus the metric was valid in the Intro House, Outside and Mine.

For each location, we performed a partial correlation analysis on each behavioral metric versus each personality trait (n=5) and facet (n=30) score. Since previous game experience could have a substantial influence on play behavior, the experience measure derived from the demographic questionnaire (average number of hours per week spent playing games) was used as the control variable. By using the partial correlation method, we effectively included experience as an additional regressor so it would not introduce spurious significant correlations. In order to

organize the number of correlations performed, we organized them into "cells". One cell contained a single personality trait with its facets, in a single location, with all the behaviors of a single class (navigation, conversation or narrative).

With so many tests performed, the possibility of Type I error is a serious concern. Furthermore, a simple heuristic such as multiplying the number of tests by the alpha value to yield an estimate of false positives is insufficient, since neither the facets with their governing trait nor the behavior measures in a class are independent of each other. We therefore needed to estimate how many correlations a cell had to contain in order to be reliable; that is, how many "significant" values do we expect to find by chance, given the dependencies in the data set? We computed the estimate using a bootstrap meta-analysis. Any cell that had fewer significant correlations than the bootstrap cutoff was considered non-significant as a whole.

To compute the bootstrap distribution, each subject kept their personality trait data but was assigned behavioral data from a different subject, chosen randomly with replacement. Partial correlations were then recomputed for each trait/behavior pair, and the number of significant values ($p < 0.10$) in a cell was counted. The shuffle and recomputation was performed for 10,000 iterations, yielding a distribution of count values. The counts of significant correlation values for each data cell were then checked against the 90^{th}, 95^{th} and 99^{th} percentiles of the bootstrapped distributions, corresponding to significance alphas of 0.10, 0.05 and 0.01 respectively. For example, a count that falls above the 95^{th} percentile of the bootstrap distribution can be taken as significant with $p < 0.05$. Note that the personality scores and behavior measures were never themselves shuffled, only decoupled at the group level, to preserve any internal correlations that could inflate the overall correlation counts.

5. RESULTS

The sample of 41 subjects had the following diversity in gender, occupation, game expertise and background. Occupation: 40% students, 28% full time employees, 32% other; Nationality: 60% Danish, 18% German, 12% British, 5% Spanish, 5% Swedish; Gender: 42% female, 58% male; Familiarity with games: 19% non-gamers, 12% occasional gamers, 69% gamers. Figure 2 depicts the overall percentage of time the subjects as a group engaged in eight representative behaviors drawn from the four classes enumerated in Section 4.2.

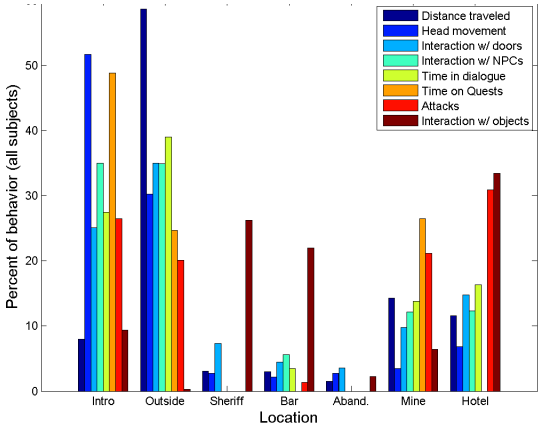

Figure 2: Breakdown of game areas by aggregate player behavior

The six behaviors targeted for additional analysis are shown (3 navigation, 2 conversation, 1 narrative), as well as two additional behaviors (attacks and object interactions) that did not meet the 90% cutoff described previously. The behaviors are broken down by location. The chart demonstrates the extent to which the locations vary in the behaviors they afford. The Intro House and Outside were two hotbeds of activity, showing high percentages of a variety of behavior types. At the other end of the spectrum, there was little to do in the Bar and Sheriff's Office besides scrounge for objects, and not much of interest in the Abandoned House at all. It is also evident which behaviors, such as dialog and combat, were not possible in every location.

We next examined the six behavioral measures over the entire course of the game session, without accounting for location. Using the partial correlation analysis on the trait scores we found only one significant relation at the 0.05 level, between Openness to Experience and Quest Time (rho = -0.35). Expanding the analysis to include the facets yielded just four more results: Gregariousness vs. Distance Traveled (rho = 0.38), Assertiveness vs. Quest Time (rho = -0.33), and Achievement vs. both Head Movement and Door interaction (rho = 0.34 and 0.41, respectively. Furthermore, the bootstrap analysis indicated that for a given trait plus its facets, a minimum of four correlations at the 0.05 level across all behaviors were required for meta-significance. Thus it cannot be ruled out that some of the above correlations were due to chance. Aggregating the data without accounting for game area (context/situation) was insufficient.

The next step was to repeat the analysis, this time accounting for context by grouping behavioral measurements by game areas. As expected, this yielded more interesting results. We once again used the bootstrap analysis to attempt to avoid type I errors. We divided the data into cells, each of which contained a personality trait

	Navigation Outside			Navigation Sheriff		
	Head	Dist.	Door	Head	Dist.	Door
Extraversion	**.395***	**.320***	**.359***	.291	**.301+**	**.318+**
Friendliness	**.283+**	.253	**.420****	.161	.220	**.322+**
Gregariousness	**.326***	.261	**.408****	.175	.149	.052
Assertiveness	.076	.083	-.051	.089	.070	**.342***
Activity Level	**.488****	**.402***	**.303***	**.373***	**.388***	.086
Excitement Sk.	.122	.021	.180	.249	.224	.184
Cheerfulness	**.269+**	.218	.161	.191	.226	.256

	Navigation Aband. H.			Conversation Intro H.	
	Head	Dist.	Door	NPCs	Dialogue
Agreeableness	.282	.308	.142	**-.420****	-.112
Trust	**.405+**	**.369+**	.137	**-.357***	.039
Morality	.336	**.396+**	.288	-.254	.088
Altruism	.345	**.391+**	.276	**-.337***	-.165
Cooperation	.067	.079	-.116	-.116	-.015
Modesty	.107	.097	.100	-.221	.006
Sympathy	.081	.108	.046	**-.299+**	**-.344***

	Conversation Hotel		O. Out.	O. Mine
	NPCs	Dialogue	Main	Captive
Conscient.	.116	.204	**-.281+**	.035
Self-efficacy	.162	.142	-.003	.101
Orderliness	-.084	-.084	**-.286+**	-.114
Dutifulness	-.197	-.072	-.005	**.372+**
Achiev. Striving	**.445***	**.534****	-.112	**-.433***
Self-discipline	**.398***	**.476****	**-.322***	.025
Cautiousness	-.187	-.184	-.074	.210

	Navigation Aband. H.			O. Out.	O. Mine
	Head	Dist.	Door	Main	Captive
Openness	-.257	-.236	**-.373+**	**-.355+**	**-.266+**
Imagination	-.190	-.170	-.228	-.062	.001
Artistic Interests	-.203	-.230	**-.509***	**-.367+**	-.160
Emotionality	-.243	-.209	.248	-.164	**-.295+**
Adventurous	-.056	.049	.219	-.085	.014
Intellect	-.088	-.082	**-.444***	-.281	**-.305***
Liberalism	-.108	-.159	-.298	-.038	-.160

Table 1. Total number of significant correlations per location per behavior category for each FFM trait. Highlighted cells are shown expanded in Table 2. (Nav: navigation, Con: conversation, Nar: narrative; Shf.: Sheriff's Office, Abn.: Abandoned House. Bootstrap significance estimates: + p ≤ 0.10; * p ≤ 0.05; ** p ≤ 0.01)

(5 traits), one game location, and one behavior category using the three categories discussed above: navigation, conversation or narrative. We calculated correlations between the three behaviors and each personality trait for each location, resulting in 7 to 21 separate correlation computations. Table 1 shows results for three locations.

The table shows which trait/facet combinations had stronger linkages with behavioral variables, and underlines the crucial importance of context. For example, Extraversion and its facets showed 11 significant correlations with navigation behavior in the expanse of the Outside, but none in the confines of the Intro House. Agreeableness had five linkages with conversation behavior in the Intro House but fewer in other areas. Conscientiousness and Openness were both linked to narrative (quest) behavior Outside, with the former showing correlations with NPC conversation in the Hotel as well. Neuroticism proved the most difficult trait to capture, with only a marginally significant five correlations with Intro House navigation. Note that most of the other cells, despite containing up to four individually significant correlations, were not significant at the meta-level. Nonetheless there were far more correlations evident in the location-specific data than there were in the whole game aggregate.

As a final step, we selected ten of the most reliable cells and examined the effect of introducing facets. Table 2 shows those cells in expanded format, with the correlation values for all traits, facets and behaviors.

	Intro House			Outside			Mine		
	Nav	Con	Nar	Nav	Con	Nar	Nav	Con	Nar
E	0	0	2	11*	0	1	0	1	0
A	2	5*	4	2	1	0	2	1	0
C	0	0	2	3	2	3*	2	1	2+
N	5+	1	2	2	1	0	2	1	1
O	0	2	0	1	1	3*	0	0	2+

	Bar		Hotel		Sheriff's Office	Aband. House
	Nav	Con	Nav	Con	Nav	Nav
E	1	0	2	0	6+	0
A	0	0	0	0	2	4+
C	2	1	3	4*	4	2
N	2	0	2	0	3	0
O	4	0	0	0	0	3+

Table 2. Breakdown of significant correlations between personality facets and behaviors. H. House; Q. Quest; Out. Outside.

The inclusion of facets led to either higher behavioral correlation values or improved significance levels. We highlighted two examples. First, both the Outside and Sheriff's office showed positive correlations between Extraversion and both distance traveled and head movement, which were improved by considering Activity Level. Second, Conscientiousness as a trait showed no significant correlations with conversation behaviors in the Hotel, but its facets Achievement and Self-discipline were both strongly related. Overall, the inclusion of facets helped account for behavior that traits alone could not.

6. DISCUSSION

The study results confirm that personality is expressed through behavior in virtual gaming environments. In addition, we have shown that considering the finer-grained personality facets strengthened some correlations and uncovered others that were invisible when using only traits. Human personality is far too complex to be captured by only five factors. Thus, the inclusion of facets represents a necessary step towards forming a more complete and accurate assessment of personality, which allows a more precise differentiation between individuals and their behavior patterns.

In addition, the inclusion of context uncovered multiple correlations that were invisible in the aggregate data. The correlations held despite the fact that the number of experimental variables increased, restricting the criteria for significance, and experimental power decreased, as behavioral measurements needed to be parceled by location rather than averaged *en masse*. However, context is arguably even more important. Personality can be approximated by using the five principle traits of the FFM,

but environment is integral to determining behavior and it is very difficult to justify its omission. Context represents the alpha press of Murray [21]; it is the basis upon which personality operates in order to form an individual's subjective impressions of a given situation, which in turn inform their actions. As a final point, note that context can be defined at different scales. Aggregate studies implicitly use the single value "playing a game", and our work introduces one level of refinement by breaking the game into multiple areas.

6.1 Implications for Games Research

These results contribute to the previous research in personality and games. In particular, they illustrate the link between behavior, situation, and personality (examining personality beyond Big Five and including facets). This allows us to take a step forward towards building more robust adaptive models that take the additional significant variables into account. The results also allude to individual differences exhibited through behavior, something that game user researchers examining engagement will need to take into account. Lastly, understanding the influence of location affordances on play behaviors and their impact on players' interest given their personality will allow designers to think more inclusively about their designs.

6.2 Limitations

The use of personality facets in addition to traits has a few drawbacks. First, while there is a large body of data backing the Big Five, the facets are relatively less established and their population distributions are commensurately less reliable. Furthermore, while the Big Five traits have been shown to be orthogonal to each other [11], the facets exhibit more co-variability. As a result, it is more difficult to parcel out which observed characteristic (or survey question response) indicates which facet. Finally, the use of facets represents a six-fold increase in the number of parameters to test or correlations that need to be performed.

Additionally, in real life, single traits do not work in isolation; all aspects of an individual's personality are operating simultaneously, and behaviors are the product of multiple factors operating in unison. By focusing only on first-order effects, we potentially miss some correlations. Our reasons for concentrating on single-factor correlations are threefold: first, all of the previous studies also used single factors, and we wanted to compare our results to the growing literature in the field to see if the approach we are using can advance the current state of the art. Second, accounting for both facets and locations already left us with an enormous quantity of data to present; higher-order comparisons would have muddied our message. Third, if single personality factors can be reliably correlated with behavioral data, the relations can potentially be inverted to make a predictive model: given a behavior, what is the probable value of personality trait X? We have done some preliminary work in this direction and we were able to predict one trait value with an accuracy of 70% in 75% of subjects, but further refinement is needed and is ongoing.

We have several ongoing projects designed to overcome the previous limitations and further explore the dataset. To more precisely quantify in-game behavior, we are using sequence-mining techniques to extract frequent action patterns and test their connection to personality traits. To further explore the effect of context, we are breaking the different game areas into microlocations that enable us to compare across specific feature profiles, rather than simple geographical locations. To explore the joint effects of personality traits were are using cluster analysis to identify player typologies. Taken together, we expect these research methods will allow us to progress beyond trend identification and allow us to ultimately build actionable predictive models.

7. CONCLUSIONS

Research has shown that behavior is not just a function of personality, but rather a function of both the personality of the individual and the characteristics of the situation in which he is placed. By using facets to form a more precise description of personality and segregating behaviors by location to model situation, we were able to greatly increase the power of personality to explain behaviors. Future studies can incorporate other factors such as mood, physiology, personal history and recent events to further increase their explanatory power. Situations are complex constructs that transcend the game environment. If we want to enhance our ability to player behaviors, we need to be able to account for the cognitive factors that scaffold the interpretation of a situation from an alpha press into a beta press and accurately predict behavior. Such an achievement will have direct implications on game research and design.

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