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ORIGINAL PAPER

Flow and enjoyment beyond skill-demand balance: The role of game pacing curves and personality

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Abstract According to flow theory, skill-demand balance is optimal for flow. Experimentally, balance has been tested only against strong overload and strong boredom. We assessed flow and enjoyment as distinct experiences and expected that they (a) are not optimized by *constant* balance, (b) experimentally dissociate, and (c) are supported by different personality traits. Beyond a constant balance condition ("balance"), we realized two *dynamic* pacing conditions where demands fluctuated through short breaks: one condition without overload ("dynamic medium") and another with slight overload ("dynamic high"). Consistent with assumptions, constant balance was not optimal for flow (balance ≤ dynamic medium < dynamic high) and enjoyment (balance ≤ dynamic high < dynamic medium). Action orientation enabled high flow even under the suboptimal condition of balance. Sensation seeking increased enjoyment under the suboptimal but arousing dynamic high condition. We discuss dynamic changes in positive affect (seeking and mastering challenge) as an integral part of flow.

The research was conducted during the last author's affiliation at the University of Trier.

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Introduction

People spend many hours of their life-time playing computer games and psychologists and game developers alike try to understand the incentives of this kind of highly attractive leisure activity. While playing, people are often totally immersed in the ongoing activity without reflective self-consciousness but with a deep sense of control. Csikszentmihalyi (1975/2000) defined this state of experience as *flow*. To experience flow is a major incentive for playing computer games (Choi and Kim 2004; Hsu and Lu 2004). Flow is enjoyable in itself and can be described as a special form of *enjoyment*. Ratings of flow and enjoyment are often highly correlated (Landhäußer and Keller 2012) and sometimes enjoyment ratings are even used to infer flow (e.g., Jennett et al. 2008; Keller and Bless 2008). However, not every form of enjoyment is flow (e.g., lying on the beach is enjoyable but most likely without the experience of flow). Therefore, it is informative to measure flow and enjoyment (in terms of global, unspecified enjoyment) independently in order to test conditions where they dissociate (cf. Engeser and Schiepe-Tiska 2012).

According to classical flow theory (Csikszentmihalyi 1975/2000), flow is achieved best if the demands of a task are in balance with the skills of a person. This assumption has not been tested for a long time because researchers used balance ratings to measure flow and, thus, confounded both aspects (cf. Engeser 2012; Engeser and Rheinberg 2008). Only recently have researchers started to measure flow independently and to investigate its magnitude as a function of experimental variations of the skill-demand ratio in computer games (Keller and Bless 2008; Keller and Blomann 2008; Moller et al. 2010; Rheinberg and Vollmeyer 2003). The findings confirm that flow is higher under experimentally induced balance (skill = demands) compared to strong overload (skills < demands) and strong boredom (skills > demands). However, the findings do not tell us how optimal conditions are created on a micro-level of analysis.

In the cited studies, demands have been constantly adapted to match participants' current level of skills. We do not expect that *constant balance* throughout a game is optimal. First, we expect a *slight overload* to be more conducive to flow than perfect balance (e.g., Ceja and Navarro 2012). Second, it is important that demands fluctuate over time and expose the player to phases of high demands and rest (e.g., Schell 2008). Therefore, we expect *dynamic conditions* (in which long phases of slight overload alternate with short phases of rest) to be more conducive to flow than constant balance.

In addition to game design, the experience of a game also depends on the player's personality (e.g., Park et al. 2011; Quick et al. 2012). There are considerable individuals differences in the extent to which people seek and are able to self-regulate experiences of flow and enjoyment (e.g., Baumann 2012; Keller and Bless 2008). Specifically, we examine *action orientation* (Kuhl 1994) as the ability to self-regulate flow. As outlined below, we also included *sensation seeking* (Zuckerman 1994) as the tendency to enjoy arousing game features that are not related to flow.

To summarize, in the present paper we measure flow and enjoyment independently and aim at showing that (a) constant skill-demand balance is not the optimal condition for flow and enjoyment, (b) flow and enjoyment experimentally dissociate, and (c) flow and enjoyment are supported by different personality traits.

Slight overload

In motivation research, it is well established that people prefer tasks with a medium (50 %) subjective probability of success (Atkinson 1957). Interestingly, they report this at tasks with clearly lower (37 %) objective probability of success (e.g., when playing tabletop soccer; Schneider 1973, p. 154). To assess the subjective probability of success more indirectly, Schneider (1973) varied the goal-width and asked participants to predict their score in the next ten shots and to rate their confidence in this prediction. At the subjective midpoint (50 %), they should be least confident in and most hesitant about their prediction because failing and succeeding are equally likely. Schneider (1973) observed the lowest values and highest RTs in the confidence ratings at an even lower (29 %) objective probability of success. When asked to choose the goal-width, participants prefer exactly this *implicit* medium task difficulty that is 8 % below the self-reported and 21 % below the objective midpoint. The findings indicate that people prefer challenge over balance in a game context, that is, in tasks that do not have important consequences for their life (cf. Engeser and Rheinberg 2008).

Several studies using an experience-sampling method support the assumption that slight overload is conducive to flow. For example, Moneta and Csikszentmihalyi (1999) found conditions with slight overload to be optimal for the flow-facet of concentration using a linear model with quadratic effects of skill-demand balance. Ceja and Navarro (2012) found that the optimal condition for flow is slight overload using a non-linear dynamical systems model (i.e., cusp catastrophe model). Although the authors measured flow by computing the average of scales that also included a global enjoyment rating, several findings indicate that slight overload is less important for global enjoyment than flow. Many studies report no significant (or even negative) relationships between global enjoyment and challenge when examining a broad range of daily activities (e.g., Chen et al. 2001; Hektner 1996; Moneta and Csikszentmihalyi 1996; Shernoff et al. 2003).

More recently, Abuhamdeh and Csikszentmihalyi (2012a) demonstrated that the inverted U-shaped relationship between challenge and enjoyment differs from the one between challenge and attentional involvement (i.e., a central aspect of flow): enjoyment is optimal under lower challenge conditions than attentional involvement. Furthermore, Abuhamdeh and Csikszentmihalyi (2012b, Study 1) replicated this relationship between challenge and enjoyment for an intrinsic, goal-directed activity like chess: Experienced chess players most enjoyed chess games in which they held a slight advantage over their opponents (as assessed by relative performance scores, controlling for relative skill levels). Thus, we expect slight overload in computer games to be conducive to flow but not necessarily to global enjoyment.

Demand fluctuation

From a game developer perspective, finding the optimal demand level is only half the truth. Demands should also fluctuate over time and the cycle of tension and release is one of the key ingredients in game design (Schell 2008, pp. 121–122). According to Lazzaro (2009), for example, a flow sequence ("hard fun") typically starts with players getting so much frustrated that they are on the verge of quitting. Upon accomplishing a hard part, they arrive at a state of pride ("fiero") that comes with completing a difficult task and requires some frustration upfront. Finally, there is a relief part when players can enjoy previous mastery and relax until the cycle starts with frustration again. From the very beginning, Csikszentmihalyi (1975/2000) shared this dynamic view when he portrayed the flow process as a *dynamic* walk through the challenges by skills space. Thus, the few experimental studies in which demands were constantly adapted to match skills may not have optimized flow on a micro-level of analysis.

Empirical evidence supports the assumption that demand fluctuations (and the associated changes in positive affect) are conducive to flow. Baumann and Scheffer (2010, 2011), for example, found combinations of personality traits and overt behaviors that foster dynamic changes in positive affect (associated with seeking and mastering difficulty) to be conducive to flow in achievement contexts. Thus, people tend to experience flow when they are able to "manage a rewarding balance between the 'play' of challenge finding and the 'work' of skill building" (Csikszentmihalyi et al. 1993, p. 80). Ceja and Navarro's (2012) findings further support the assumption that departure from balance (e.g., upfront frustration through difficulty) may activate useful psychological resources that facilitate flow. Finally, findings on the positive effect of states of being recovered on subsequent levels of flow suggest that short phases of rest during tasks may be conducive to flow (Debus et al. 2014). Flow researchers (Engeser and Baumann 2014; Fullagar and Kelloway 2009; Nakamura and Csikszentmihályi 2009) and game developers (Lazzaro 2009) view demand fluctuation as important aspects for both flow and enjoyment. Therefore, we expect dynamic game features (i.e., demand fluctuation) to be conducive to both flow and enjoyment.

Realization in the computer game

A condition of balance can be realized by taking the performance of an individual as an indicator of skills and adapting the demands of the game to match this. Game developers distinguish between two aspects of demands: pacing (i.e., the time pressure to make decisions and the development of it) and ramping (i.e., the decision complexity and the development of it). In our study, we changed the pacing (but not the ramping) across three experimental conditions because it is easy to quantify and consistent with previous research (e.g., Keller and Bless 2008). In our *constant balance* condition, we adapted the pacing to constantly match the individual performance of the player within an expected optimal range of demands (i.e., within the grey bar region illustrated in Fig. 1). As argued above, we do not expect constant balance to be optimal because it does not contain the two flow-conducive features of demand fluctuation and slight overload.

In our *dynamic high* pacing condition, we integrated dynamic features with slight overload: we altered pacing to the high end of the expected optimal range of demands and offered three short breaks (see solid line in Fig. 1). Additionally, we realized a *dynamic medium* pacing condition to test the effects of some dynamic features without the slight overload and upfront frustration: we started pacing at the low end of the expected optimal range of demands, altered it to the high end of the range, and offered a short break before restarting the cycle twice (see dashed line in Fig. 1). Note that dynamic medium pacing was not more difficult than constant balance.

H1: The dynamic high pacing achieves a higher flow than the constant balance (with the dynamic medium pacing in between).

H2: The dynamic medium pacing achieves a higher global enjoyment than the constant balance (with the dynamic high pacing in between).

Personality moderators of flow and enjoyment

Action orientation

In addition to game features, personality traits influence the extent to which people experience flow and enjoyment (Baumann 2012; Park et al. 2011; Quick et al. 2012). Self-regulatory abilities such as "action orientation" correlate positively with flow in computer games (Keller and Bless 2008; Keller and Blomann 2008). Note that these correlations were observed only under conditions of balance. Strong overload and strong boredom were so maladaptive that flow was low regardless of self-regulatory abilities. Under balance, in contrast, good self-regulators experienced significantly higher flow than under maladaptive conditions whereas poor self-regulators experienced as little flow as under maladaptive conditions. Keller et al. interpret their findings as pointing to personal boundaries for flow: Even when conditions are optimal (i.e., balanced) only good self-regulators are able to experience flow. Alternatively, the finding could indicate that constant balance was indeed not optimal (as we hypothesize): When conditions are suboptimal (neither completely maladaptive nor fully optimal) only good self-regulators can compensate for missing features.

As mentioned above, the affective changes associated with demand fluctuation are expected to play a crucial role for experiencing flow. A constant balance may not trigger the affective changes (i.e., demand fluctuation) supporting flow. However, players can self-regulate affective changes

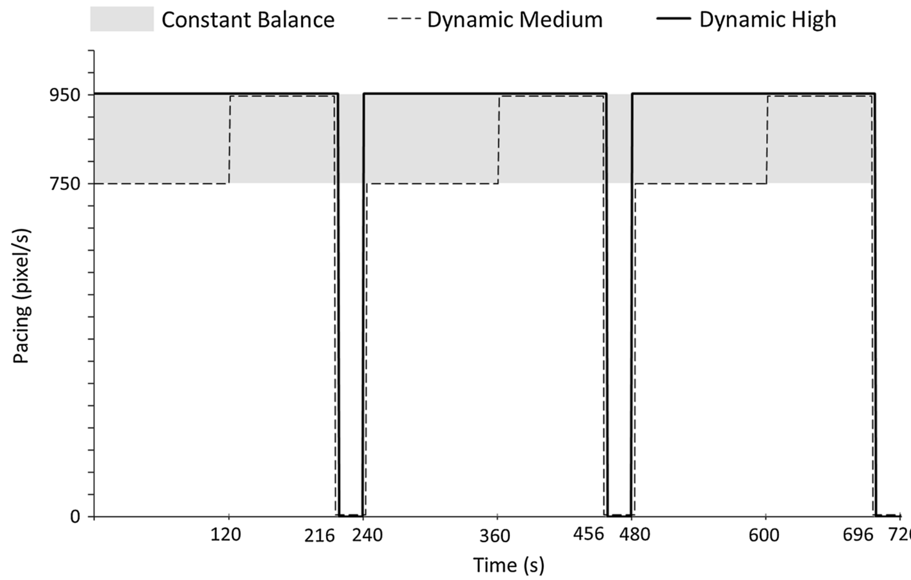

Fig. 1 Pacing curves in the three experimental conditions. Note that for 60 % of the time (144 out of 240 s) dynamic medium pacing was equal or smaller than pacing in the balance condition

by alternating between opening their attention to new information (seeking challenges) and focusing on those units of information just far enough ahead of current skills to be manageable (mastering challenges) (cf. Baumann 2012, p. 167). Task-related action orientation (Kuhl 1994) assesses individual differences in exactly this kind of self-regulatory ability (Dieffendorf et al. 2000; Kuhl and Beckmann 1994). For example, it is increased among top athletes in long-distance disciplines that require self-regulatory processes over long periods of time (Beckmann and Kazén 1994). Therefore, we expect action orientation to enable flow despite suboptimal game pacing curves.

H3: Action orientation supports flow under suboptimal conditions (i.e., constant balance and/or dynamic medium pacing) and is less relevant under optimal conditions (i.e., dynamic high pacing).

Sensation seeking

People do not only differ in the ability to self-regulate their experiences (i.e., action orientation) but also in their preference for certain types of experiences. Sensation seeking, for example, grasps individual differences in the preference for sensory stimulation (Zuckerman 1994; Zuckerman et al. 1978): Sensation seekers prefer high levels of sensory stimulation and physiological arousal, engage in risky behaviors in order to experience such sensations, and enjoy excitement. Therefore, they should enjoy our strongly stimulating dynamic high pacing—even if this condition is "suboptimal" in the sense that it does not elicit the highest enjoyment levels across participants. Although sensation seekers are likely to engage in tasks associated with flow (e.g., rock climbing), they are expected to be merely interested in the excitement and not in the opportunity to master challenge. Therefore, we do not expect sensation seeking to be relevant for flow but for enjoyment.

H4: Sensation seeking is associated with higher enjoyment in the most arousing (dynamic high pacing) condition and with lower enjoyment in the least arousing (constant balance) condition.

Method[1]

Participants

Ninety-three participants (59 female) were recruited at the University of Trier and from the broader social network of the experimenter. Their age ranged from 19 to 61 years ($M = 24.38$, $SD = 5.70$). Participation was voluntary. Participants were given no compensation in return for their participation.

Design and procedure

The experiment was realized as a 3 (Conditions: constant balance vs. dynamic medium vs. dynamic high; between-subjects) × 2 (Experience: flow vs. enjoyment; within-subjects) design. It consisted of two consecutive parts: an online part and a lab part. Online part: Participants answered questionnaires about personality (including

[1] We thank Vitali Maurer, Michael Kulikow, and Johannes Strack for the programming of the game, Jonas Tsigos for providing the artwork, Barbara Riedhammer for collecting the data, and Max Birk for feedback on an earlier version of the paper.

action orientation and sensation seeking), demographics (e.g., age, gender), and gaming expertise. Lab part: Within the next 2 weeks, they were invited individually to the lab. Participants were randomly assigned to one of three pacing conditions. They played the computer game ("Sideway Runner") for 720 s (12 min) on a PS Vita. Afterwards, they rated their experiences of skill-demand balance, flow, and enjoyment during the game. Finally, participants were debriefed, thanked, and dismissed.

Materials

Action orientation

We measured the task-related subscale of the Action Control Scale (Kuhl 1994). It is a forced choice self-report measure with 12 items (Cronbach's $\alpha = .74$). An example item is: "When I am busy working on an interesting project: (A) I need to take frequent breaks and work on other projects. (B) I can keep working on the same project for a long time". Option A represents state-oriented volatility and option B action-oriented persistence. The sum of action-oriented responses was used in all analyses (thus values could range from 0 to 12). Low scores indicate state orientation (i.e., low action orientation) and high scores indicate action orientation.

Sensation seeking

We measured sensation seeking with the German version (Beauducel et al. 2003) of the Sensation Seeking Scale Form V (Zuckerman et al. 1978). Similar to the Action Control Scale, it is a forced choice self-report measure designed to assess thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility (e.g., "A: I would like to try parachute jumping; B: I would never want to try jumping out of a plane with or without a parachute."A: I get bored seeing the same old faces; B: I like the comfortable familiarity of everyday friends."). Options A reflect sensation seeking. The scale consists of 40 items (Cronbach's $\alpha = .78$). The sum of sensation seeking responses was used in all analyses (thus values could range from 0 to 40) with higher scores indicating stronger sensation seeking.

Balance

We measured perceived skill-demand balance with a single item ("For me personally, the current demands are ….") to be rated on a 7-point scale (1 = "too low"; 4 = "just right"; 7 = "too high"). Thus, scores below 4 indicate boredom, a score of 4 indicates perfect balance, and scores above 4 indicate overload. The item is comparable to previous single item measures (Engeser 2012; Engeser and Rheinberg 2008; Keller and Bless 2008).[2]

Flow

We measured flow with the Flow Short Scale (Engeser 2012; Rheinberg and Vollmeyer 2003). The Flow Short Scale has been validated and successfully used in various applications (e.g., Baumann and Scheffer 2010, 2011; Engeser and Rheinberg 2008; Schüler 2010). It measures the components of flow experience with 10 items (Cronbach's $\alpha = .97$) including *fluency* (e.g., "My thoughts/activities run fluidly and smoothly", "I have no difficulty concentrating") and *absorption* (e.g., "I am totally absorbed in what I am doing", "I don't notice time passing") on a 7-point scale (1 = "not at all"; 7 = "very much"). The mean of the 10 items was calculated as the flow score used in all analyses (thus values could range from 1 to 7) with higher values indicate stronger experiences of flow.

Enjoyment

We measured global enjoyment with the enjoyment subscale from the Immersion Experience Questionnaire (Jennett et al. 2008, Exp. 3) because it is widely used in the computer game literature. It consists of four items (Cronbach's $\alpha = .82$) measuring enjoyment of the game (e.g., "How much would you say you enjoyed playing the game?" "When at the end, were you disappointed that the game was over?"). Items were rated on a 7-point scale (1 = "not at all"; 7 = "very much"). The mean of the items was calculated as the enjoyment score used in all analyses (thus values could range from 1 to 7) with higher values indicating stronger experience of global enjoyment.

Game: sideway runner

We developed the game "Sideway Runner" (a variation of the sidescroller "Bit Trip Runner"; implemented in "playstation mobile studio") in which the player collected flies and avoided bees by jumping and crouching. Flies added positively to the score and bees negatively (1000 points each). The total score was not allowed to get below

[2] In addition, we subtracted a single-item measure of *skills* ("I think that my competence in this area is …" to be rated on a scale from 1 = "low" to 7 = "high") from a single-item measure of *task difficulty* ("Compared to all other activities which I partake in, this one is …" to be rated on a scale from 1 = "easy" to 7 = "difficult"). This difference measure of balance was highly correlated ($r = .64$, $p < .001$) with the single-item measure of balance and yielded conceptually identical results in all analyses.

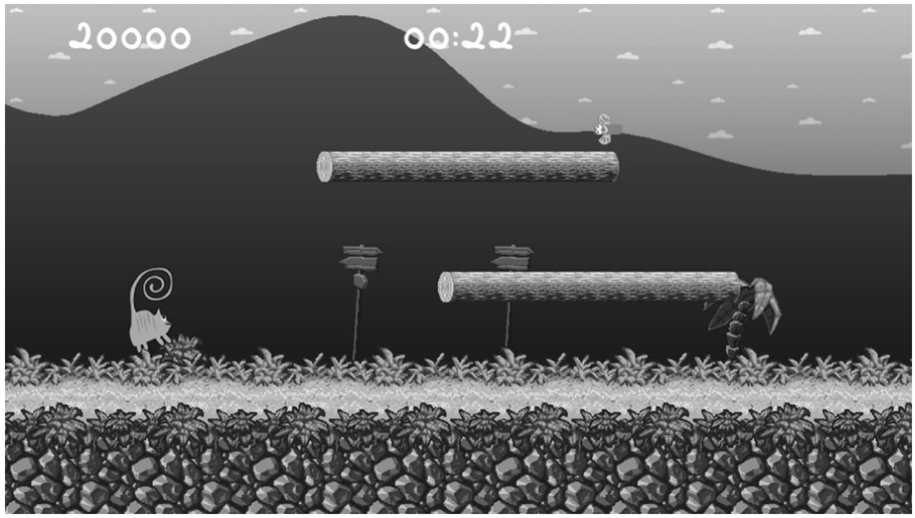

Fig. 2 Example screen-shot of the computer game (at level 1)

zero. Sideway Runner consisted of three levels (240 s each): In Level 1, only flies were present and jumping was sufficient to collect them (see Fig. 2). In Level 2, flies and bees were present but jumping alone was still sufficient to collect flies and avoid bees. In Level 3, jumping and crouching was required to collect flies and avoid bees. This increase in the decision complexity from Level 1 to 3 (i.e., ramping) was kept the same across conditions.

The pacing value of the player character was not directly influenced by the player's action but determined by the game system. Thus, we directly controlled the pacing of the game. In our experiment, pacing was a function of the playing performance (**e**) measured in the range of 0–1 and of the time (**t**) of the game in the area of 0–240 s. We had three relevant pacing values which are 0 (indicating a break in which the player was presented with some non-interactive cut scene), a lower value p_{lower} and an upper value p_{upper} The lower and upper values were defined as $p_{lower} = 750 \frac{pixel}{s}$ and $p_{upper} = 950 \frac{pixel}{s}$. To put things into perspective, the screen width of the PS Vita was 960 pixels. These parameters were estimated by the game designer based on the established methods of bisection and experienced estimation (Schell 2008, p. 201). Lower and upper bounds were estimated by eliminating pacing values that were obviously too low or too high. We realized three different pacing functions (see Fig. 1).

The constant balance pacing $p_{balance}$ was independent of time and defined as $P_{balance}(e,t) = p_{lower} + e \cdot (p_{upper} - p_{lower})$. In consequence, the performance parameter e was blending linearly between the lower and upper pacing values. By this definition, we guaranteed that in the balanced condition the pacing value was always between an optimal lower and upper value.[3] The performance of the player was measured based on the score obtained within the last 8 s.[4] In the dynamic medium pacing p_{medium} the first half of each cycle was at the lower level (120 s), then at the higher level (96 s), and for the last 10 % of the time it dropped to zero when the cut scene was presented as a phase of rest (24 s). In the dynamic high pacing p_{high} we basically skipped the first lower part and went straight for the upper level (216 s) until it dropped to zero (24 s). More formally, the two dynamic pacing functions were:

[3] This is different from the pacing condition of Tetris in the studies by Keller and Bless (2008) and Keller and Blomann (2008) where the speed may be increased and decreased to an infinite degree. We included these boundaries to have consistent pacing boundaries with the experimental conditions of dynamic medium and dynamic high pacing.

[4] We used a two-step method to determine participants' performance level. In a first step, we determined a raw performance $\widetilde{e}$. In a second step, we computed the filtered performance e by dampening too drastic changes in the measured raw performance $\widetilde{e}$ over time. The measured raw performance $\widetilde{e}$ is based on the player behavior in the last 8 s. We calculated a sliding score within this time interval where every collected fly added one point and every collected bee subtracted one point. If this value fell below zero it was clamped to zero. That score was divided by the total number of flies the player encountered during that period of time. The resulting value was the measured raw performance $\widetilde{e}$. If we executed a series of filtered performance estimates $e_0, e_1, \ldots$ over time, each of the performance estimates being a constant time step $\Delta t = 0.01666$ s apart, we used the following relation between filtered and raw performance and, thus, guaranteed that the filtered performance did not change more than 0.2 in one second: $e_{i+1} = \begin{cases} \widetilde{e_{i+1}} & |\widetilde{e_{i+1}} - e_i| \leq 0.2 \cdot \Delta t \\ e_i + 0.2 \cdot \Delta t & \widetilde{e_{i+1}} > e_i + 0.2 \cdot \Delta t \\ e_i - 0.2 \cdot \Delta t & \widetilde{e_{i+1}} < e_i + 0.2 \cdot \Delta t \end{cases}$.

Table 1 Means, standard deviations, and bivariate correlations (spearman) between study variables

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	*M*	*SD*
(1) Gender[a]	.16	.18	.03	.32**	−.04	.40***	.33***	.22		
(2) Age		−.22*	−.05	.02	.24*	−.24*	−.31**	−.17	24.38	5.70
(3) Gaming expertise			.12	.08	−.29**	.61***	.34***	.31**	3.52	1.77
(4) Action orientation				−.07	.11	.17	.39***	.37***	7.56	2.10
(5) Sensation seeking					−.11	.22*	.04	.12	20.84	5.87
(6) Skill-demand balance						−.47***	−.18	.11	4.38	1.49
(7) Performance[b]							.37***	.29**	448	165
(8) Flow								.58***	5.14	1.04
(9) Enjoyment									4.71	1.56

[a] Gender: 1 = female, 2 = male

[b] Points in thousands (corrected for phases of rest)

* $p < .05$; ** $p < .01$; *** $p < .001$

$$p_{medium}(e,t) = \begin{cases} p_{lower} & t < 120\,\mathrm{s} \\ p_{upper} & 120\,\mathrm{s} \le t < 216\,\mathrm{s} \\ 0 & 216\,\mathrm{s} \le t < 240\,\mathrm{s} \end{cases}$$

$$p_{high}(e,t) = \begin{cases} p_{upper} & t < 216\,\mathrm{s} \\ 0 & 216\,\mathrm{s} \le t \end{cases}$$

Results

Descriptives and correlations

Table 1 gives an overview of the descriptive results and correlations among our study variables. Action orientation and sensation seeking did not correlate with each other. Thus, they grasp different aspects of personality. Gender, age, and gaming expertise significantly correlated with flow (and enjoyment). Therefore, we controlled for gender and gaming expertise in all subsequent analyses (we did not control for age as it was less strongly correlated; including age did not change any results). Flow was highly and significantly correlated with enjoyment. The finding underlines the necessity to search for experimental dissociations to confirm them as distinct constructs.

Perceived skill-demand balance did not significantly correlate with flow and enjoyment (see Table 1). To test for the inverted U-shaped (i.e., quadratic) relationships predicted in flow theory (Csikszentmihalyi 1975/2000), we conducted hierarchical regression analyses with gender and gaming expertise entered as control variables in step 1, balance entered in step 2, and squared balance entered in step 3 (balance was centred before being squared). For flow, balance was not significant, $\beta = -.03$, $t(1, 89) = -0.28$, *ns*, whereas squared balance was highly significant, $\beta = -.37$, $t(1, 88) = -3.37$, $p < .001$, $\Delta R^2 = .117$ (total $R^2 = .263$). For enjoyment, balance was not significant, $\beta = .10$, $t(1, 89) = -0.99$, *ns*, whereas squared balance was also highly significant, $\beta = -.36$, $t(1, 88) = -3.61$, $p < .001$, $\Delta R^2 = .110$ (total $R^2 = .222$). Figure 3 illustrates the distribution of flow and enjoyment at all levels of the skill-demand balance. The inverted U-shape of the relationship between flow and balance is consistent with flow theory (Csikszentmihalyi 1975/2000) and previous findings for flow (e.g., during Pac-Man; Engeser and Rheinberg 2008, Study 2) and enjoyment (e.g., during chess, Abuhamdeh and Csikszentmihalyi 2012b, Study 1).[5]

Manipulation check of pacing curves

To check whether our pacing curves achieved the skill-demand ratios we aimed at, we conducted an ANCOVA on perceived skill-demand balance with Condition (constant balance vs. dynamic medium vs. dynamic high) as a

[5] Because the revised flow model (Csikszentmihalyi and LeFevre 1989) predicts flow only under balance achieved for *high* skills and *high* demands, we performed a median split for subjective task difficulty and tested whether squared balance was a significant predictor of flow and enjoyment in each subsample. In the subsample with low task difficulty ($M = 2.05$, $SD = 0.84$, range 0–3), squared balance significantly predicted flow ($\beta = -.40$, $t(1, 48) = -2.53$, $p < .02$) and enjoyment ($\beta = -.54$, $t(1, 48) = -3.51$, $p < .001$). In the subsample with high task difficulty ($M = 4.98$, $SD = 0.99$, range 4–7), squared balance significantly predicted flow ($\beta = -.65$, $t(1, 35) = -3.29$, $p < .002$) but not enjoyment ($\beta = -.25$, $t(1, 35) = -1.07$, $p = .29$). The results show that the effect of balance on flow does not substantially alter for high difficulties compared to low difficulties. In addition, including subjective task difficulty (and/or performance) as a further control variable in our main analyses did not change any of the results or made the findings even stronger.

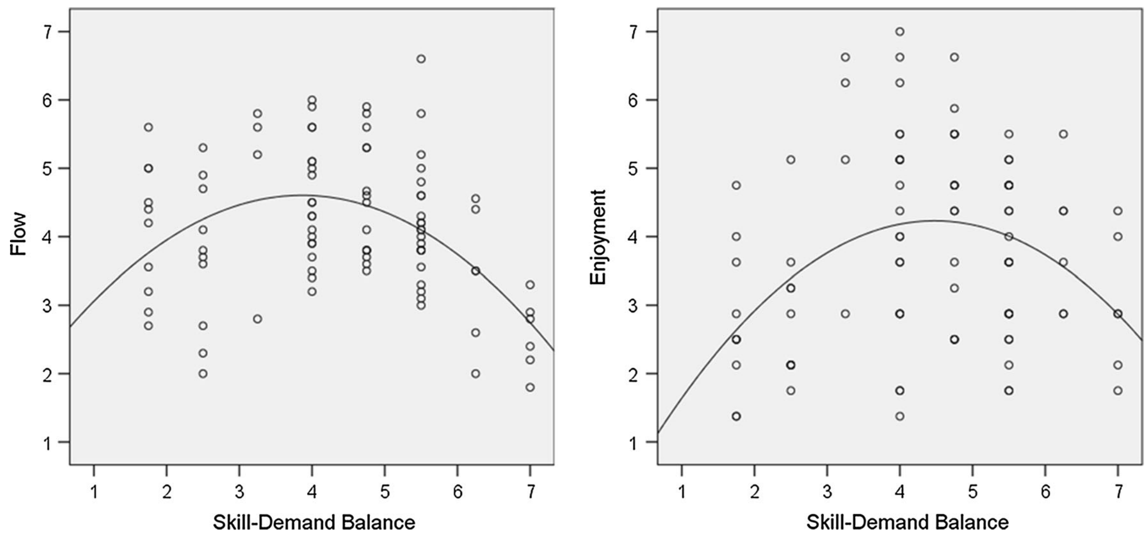

Fig. 3 Flow and enjoyment as a function of skill-demand balance

Table 2 Experiences during computer games as a function of pacing

	Pacing		
	Constant balance	Dynamic medium	Dynamic high
Skill-demand balance	4.02[a] (1.64)	4.29 (1.55)	4.82[b] (1.18)
Performance[c]	506[a] (169)	498 (170)	431[b] (149)
Flow	4.85[a] (1.09)	5.18 (0.99)	5.39[b] (0.99)
Enjoyment	4.39[a] (1.51)	5.21[b] (1.62)	4.53 (1.46)

[a, b] Different superscripts indicate significant differences between conditions ($p < .05$) in pairwise comparisons

[c] Points in thousands (corrected for phases of rest)

between-subject factor, controlling for gender and gaming expertise as covariates. There was a significant main effect of condition, $F(2,\ 88) = 3.43$, $p < .04$, $\eta_p^2 = .072$. As depicted in Table 2, demands were perceived as "just right" in the constant balance condition, significantly higher in the dynamic high pacing condition, and in between in the dynamic medium pacing condition that did not significantly differ from constant balance and dynamic high conditions. Thus, we succeeded in creating a condition of perfect balance and dynamic conditions with and without slight overload.

A similar ANCOVA was conducted on performance scores (corrected for phases of rest). There was a significant main effect of condition, $F(2,\ 88) = 4.05$, $p < .03$, $\eta_p^2 = .084$. As listed in Table 2, performance was significantly lower in the dynamic high pacing condition compared to the constant balance condition and in between in the dynamic medium pacing condition that was not significantly different from the two other conditions. Thus, the slight overload in the dynamic high pacing yielded lower performance scores.

Pacing curves, flow, and enjoyment

To test whether the experimental conditions yielded significantly different patterns of experience, we conducted a 3 (Condition: constant balance vs. dynamic medium vs. dynamic high; between-subjects) × 2 (Experience: flow vs. enjoyment; within-subjects) ANCOVA on participants ratings, controlling for gender and gaming expertise as covariates. There was a significant Condition x Experience interaction, $F(2,88) = 4.15$, $p < .02$, $\eta_p^2 = .086$. As can be seen in Table 2, flow was highest in the dynamic high condition whereas enjoyment was highest in the dycnamic medium condition. The finding indicates that, consistent with our conceptual distinction, flow and enjoyment experimentally dissociate.

Based on this dissociation, we ran two seperated ANCOVAs on flow and enjoyment with condition as a between-subject factor, controlling for gender and gaming expertise as covariates. The analysis of flow yielded a significant main effect of condition, $F(2,88) = 4.06$, $p < .03$, $\eta_p^2 = .085$. Independent t tests show that, consistent with *H1*, flow in the dynamic high condition was significantly higher compared to constant balance, $t(60) = -2.01$, $p < .05$, *CI* −1.060 to −.001, and flow in the dynamic medium condition was in between and did not significantly differ from constant balance, $t(60) = -1.22$, *ns*, *CI* −0.851–0.207, and dynamic high conditions, $t(60) = -.83$, *ns*, *CI* −0.712 to 0.294.

The analysis of enjoyment yielded a significant main effect of condition, $F(2,88) = 3.76$, $p < .03$, $\eta_p^2 = .079$. Independent *t* tests show that, consistent with *H2*, enjoyment in the dynamic medium condition was significantly higher compared to constant balance, $t(60) = -2.07$, $p < .05$, *CI* −1.619 to −.027, and enjoyment in the dynamic high condition was in between and did not significantly differ from constant balance, $t(60) = -.38$, *ns*, *CI* −0.901 to 0.611, and dynamic high conditions, $t(60) = 1.73$, *ns*, *CI* −0.105 to 1.460. Findings are consistent with the assumption that constant balance is not optimal for flow and enjoyment on a micro-level of analysis.

Table 3 Hierarchical regression analyses predicting flow and enjoyment as a function of personality traits and pacing conditions

	Flow		Enjoyment	
	ΔR^2	β	ΔR^2	β
Step 1	.15***		.10*	
Gender		.18		.00
Gaming expertise		.31**		.31**
Step 2	.13**		.18***	
C1 (balance vs. medium)		.03		.22*
C2 (balance vs. high)		.16		−.12
Action orientation (AO)		.31**		.37***
Sensation seeking (SS)		.02		.06
Step 3	.07		.04	
AO × C1		.01		.09
AO × C2		−.22*		−.08
SS × C1		−.01		−.14
SS × C2		.15		.23*
Total R^2	.35***		.32***	

* $p < .05$; ** $p < .01$; *** $p < .001$

Flow and personality

To test for personality moderators of flow, we conducted a hierarchical regression analysis. In step 1, we entered gender and gaming expertise as control variables. In step 2, we entered the pacing conditions. Consistent with Cohen and Cohen (1983, pp. 204–207), we compared each dynamic condition against the balance condition as the reference (C1 constant balance = −1, dynamic medium = 1, dynamic high = 0; C2: constant balance = −1, dynamic medium = 0, dynamic high = 1). In step 3, we entered the personality traits (action orientation and sensation seeking). In step 4, we entered the interaction terms of the pacing conditions with the personality traits. Consistent with Aiken and West (1991), we standardized our predictor variables before calculating the interaction terms. The results are summarized in the left columns of Table 3. There was a significant main effect of gaming expertise ($\beta = .31$, $t(90) = 3.17$, $p < .01$). More importantly, there was a significant main effect of action orientation ($\beta = .31$, $t(86) = 3.26$, $p < .01$). This was qualified by a significant Action Orientation × C2 interaction ($\beta = -.22$, $t(82) = -2.12$, $p < .04$). The interaction is illustrated in Fig. 4.

Simple slope analyses showed that, in the constant balance condition, state-oriented participants experienced less flow than action-oriented participants ($\beta = .59$, $t(82) = 3.62$, $p < .001$). This effect (state: 4.12 vs. action: 5.31) perfectly replicated the finding by Keller and Bless (2008, Exp. 2, state: 3.9 vs. action: 5.0). In the dynamic high pacing condition, in contrast, flow did not differ as a function of action orientation but was strongly experienced by all participants ($\beta = .03$, $t(82) = .21$, *ns*; state: 5.13 vs. action: 5.20). Findings indicate that, consistent with *H3*, action orientation was conducive to flow under conditions that were suboptimal for flow (i.e., constant balance).

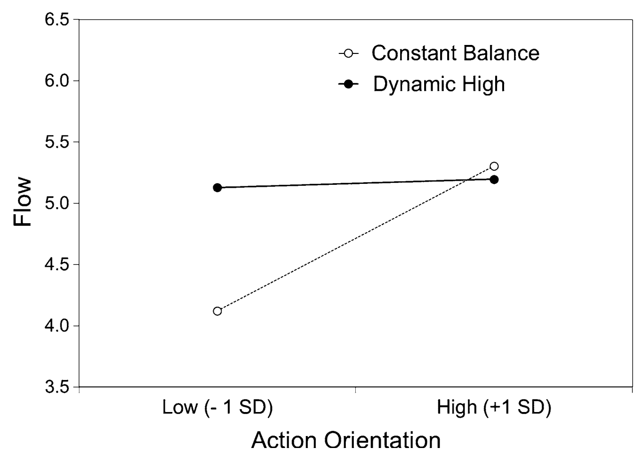

Fig. 4 Flow during the computer game as a function of action orientation and pacing

Enjoyment and personality

To test for personality moderators of enjoyment, we conducted a similar hierarchical regression analysis on enjoyment as on flow. The results are summarized in the right columns of Table 3. There were significant main effects of gaming expertise ($\beta = .31$, $t(90) = 3.06$, $p < .005$) and C1 ($\beta = .22$, $t(86) = 2.08$, $p < .05$) indicating that enjoyment was higher in the dynamic medium pacing compared to the constant balance condition. In addition, there was a significant main effect of action orientation ($\beta = .37$, $t(86) = 3.92$, $p < .001$). More importantly, there was a significant Sensation Seeking × C2 interaction ($\beta = .23$, $t(82) = 2.09$, $p < .04$). The interaction is illustrated in Fig. 5.

Simple slope analyses showed that, in the constant balance condition, enjoyment did not differ as a function of sensation seeking ($\beta = -.34$, $t(82) = -1.31$, *ns*; low: 5.26 vs. high: 4.59). In the dynamic high pacing condition, in contrast, high sensation seekers experienced more enjoyment than low sensation seekers ($\beta = .52$, $t(82) = 2.08$, $p < .05$; low: 4.06 vs. high: 5.10). Findings indicate that, consistent with *H4*, sensation seeking moderated enjoyment under conditions that were suboptimal for enjoyment (i.e., dynamic high pacing and constant balance).

Discussion

In the present article, we tested which game features are conducive to flow on a micro-level of analysis. Starting from the general assumption that *constant* skill-demand balance (although certainly better than strong overload and boredom) is not the best and only ingredient for flow, we have shown that we can further optimize it through *dynamic* features. This is common sense knowledge among game developers and supported by empirical findings in flow research (e.g., Baumann and Scheffer 2010, 2011; Ceja and Navarro 2012; Debus et al. 2014). In our constant balance condition, we successfully achieved perfect balance. In our two dynamic pacing conditions, we

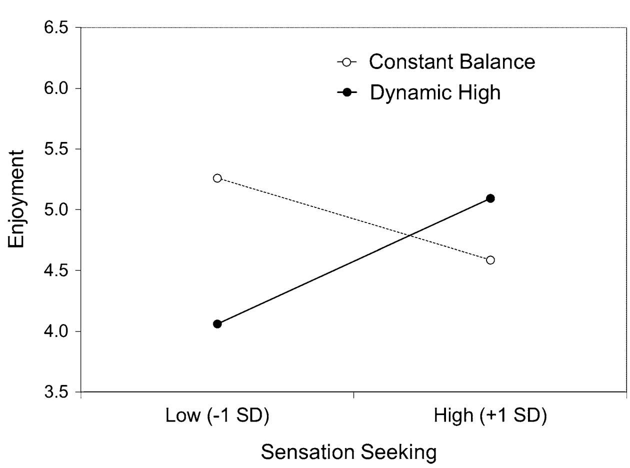

Fig. 5 Enjoyment during the computer game as a function of sensation seeking and pacing

implemented demand fluctuation over time through short phases of rest and achieved conditions without overload (dynamic medium) and with slight overload (dynamic high).

Consistent with our expectations, flow was significantly lower in the constant balance condition than in the dynamic high conditions. Thus, a first important contribution of our work is the finding that there is indeed flow beyond skill-demand balance. According to the revised flow model (Csikszentmihalyi and LeFevre 1989), flow is expected only under conditions of *high* skills and *high* demands. Therefore, one could argue that the pacing in the constant balance condition was simply too low to induce substantial flow. However, flow was descriptively higher in the dynamic medium pacing than in the constant balance condition. Remember that dynamic medium pacing was for 60 % of the time equal or smaller than pacing in the balance condition (see Fig. 1). Thus, if demands in the balance condition were already too low to induce significant flow, the medium dynamic pacing should achieve even less rather than more flow. Thus, our data do not support this alternative account of our findings.

With respect to the dynamic conditions, one may question whether short phases of rest are always positive. Participants may have failed before the rest, in which case they would be dwelling on their failure rather than enjoying their success. However, pacing was in a range were success was more likely than failure (even in the slight overload condition). Furthermore, short phases of rest may help people to recover despite dwelling. Consistent with this reasoning, our findings show that the dynamic conditions (i.e., with short phases of rest) were conducive to flow and global enjoyment.

In addition to this commonality, our study also revealed a clear experimental dissociation between flow and global enjoyment: the slight overload in the dynamic high condition was conducive only to flow but not to global enjoyment. As outlined in the introduction, flow is a special form of enjoyment but not every experience of enjoyment is indicative of flow. Thus, a second important contribution of our work is the finding that we have to differentiate between positive experiences supported by slight overload (flow) from those that are not (global enjoyment). This is consistent with theories and findings in game analysis (Bartle et al. 2009; Lazzaro 2009) and motivation psychology (Baumann and Scheffer 2010, 2011; Csikszentmihalyi et al. 1993) that demand fluctuation and the associated changes in positive affect (e.g., seeking and mastering challenge) are conducive to flow. Enjoyment, in contrast, is a positive experience that may also be based on the mere presence of positive affect and not stimulated by significant increases in challenge (cf. Abuhamdeh and Csikszentmihalyi 2012a, b).

In further support of our distinction between flow and global enjoyment, our study revealed that they were supported by different personality traits, respectively. Action orientation (Kuhl 1994) was conducive to flow whereas sensation seeking (Zuckerman et al. 1978) was conducive to enjoying dynamic high pacing. A commonality in the workings of these two different traits was that they were effective under pacing conditions that were suboptimal for the respective experience. More specifically, under optimal flow conditions (dynamic high pacing), participants experienced high flow regardless of their level of action orientation. Under suboptimal flow conditions (constant balance), in contrast, action-oriented participants experienced high flow whereas state-oriented participants experienced significantly less flow. In a similar vein, under optimal conditions for the experience of global enjoyment (dynamic medium pacing), participants experienced high enjoyment regardless of their tendency towards sensation seeking. Under suboptimal conditions for the experience of global enjoyment (constant balance and dynamic high pacing), in contrast, sensation seeking moderated the experience of enjoyment according to the arousal potential of the pacing condition: High sensation seekers enjoyed dynamic high pacing and low sensation seekers enjoyed constant balance conditions to greater extents.

In our constant balance condition, the effect of action orientation on flow perfectly replicates the finding by Keller and Bless (2008, Exp. 2) in their balance condition. Because they contrasted balance against conditions that were clearly detrimental to flow for everybody, they discussed self-regulatory abilities such as action orientation (or an internal locus of causality; Keller and Blomann 2008) as personal resources that are necessary for flow even if task conditions are optimal. In our study, we derive at a different conclusion because we identified two task conditions that allowed for even higher flow irrespective of participants' self-regulatory abilities. Neither does action orientation seem to be necessary for flow nor state orientation limiting flow under optimal task conditions. This is consistent with extensive literature indicating that action orientation is a resource that unfolds under stressful (suboptimal) conditions (Koole et al. 2012; Kuhl and Beckmann 1994). Thus, the boundaries that personality traits set on our ability to experience flow seem to become evident especially under conditions capable of inducing moderate rather than high or low levels of flow in most people (cf. Baumann and Scheffer 2010).

Limitations and future perspectives

We do not claim that our dynamic high and dynamic medium pacing conditions already maximize the experiences of flow and global enjoyment, respectively. Our findings are limited in several ways. First, we do not know if the increase in the subjective task difficulty that we observed in our adaptive high condition already catches the *implicitly* medium task difficulty that participants prefer in a game context (cf. Schneider 1973). Furthermore, succeeding in difficult tasks allows a sense of mastery that is associated with increases in positive affect. In future studies it would be informative to measure both independently to test which one of the two fosters flow: mastering higher challenges versus increases in positive affect or both in a mediation chain.

Second, flow is a multifaceted construct characterized by absorption, concentration, fluency, and transformation of time. The experience of flow is inherently enjoyable and a *specific* form of enjoyment. Nevertheless, our measure of flow did not include enjoyable aspects. We see this as an advantage because a central aspect of flow theory is that flow helps us to explain why people engage in some (leisure) activities even at great cost, for the sheer sake of doing it. If we would include enjoyment in the measure of flow, we would include the aspect we often try to explain by the flow construct. However, the fact that we contrasted flow with general enjoyment does not mean that we expect all flow facets to completely correlate. For example, we analyzed absorption and fluency separately (not reported) and found a similar pattern of results (i.e., slight differences between these two facets of flow were not significant). In future research, it would be informative to explore conditions where facets of flow dissociate.

Third, our dynamic high pacing condition integrates fluctuation and slight overload. Thus, we cannot estimate the contribution of each component alone. The dynamic medium pacing condition, in contrast, differs from constant balance only with respect to fluctuation and from dynamic high pacing only with respect to slight overload. In future research, it would be informative to include two separate factors: Fluctuation (absent vs. present) × Balance (slight underload vs. balance vs. slight overload). Fourth, we used a task with low outcome importance and the effects of demand level and demand fluctuation may be different for tasks with high outcome importance (cf. Abuhamdeh 2012; Engeser and Rheinberg 2008).

Fifth, findings by Eisenberger et al. (2005) show that only for employees with high need for achievement balance enhanced positive mood and task interest (see also Engeser and Rheinberg 2008). Because the task in our study was a game, it is not clear whether need for achievement was activated. If it was not activated, one might argue that balance did not have a chance to prove its superiority over slight overload. However, skills and demands were also perceived as balanced in the dynamic medium pacing condition (see Table 2) and this condition yielded significantly higher levels of enjoyment than constant balance. Furthermore, the findings by Schneider (1973) clearly show that balance (or medium task difficulty) is implicitly perceived at levels that are way above the explicit ratings of balance. Thus, if the need for achievement was not aroused, this should have been more detrimental for the slight overload condition. The finding that this condition yielded highest levels of flow supports the assumption that our game activated the need to achieve. Nevertheless, in future studies, it would be informative to include measures of the achievement motive and test whether our results replicate with clearly achievement-oriented tasks.

Finally, game development is a multidimensional optimization problem. Pacing (i.e., time pressure for a decision) is only one aspect of task difficulty that has to be optimized with regard to the respective complexity of a decision (i.e., ramping). In our game, decision complexity increased across the three levels (4-min periods) of the game. Future studies may investigate whether a slight overload in decision complexity (ramping) is equally conducive to flow than a slight overload in time pressure for decisions (pacing).

Conclusion

Our findings offer three important conclusions. First, experiences of flow and general enjoyment can be optimized by task features that lie beyond perfect skill-demand balance. Second, flow and general enjoyment experimentally dissociate: whereas demand fluctuation is sufficient to enhance general enjoyment, it additionally requires slight overload to enhance flow. Finally, the personality traits supportive of flow and general enjoyment suggest that—when conditions are suboptimal—flow is a question of ability to make this experience happen whereas general enjoyment is a question of preference.

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