A Closer Look at the Challenge-Skills Relationship and its Effect in the Flow Experience: An Intra- and Inter- Participant Analysis

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RUNNING HEAD: A Closer Look at the Challenge-Skills Relationship

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Abstract: *A debate has taken place on the relationship between challenge and skills as the universal precondition of flow. Flow's precursor, Csikszentmihalyi, states that these two constructs are independent, while other scholars state the opposite. This research aims to better understand this relationship and explore its effect on the flow experience. As flow is considered a nonergodic and nonlinear process, we will base our analysis on an intra-individual level and then shift to an inter-individual level. The database consisted of 3,630 registers collected from a sample of 60 employees. At an intra-individual level, we observed the nature of the challenge-skills relationship classifying the participants according to the direction of these relationships (positive, negative, or nonsignificant correlation). At the inter-individual level, we explored the effect that the three groups had on the flow experience. We also examined nonlinear relationships (cusp modeling) among challenge, skills, and flow. The results showed that the challenge-skills relationship is not homogeneous between individuals. Flow theory is represented by the positive correlation group, but this pattern is the least frequent (21,6% of the cases) in our sample. Finally, the results showed that the nonlinear models fit the data better* (R^2*nonlinear* $= .48$, R^2*linear* $= .35$, $p < .01$).

Key Words: flow, challenge-skills relationship, intra-individual analysis, nonergodic process, nonlinear relationship.

INTRODUCTION

Research has revealed the importance of flow at the workplace (e.g., Bakker, 2005; Demerouti, 2006; Ceja & Navarro, 2012) because this phenomenon may offer a window for action to boost employee performance and well-being. Flow is an intrinsic motivational process characterized by the complete immersion of a person in an activity that later has positive affective and cognitive outcomes (Csikszentmihalyi, 1975, 1990, 2002; Engeser & Schiepe-Tiska, 2012; Landhäuβer & Keller, 2012). The flow concept is not new and has been studied over the past decades, mainly from a between-individual perspective (Ceja & Navarro, 2012). However, we consider the phenomenon to be more relevant to study it from a within-individual perspective, since flow is considered as a nonergodic process (Ceja & Navarro, 2017), meaning that it will be different for each individual and that it will vary over time (Molenaar & Campbell, 2009). The main objective of this paper is to study the relationship between perceived challenge and perceived skills at an intra-individual level and to explore its effect on the flow experience. This will allow us to shed some light on the ongoing debate about the universal precondition of flow (i.e., perceived challenge-skills balance), in which Csikszentmihalyi, the precursor of the flow concept, states that these two constructs are independent, while other flow scholars (e.g., Landhäuβer and Keller (2012), and even authors from other areas of psychology (Lazarus, 1991), state the contrary.

FLOW THEORY

Origins and Definition

Flow is a sudden and intense subjective experience in which individuals are completely focused and immersed in an activity that later provides a feeling of enjoyment. It was first described in the book "*Beyond boredom and anxiety*" by Mihaly Csikszentmihalyi in 1975, while studying the creative process of artists. What seemed important to the painters was the making rather than the final piece. As they painted, the artists were completely absorbed in their composition and greatly enjoyed what they were doing at that precise moment. The author later interviewed chess players, rock climbers, athletes, surgeons, and others who reported having the same experience. Csikszentmihalyi (1990) defined this experience as “the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it” (p.4). The experience was defined as intrinsically motivating, meaning that individuals choose to do activities because they are rewarding, and not because they will obtain an external incentive; Csikszentmihalyi named this the autotelic nature (Csikszentmihalyi 1975, 1990; Engeser & Schiepe-Tiska, 2012; Landhäuβer & Keller, 2012). This autotelic activity contributes to a feeling of well-being, personal development, and even performance (e.g., Csikszentmihalyi 1975, 1990, 2002; Landhäuβer & Keller, 2012). However, it is neither easy nor common to engage in this kind of state. Flow scholars have identified certain conditions that must be met for the experience to be triggered; the activity must (1) have clear goals, (2) give continuous and unambiguous feedback, and (3) the perceived challenge and skills of the person must be in balance (e.g., Csikszentmihalyi, 1975, 1990, 2002; Csikszentmihalyi & Csikszentmihalyi, 1992; Csikszentmihalyi et al., 2005; Landhäuβer & Keller, 2012).

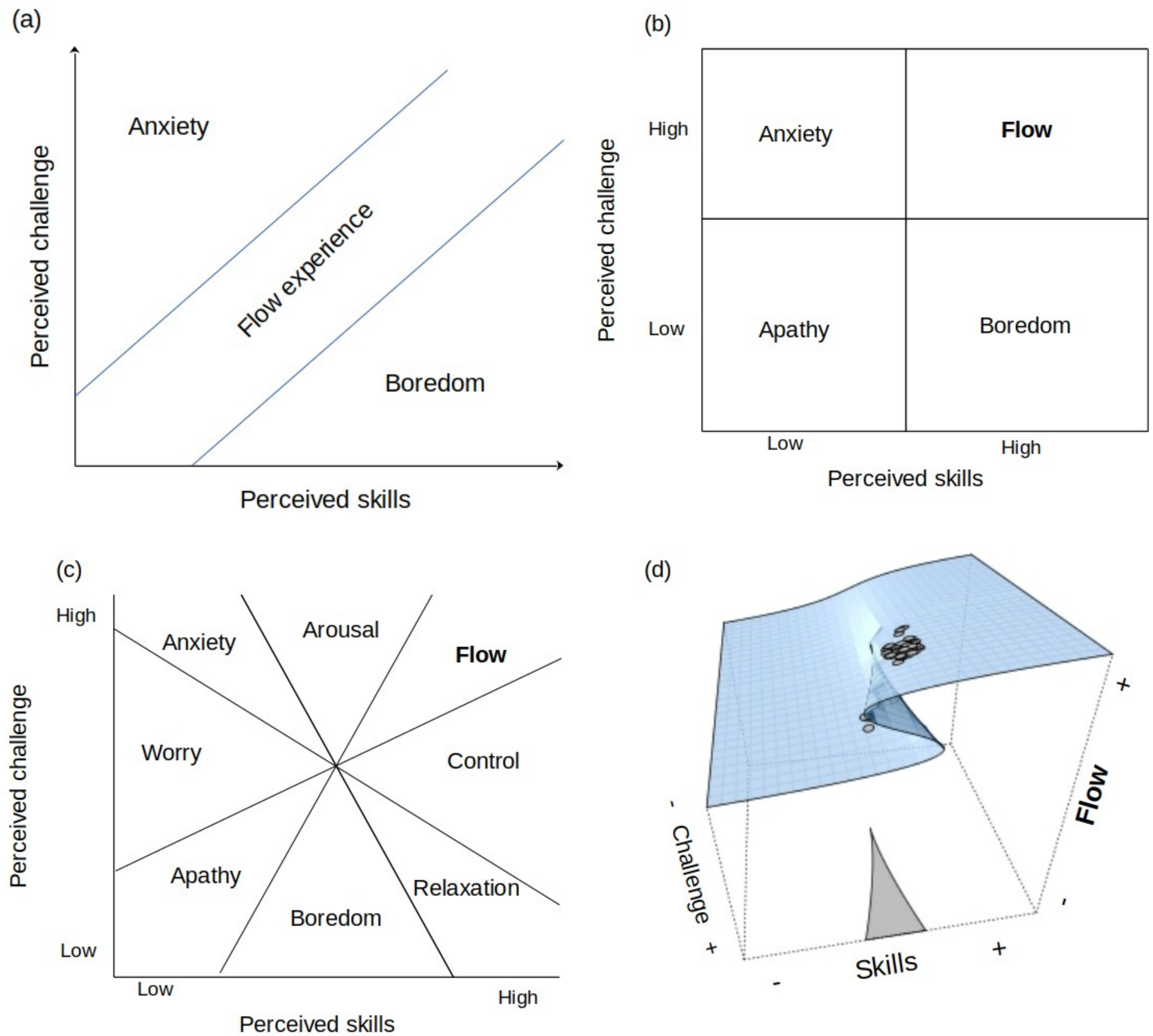
Measurements and Models

Several methods have been used over the years to measure and study the flow experience: interviews, questionnaires, diary methods, among others. A technique that allowed the empirical study of flow and provided data to make important theoretical advances is a diary method called the Experience Sampling Method (ESM; Csikszentmihalyi, 2002; Hektner, Schmidt, &

Csikszentmihalyi, 2007; Larson & Csikszentmihalyi, 2014; Moneta, 2012). It consists of "a research procedure for studying what people do, feel, and think during their daily lives." (Larson & Csikszentmihalyi, 2014, p.21). Participants are given, for example, an app on a smartphone which is programmed to beep randomly a certain number of times per day. The individual is instructed to answer some questions each time the device is turned on. This allows researchers to capture the objective and subjective perceptions of a person of the present moment. An advantage is that reporting the phenomenon as it occurs avoids possible memory biases, which are likely to appear when completing a questionnaire, for example (Csikszentmihalyi, 2002; Moneta, 2012). However, this technique has been criticized because it interrupts the flow state as it occurs. For the moment, it is considered the most appropriate method to study that optimal experience. Researchers have been strongly encouraged to explore alternative ways of recognizing flow, for example, by means of neurological markers (Csikszentmihalyi, 2002) without significant advances for the moment.

The measurement techniques allowed the construction of several models that represent diverse ways of understanding the flow experience. The first model, also known as the channel model, was built by Csikszentmihalyi in 1975 and is shown in Figure 1A. It consists of a Cartesian space, showing the level of perceived challenges in one axis and the level of perceived skills in the other one. This model displays three states (i.e., flow, boredom, and anxiety) that will vary depending on the challenge-skills interplay. When an individual's level of skills matches the level of opportunities for action, the flow state is experienced. But when the level of challenge and skills do not match, the individual can feel anxiety, if challenge exceeds skills, or boredom if skills exceed challenge. Two other models, based on the same Cartesian space, were created later: the quadrant model and the octant model. The quadrant model, shown in Figure 1B, added a fourth state; a person experienced apathy when perceived challenge and skill matched at a low level. The octant, also called the fluctuation model, shown in Figure 1C, included a wider range of states (Della Fave, Massimini, & Bassi, 2011). The main difference between the first and the last two models lies in the challenge-skills balance condition. These two constructs need to be in balance at a high level and, more specifically, the balance between the two needs to be higher than the weekly average for the individual to enter a flow state. In the channel model, flow can be experienced independently if perceived challenge and skills are at a low, medium, or high level. Finally, a consideration of flow as a process resulting from the nonlinear interaction between challenge and skills has also been proposed (Ceja & Navarro, 2012). Thus, flow would be regarded as a sudden emerging experience once certain critical values in the challenge and skill variables are surpassed. In this model, the discontinuous nature of flow is emphasized, as a phenomenon that appears suddenly. This model is presented in Figure 1D.

Fig. 1. A) Original flow model (Csikszentmihalyi, 1975); B) Quadrant model (Csikszentmihalyi & LeFevre, 1989); C) Octant or fluctuation model (Della Fave, Massimini, & Bassi, 2011); D) Nonlinear model (Ceja & Navarro, 2012).



Nonlinear Dynamics of Flow

There is substantial evidence that flow is a fluctuating process over time and for that nonlinear models better explain its occurrence compared to linear models. In a recent meta-analysis of various motivational processes, Navarro, Rueff-Lopes, and Laurenceau (2022) found that longitudinal studies addressing flow show intra-participant variance values (i.e., ICC1 values) between 47% and 95%, with an average value of 71.5%. This suggests that flow is one of the most dynamically changing motivational processes over time. For instance, in the same meta-analysis, engagement showed an intra-participant variance value of 47%, while positive affect or positive emotions had values of 45.3% and 49%, respectively, all of which are significantly lower than that shown by flow.

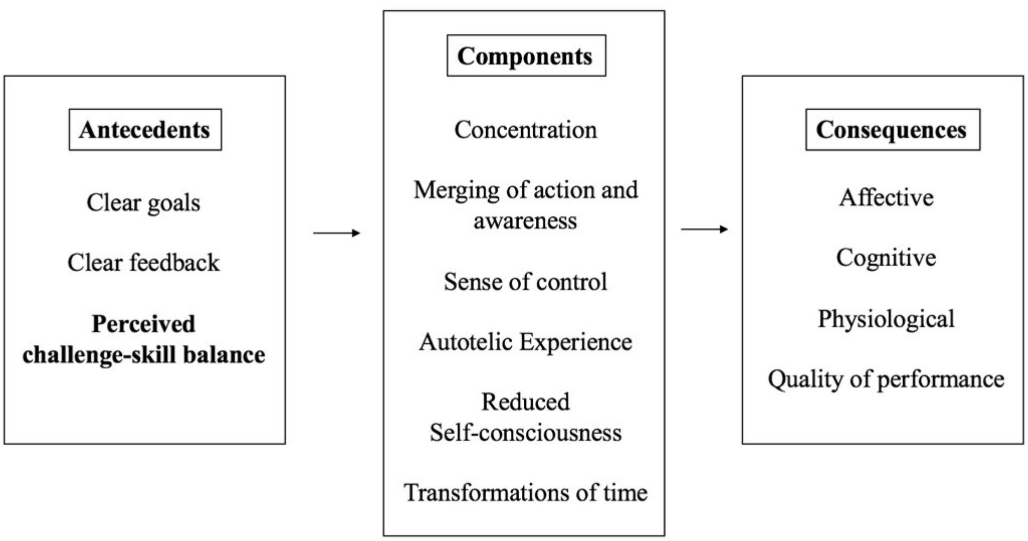
Furthermore, since the pioneering work of Guastello, Johnson, and Rieke (1999) where the nonlinear dynamics of motivational flow were first studied, evidence supporting the superiority of nonlinear models in explaining the occurrence of flow has been consistently replicated (e.g., Bricteux et al., 2017; Ceja & Navarro, 2009, 2012). For example, in the study by Ceja and Navarro (2012), it is demonstrated that the nonlinear dynamics (i.e., catastrophe cusp models) between challenge and skills explain the emergence of flow, especially in cases where participants exhibit high levels of flow and considering challenge as the bifurcation parameter and skills as the asymmetry. Specifically, in these cases, nonlinear models exhibit R^2 values of .53 compared to R^2 values of .31 for linear regression models (these linear models included the interactive effect of challenge and skills on flow). All of this has led nonlinear models of flow to become one of the most fruitful avenues for furthering our understanding of this peak experience (Moneta, 2021).

Furthermore, in Csikszentmihalyi's (1975) own description of the flow phenomenon, he captures the idea of its sudden emergence, where this experience appears abruptly when action and consciousness seem to synchronize properly, leading the individual to optimal performance. This notion of sudden appearance has been incorporated into nonlinear models of flow (e.g., Ceja & Navarro, 2012) when specifically applying catastrophe models to explain this phenomenon. Flow and non-flow would be the two possible stable states resulting from the nonlinear interaction between challenge and skills (Moneta, 2021). Finally, these arguments are also in line with previous evidence that has demonstrated the appropriateness of catastrophe models in the study of motivation and performance (e.g., Guastello, 1987).

Flow's Structure

The definition of flow has not changed much over time (Moneta, 2012). However, what has changed in the past few years is the way researchers measure and structure flow. We will focus more on the structure. Csikszentmihalyi (2002) started structuring flow by stating that the experience was composed by conditions and characteristics. Later, Landhäuβer and Keller (2012) separated the flow experience into conditions or antecedents, components, and consequences, as shown in Figure 2.

Fig. 2. Antecedents, components, and consequences of flow. Adapted from Landhäuβer & Keller, 2012.



The components of flow are what individuals feel and experience when they are in this state, while the antecedents are the elements that need to be present for the flow experience to emerge. Antecedents do not represent flow in itself but are the perceptions that precede the experience (Moneta, 2012). The consequences, on the other hand, are the effects or results after having experienced this subjective state.

Flow structure has been subject to some changes as the research in this area has advanced. Regarding the components, in 1975 Csikszentmihalyi described six of them: the merging of action and awareness, the centering of attention, the loss of self-consciousness, the feeling of control, the coherent and non contradictory demands, and the autotelic nature. This list was modified later, for example, the “feeling of time distortion” was added (Csikszentmihalyi & Csikszentmihalyi, 1992; Engeser & Schiepe-Tiska, 2012) and the element of “coherent and non-contradictory demands” was removed as a component and added as a condition (Engeser & Schiepe-Tiska, 2012). There also tend to be disagreements on the structure regarding the classification of elements as conditions, components, or consequences. Engeser and Schiepe-Tiska (2012) stated that in some cases, authors consider certain conditions as components or some components as consequences. An example of this is the classification of the autotelic experience as a precondition instead of a component, or the challenge-skills balance as a component instead of a condition (Landhäuβer & Keller, 2012). Apart from these classification disagreements, there are also some debates within each of the conditions, components, and consequences groupings. This paper will focus on the current discussion of the conditions that generate the flow experience.

The Condition of Challenge-Skills Balance

Authors generally agree on the three conditions that foster flow experience and consider the equilibrium of perceived challenge and skills as a golden rule for the appearance of the phenomenon (e.g., Csikszentmihalyi, 1975, 1990, 2002; Csikszentmihalyi & Csikszentmihalyi, 1992; Keller and Landhäuβer, 2012; Fong, Zaleski & Leach, 2015; Jackson & Csikszentmihalyi, 1999). The two constructs, challenge and skills, are of utmost importance and are the base of the flow models that allow us to better understand the phenomenon (see Figure 1). Challenge is defined as the opportunities perceived by an individual to overcome demanding or difficult situations (Bricteux et al., 2017; Csikszentmihalyi, 1975; Csikszentmihalyi & Csikszentmihalyi, 1992). Certain scholars (e.g., Engeser & Rheinberg, 2008) believe that it is better to use the term difficulty than challenge, but there is no empirical difference when referring to “perceived challenge-skills” or “perceived difficulty-skills” (Engeser & Rheinberg, 2008). On the other hand, skills can be defined as the perceived abilities that a person has to deal with or cope with the situation (Bricteux et al., 2017; Csikszentmihalyi, 1975).

Recent studies have proven that this universal condition is not enough to enter the flow state. There are situational or personal moderators that increase or decrease the effect that the balance of challenge-skills has on engagement in the flow experience. Some examples of situational factors are the interest people have in the activity they are performing (Bricteux et al., 2017), or the fact that the activity is done in an achievement or non-achievement situation (Schiepe-Tiska & Engeser, 2012). Regarding personality factors, Keller and Blomman (2008) demonstrated that people with an internal locus of control were more likely to experience flow.

To summarize, a challenge-skills balance is a central condition necessary for the individual to experience flow, but this condition might only be valid under certain circumstances or for people with certain characteristics. Given the fact that the challenge-skills balance postulate is the most important condition and has recently been questioned, we consider it to deserve more attention.

A CLOSER LOOK AT THE RELATIONSHIP BETWEEN PERCEIVED CHALLENGE AND SKILLS

An interesting debate can be found in the literature on the relationship between perceived challenge and perceived skills. Csikszentmihalyi, the precursor of the flow concept, implies that these two are independent constructs (Csikzentmihalyi 1975, 1990). The author infers that an individual can have distinct levels of challenges and distinct levels of skills during the day, and only when the level of these two matches while doing a specific activity, the person will be prone to enter a flow state. Other flow scholars state the opposite. For example, Landhäuβer and Keller (2012) believe that perceived challenge and skills are dependent constructs. They argue that to determine the level of challenge, one inevitably refers to one’s own level of skills. Likewise, they state that people will evaluate whether they have the necessary skills to accomplish a certain task by assessing the level of challenge in that specific situation. In other words, these two constructs are interrelated, and one helps to determine the level of the other.

The challenge-skills dependence argument can also be found in other branches of psychology and not exclusively in flow theory. This idea seems to be the same as used by Lazarus’ appraisal model in the transactional stress theory (Lazarus, 1991). In his model, Lazarus explains that certain events or situations in life can produce stressful reactions. The appearance of this reaction will depend on the cognitive appraisal done by the individual. He explains that the appraisal is done in two steps, the first is an automatic response to a situation in the environment, which can be experiencing stress, for example, and the second consists of the self-evaluation of the person’s ability to cope with the stress provoked in the first step. In the second appraisal, Lazarus implies the existence of a dependent relationship between challenge and skills. In other words, the author states that to overcome the stressful reaction, which can be seen as a parallel phenomenon to “perceived challenge”, a person will always evaluate the situation by looking at their own set of abilities, which can be seen as a parallel to “perceived skills” (Lazarus, 1991; Peifer, 2012). In addition, Lazarus’ and Csikszentmihalyi’s theories both include anxiety or stress in their models. Peifer (2012), recognized these similarities and integrated the flow theory in the Lazarus transactional model in her research.

Having this issue in mind, we consider that the most appropriate way to study the relationship between these two variables is at an intra-individual level. Flow has been extensively studied at an inter-individual level in past research (Ceja & Navarro, 2012) and this has widely contributed to the advancement of its theory. However, it might not be the most relevant way to study certain types of processes, because most inter-individual analyses are designed to study ergodic phenomena. This deserves to be explained in more detail. Molenaar and Campbell (2009) warn researchers to remain cautious when inferring results from an inter- to an intra-individual level, and they explain that this shift in level is possible, only when the phenomenon is considered ergodic. But ergodicity follows two rigorous conditions: (1) homogeneity, meaning that the individuals of a population obey the same statistical model, and (2) stationarity, indicating that statistical characteristics of the data should remain invariant across time (Molenaar & Campbell, 2009). Flow has been identified as a nonergodic process and as a non-stationary process (see Ceja & Navarro, 2017). This implies that one cannot account for results at an intra-individual level based on inter-individual level research, or vice versa. Accordingly, we consider that the most adequate way to study flow is at an intra-individual level, and then observe its effect at an inter-individual level. We are interested in observing if intra-individual differences concerning the challenge-skills relationship influence the flow experience by applying then an inter-individual focus. At this point, to our knowledge, this will be the first study that explicitly tests the non-homogeneity of the flow experience creating groups with similar (i.e., homogeneous) participants allows for the testing of basic hypotheses of flow theory separately within each group.

Additionally, we would like to explore flow at work because several authors have found that flow is more likely to appear during work rather than leisure activities (e.g., Ceja & Navarro, 2011; Csikszentmihalyi & Lefevre, 1989; Engeser & Baumann, 2016; Guastello et al., 1999). This happens because of the achievement nature of the tasks done at work where the interplay between challenge and skills is important. Thus, we consider that interesting perspectives can result from the examination of the impact of challenge-skills relation on the flow experience at work.

Finally, we are also interested in exploring the potential nonlinear relationships between the challenge-skill balance and the emergence of flow, considering the previously mentioned sudden nature of flow's onset, as has been demonstrated in prior studies. To this end, the cusp catastrophe model could be a useful approach.

RESEARCH QUESTIONS AND OBJECTIVES

Considering everything discussed so far, the research questions that will guide this study are as follows: (1) What will the nature of the challenge-skills relationship be at a within-individual level? (2) Will these challenge-skills relationships influence how workers experience flow?

In greater detail, those general research questions would translate into the following objectives: (1) To study the challenge-skills relationship at within-individual level; (2) Based on the results obtained in objective 1, to elaborate groups of participants in order to study possible between-individual differences in the flow experiences (i.e., enjoyment and absorption), and (3)

To study if a nonlinear models (i.e., cusp modeling) explain better the interplay between challenge, skills and flow, in comparison to their linear model counterparts.

METHOD

Participants

Sixty employees from 29 different occupational backgrounds participated in the study (e.g., IT manager, human resource advisor, ballet dancer, assembly line worker, house cleaner, dog trainer, researcher, etc.). This sample has been previously used in other research (Ceja & Navarro, 2011, 2012) for other purposes. The mean age was 38 years in a range of 26 to 64 years. The sample was made up of 32 women and 28 men. Regarding the level of education, 8% had a high school diploma, 57% had an undergraduate degree, and 35% had a postgraduate degree. The participants had been working for the same company for an average of eight years (range: from 1 month to 28 years). They had been in the same working position for an average of six years (range: from 1 month to 28 years). The employees worked an average of 8.3 hours per day (minimum 4 hours and maximum 14 hours) and an average of 42 hours per week (minimum 16 hours and maximum 84 hours).

The inclusion criteria were that participants had a full- or part-time job and agreed to be highly committed to the study. No financial compensation was given. Instead, participants received personalized feedback on their levels of flow in the workplace. Before starting, the participants received consent explaining the objectives, procedures, and guarantee of the data.

Design and Procedure

The Experience Sampling Method (ESM; Csikszentmihalyi, 2002; Hektner et al., 2007; Larson & Csikszentmihalyi, 2014; Moneta, 2012) was used to collect the data. For three weeks, they answered a flow diary several times a day. We initially scheduled a total of six daily repeated assessments or registers per participant to be collected at random times. We will only consider the registers that participants completed while engaged in work-related activities.

Instrument and Measures

The flow diary was composed of five questions used in previous studies to assess flow (Ceja & Navarro, 2009; Csikszentmihalyi, 1975, 1990; Hektner et al., 2007). Each question refers to a specific variable of the flow experience. The list below indicates the variable studied, followed by the question in the flow diary.

1. Activity: ‘What activity am I performing at this moment?’
2. Perceived challenge: ‘How challenging do I find this activity?’
3. Perceived skills: ‘What is my skills level for performing this activity?’
4. Enjoyment: ‘How much do I enjoy this activity?’
5. Absorption: ‘How quickly does time pass while I’m doing this activity?’

In the first question, participants had to briefly describe what they were doing at the time they received a beep to answer the diary. This was an open question of the flow diary, and its objective was to make the participant focus on a specific activity while answering the rest of the questions. From questions two to five, the participants had to answer by placing a mark on a slide bar. This slide bar corresponded to a scale of 0-100, with 0 being the lowest value and 100 the highest value. The labels at the end of each scale differed for some of the questions. For questions 2, 3 and 4 the label was ‘A little’ and ‘A lot’, for question 5, it was ‘Time passes very slowly’ and ‘Time passes very fast’.

The flow measure was calculated by the average of the enjoyment and absorption measures. This type of measure was previously used by Ceja and Navarro (2009), but the authors also included the interest variable in the equation. In this research, we do not consider it in the flow measure because we only want to include the components of flow. Furthermore, Bricteux et al. (2017) identified interest as a moderator of the challenge-skills balance condition and not as a part of the experiential state. They demonstrated in their study that a model of two components (i.e., enjoyment and absorption) was more effective than Bakker's (2005) three flow component model (i.e., enjoyment, absorption, and interest) to evaluate flow experience.

Data Analysis

The data was obtained in the form of time series nested in each participant. Several analyses were applied to analyze the data and meet the objectives, all of them using R (2023) with the packages psych (Revelle, 2023), correlation (Makowski et al., 2022), ggplot2 (Wickham, 2016) and cusp (Grasman et al., 2009). The original database and the syntax applied for all the analysis can be found in the open repository https://osf.io/jb6w9/?view_only=dd854d09d0e3425f9722053028f2b017.

To begin, we plan to do an intra-individual analysis. For each participant, a Spearman correlation analysis was performed to study the nature of the challenge-skills relationship. The two variables can be positively correlated ("Positive relationships C-S"), negatively correlated ("Negative relationships C-S") or not significantly correlated ("Non-significant relationships C-S"). The next step was to classify the participants into three groups that correspond to the nature of the correlation mentioned above.

Once the participants were classified in one of the three groups, we began with the inter-individual analysis. In this part, we wanted to observe the influence that each type of challenge-skills relationship has on the flow experience. To compare the three groups, a multivariate analysis of variance (MANOVA) was applied considering the three groups (positive, negative, and non-significant) as independent variables and, perceived challenge, perceived skill, enjoyment, interest, absorption, and flow as dependent variables.

Finally, we performed a regression analysis to determine which of the three challenge-skills relationship groups better represents the flow experience. To test this, we divided the database according to the groups of participant's challenge-skills relationship. For each group (i.e., positive, negative, and non-significant) we ran the regression analysis (i.e., ordinary least square method), in which flow is the dependent variable and challenge and skill the independent variables. Apart from the linear regression, we also decided to test a nonlinear regression (i.e., cusp model) due to the fact there is evidence stating that this type of model explains more variance concerning flow in comparison with their linear counterparts (Ceja & Navarro, 2009). Based on previous research (e.g., Ceja & Navarro, 2012) we considered challenge as the bifurcation or splitting factor and skills as the asymmetry. In these last two modeling analyses, we handled the data as cross-sectional.

RESULTS

The final data set contained 3,640 registers from the 60 participants, representing an average of approximately 60.6 registers per participant (ranging between 19 and 151 registers). Table 1 shows the means, standard deviations, and correlation at the within-participant level of all measures of interest.

Table 1. Mean, Standard Deviation, and Within-Participant Correlations of the Measures of Interest.

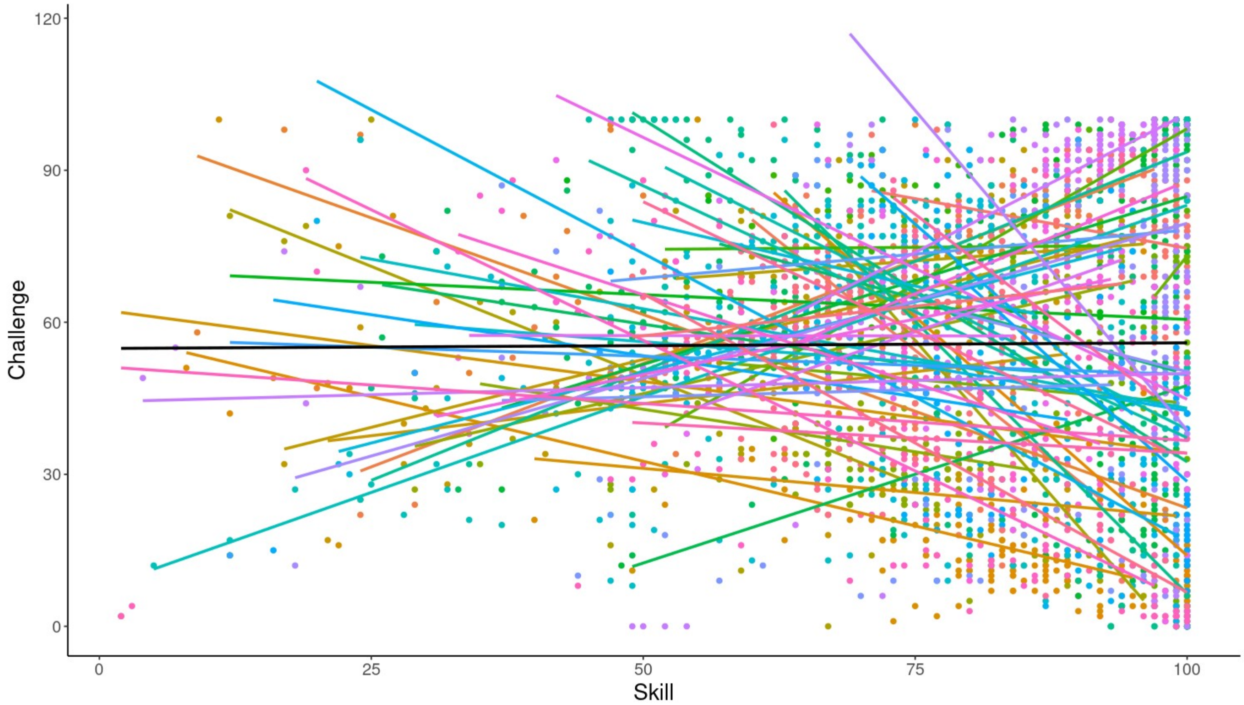
Measure	*X*	*sd*	1	2	3	4	5
1. Challenge	55.72	27.60	1				
2. Skills	80.03	17.54	.02	1			
3. Enjoyment	67.19	25.09	.43**	.36**	1		
4. Absorption	71.54	24.11	.31**	.37**	.68**	1	
5. Flow	69.36	22.59	.41**	.38**	.93**	.90**	1

Notes: N = 3640; ** p < 0.01

Skills have the highest mean value, while challenge has the lowest mean value. In general, the standard deviations are high, showing an important amount of variability of the data for each of the variables. Significant correlations were found between many variables, the highest values being those between enjoyment, absorption, and flow. As a test of construct validity, strong positive correlations were found between enjoyment, absorption and flow as the composite measure: the relationship between enjoyment and absorption appears as highly significant (r = .68; p < .01).

It is particularly interesting to pay attention to the correlation value between challenge and skills (r = .02; p = .19) because behind this non-significant value there are different realities, as we can start to see in Figure 3. In the next section, we will see in detail these differences considering the possibility of grouping the participants just considering the sign and significance of the challenge-skills relationship.

Fig. 3. Spaghetti plot of the challenge-skills relationships among the 60 participants.



Intra-Individual Analysis and Participant Classification

A non-parametric Spearman correlation analysis between challenge and skill variables was conducted for each of the 60 participants. We proceeded to classify the participants into three groups according to the nature of the challenge-skills relationship: positive (P), negative (N), and non-significant correlation (NS) considering $p < .05$. Table 2 presents the main results of this analysis. As can be observed, the majority group is the one in which there is negative significant correlation between challenge and skills (NS), comprising 45% of the cases, while the minority group is the one with a positive correlation (P) between challenge and skills, accounting for 21.6% of the cases.

Table 2. Groups of Participants Considering the Challenge-Skills Correlation Values: Main Descriptive Statistics of These Correlations Values.

Groups	N group	NS group	P group
N	27	20	13
%	45%	33.3%	21.6%
Time-series length average	62.0 registers	55.3 registers	65.9 registers
X	-.50	.00	.54
Md	-.54	-.03	.53
sd	.16	.13	.17
Range values	-.75 / -.23	-.21 / .21	.28 / .77

Inter-Individual Analysis

We were interested in studying the potential influence of the three groups of challenge-skills relationship on the flow experience. For this purpose, a MANOVA was conducted. The results showed statistical significance for group membership on the measures of flow, challenge, and skills: Wilks' lambda = .56, approx $F = 6.0$, $p < .001$ (we excluded enjoyment and absorption from this multivariate analysis to avoid multicollinearity issues with the composite flow measure). The univariate tests results showed significance for all dependent variables except for skills: Challenge [$F(2, 57) = 17.8$; $p < 0.001$], skills [$F(2, 57) = .50$, $p = .60$], enjoyment [$F(2, 57) = 7.75$; $p = 0.01$], absorption [$F(2, 57) = 3.89$; $p = 0.02$], and flow [$F(2, 57) = 6.55$; $p = 0.002$]. As these variables showed significant differences depending on the group, we observed the mean comparison with more attention (see Table 3). Overall, the group that shows higher means for all the variables is the positive correlation group, followed by the non-significant and then the negative correlation group.

As our main interest in this research lies in the flow experience, we focused on the mean differences of this measure. We observed that the positive correlation group had the highest mean (M = 76.4; sd = 13.84), followed by the non-significant correlation group (M = 70.81; sd = 12.83), and the lowest is the negative correlation group (M = 61.87; sd = 11.87). The post hoc Tukey test showed that the positively correlated group was significantly different from the negatively correlated group (mean difference = 14.53; $p < .01$) and that the mean of the negatively correlated group was significantly different from the non-significant correlation group (mean difference = 8.94; $p < 0.05$). The positively correlated group was not significantly different to the non-significantly correlated group.

Table 3. Means Comparison in Each Variable of Interest Across the Three Groups of Participants.

Measure	N group	NS group	P group	TukeyHSD contrast(1)
Challenge	44.67	56.9	72.46	N < NS < P
Skills	78.14	81.48	80.33	*ns*
Enjoyment	58.69	67.54	75.96	N < NS = P
Absorption	65.05	73.09	76.84	N = NS; NS = P; N < P
Flow	61.87	70.81	76.4	N < NS = P

Notes: N = 60; (1) Differences at p < 0.05; *ns* means no significance.

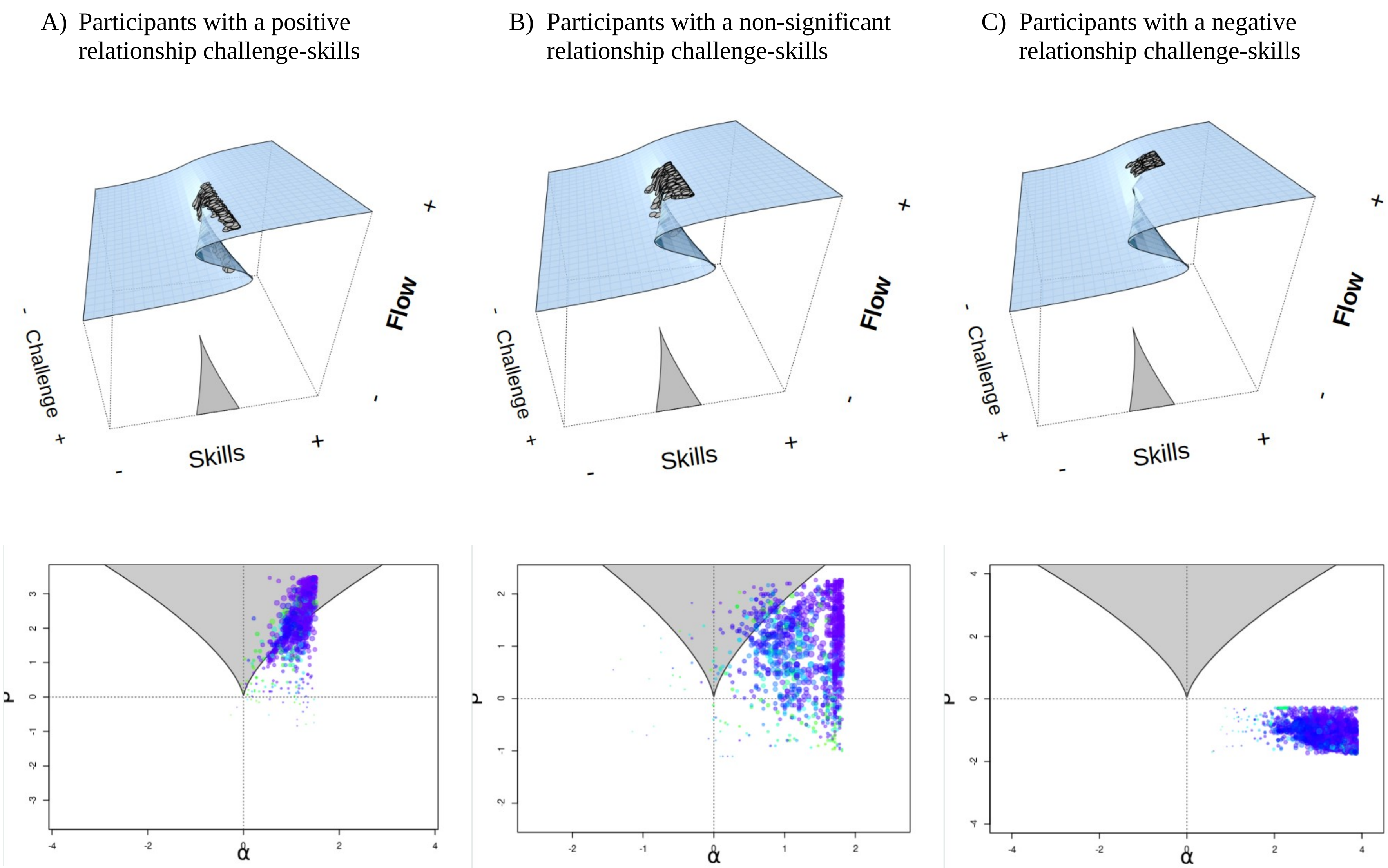
Having verified that group membership (i.e., the type of correlation between challenge and skills) is related to the values obtained in the flow experience itself, we proceeded to conduct both linear and nonlinear modeling. Specifically, we applied a linear regression model and a catastrophe cusp model, considering challenge and skills as predictor variables and the flow experience as a criterion variable. The aim was to observe which of the three types of challenge-skills interaction was able to better predict the flow experience. Table 4 shows the amount of variance for flow explained (R square values) by each of the correlation groups (P, NS, and N).

Table 4. Fit Statistics and Parameter Estimates for Linear and Cusp Models of Positive, Non-Significant and Negative Groups.

Group	Model	Parameter	Estimate	*p*	R^2	AIC	BIC
Positive	Linear	Intercept	37.47	< .001	.35	7174.93	7173.9
		Skills	.14	.06			
		Challenge	.29	.01			
		Skills*Challenge	.00	.35			
	Cusp	A Intercept	-.35	< .001	.48	1653.3	1686.44
		A Skills	.01	< .001			
		B Intercept	-1.06	< .001			
		B Challenge	.04	< .001			
		W Intercept	-2.08	< .001			
		W Flow	.04	< .001			
Non-significant	Linear	Intercept	48.87	< .001	.34	9598.43	9618.30
		Skills	.03	.66			
		Challenge	-.39	< .01			
		Skills*Challenge	.009	< .001			
	Cusp	A Intercept	-1.55	< .001	.26	2477.51	2512.57
		A Skills	.03	< .001			
		B Intercept	-1.10	< .001			
		B Challenge	.03	< .001			
		W Intercept	-1.70	< .001			
		W Flow	.03	< .001			
Negative	Linear	Intercept	55.24	< .001	.08	14893.55	14915.25
		Skills	.02	.62			
		Challenge	-.40	< .001			
		Skills*Challenge	.006	< .001			
	Cusp	A Intercept	.50	.10	.08	4512.50	4550.41
		A Skills	.03	< .001			
		B Intercept	-1.72	< .001			
		B Challenge	.01	< .001			
		W Intercept	-.35	< .001			
		W Flow	.02	< .001			

The positive and the non-significant correlation groups explained the highest amount of variance in both linear and nonlinear models. Moreover, by paying attention to the Akaike and Bayesian Information Criteria (AIC and BIC), we can observe that the lowest values are those of the positive correlation group, meaning that there is a better fit of the model for this group. Furthermore, as evident in the table's results, the nonlinear models exhibit superior goodness-of-fit indices in all groups when compared to the linear models. These differences are statistically significant ($p < .01$) in the positive correlation group. It is also highly illustrative to graphically represent the results of the three groups (Figure 4). As can be seen, it is the positive correlation group that exhibits a dispersion of points precisely at the non-linear fold in the figure. This is the reason why the cusp model performs exceptionally well in this group ($R^2 = .48$), compared to the linear modeling as well.

Fig. 4. Cusp models for the three groups of participants: 3D (first row) and 2D (second row) representations.



As an additional analysis, we also performed a direct calculation of the cusp model suggested by Guastello (see, for example, Guastello et al., 2022). The equation used for the analysis was the following:

Flow_feq_acum = b1 * z2_flow^4 + b2 * z2_flow^3 + b3 * z2_challenge* z2_flow^2 + b4 * z2_skills* z2_flow

This method produces even better results in terms of R^2 values: .80 for the positive correlation group, .51 for the non-significant correlation group, and .08 for the negative correlation group (see Table 5). Once again, particularly notable is the positive correlation group, with a highly relevant explanatory capacity of the model. The complete syntax for this new analysis in R can be seen in https://osf.io/jb6w9/?view_only=dd854d09d0e3425f9722053028f2b017

Table 5. Fit Statistics and Parameter Estimates for Cusp Models following the Direct Method.

Group	Parameter	Estimate	*SE*	*t*	*p*
Positive	b1 $Flow^4$	-.047	.000	-67.35	< .001
	b2 $Flow^3$	.326	.003	89.75	< .001
	b3 Challenge	-.007	.001	-4.76	< .001
	b4 Skills	.067	.005	11.97	< .001
	R^2 = .80				
Non-significant	b1 $Flow^4$	-.114	.001	-64.90	< .001
	b2 $Flow^3$	.592	.009	65.21	< .001
	b3 Challenge	.012	.002	6.15	< .001
	b4 Skills	.178	.007	25.22	< .001
	R^2 = .51				
Negative	b1 $Flow^4$	-.093	.001	-59.62	< .001
	b2 $Flow^3$	.505	.008	58.66	< .001
	b3 Challenge	.019	.002	8.96	< .001
	b4 Skills	.262	.007	34.48	< .001
	R^2 = .08				

DISCUSSION

This research aimed to study the universal precondition of flow, the balance of challenge and skills, to clarify if there were diverse types of challenge and skills relationships in a sample of workers and if this affected how they experience activities. More specifically, we were interested in studying whether the intra-individual differences of the challenge-skills relationships influenced the flow experience. Additionally, we also wanted to explore whether nonlinear models (i.e., cusp modeling) fit the results better in comparison with their linear counterparts. To achieve this, three research objectives were followed: first, we studied the challenge-skills relationship at a within-individual level in order to find possible differences, then we proceeded by classifying participants into three groups according to the type of relationship between these two variables; positive, negative, and non-significantly correlated groups. Finally, we applied linear and nonlinear models to determine which group was better able to predict the flow experience.

By analyzing the data from an intra-participant to an inter-participant level, we were able to obtain interesting outputs. Three main findings emerge from this research: first, the challenge-skills relationship was identified as a non-homogeneous process. Second, the types of challenge-skills relationships have different effects on the flow experience. We will suggest that the positive correlation group represents Csikszentmihalyi's flow theory, due to the fact that in their channel model, a positive relationship between challenge and skills is a prerequisite for the emergence of flow. This is precisely the group that has achieved the best results in terms of goodness of fit indices in the various models (R^2 = .48 and .80, following the two methods of calculus used in the nonlinear modeling). Furthermore, the nonlinear modeling, using the catastrophe cusp model, has clearly outperformed linear modeling.

The first main finding is that the challenge-skills relationship is non-homogeneous across the sample. This would support research that states that flow is a nonergodic process (Ceja & Navarro, 2017), since it demonstrates that at least one of the two ergodicity conditions, i.e., homogeneity, is not followed. Homogeneity means that a population follows the same statistical model, thus behaves in the same way; in this case, the results clearly show three different patterns of behavior. Taking this into account and considering flow is the focus of this research, we based our inter-individual analysis on these intra-individual variations. This is considered an appropriate way of shifting between these two levels of analysis (Ceja & Navarro, 2017; Molenaar & Campbell, 2009). More specifically, for the intra-individual level, we analyzed the correlation between challenge and skill for each one of the participants, which then allowed us to classify them in three groups and observe their possible effect on the flow experience. The relationship between challenge and skills was much more complex than expected.

As stated previously, the sample was not homogeneous; instead, there was great variability regarding the relation between challenge and skill between participants. Some individuals presented positive correlations, others negative correlations, while others did not show significant correlations. Of course, this can also be influenced by the fact that the sample was composed by an heterogeneous group of participants in terms of ages and work tasks. Although the sample consisted of participants with different types of challenge-skills interaction, we found certain tendencies with respect to the number of participants in each group. In fact, the negative significant correlation group was the one that contained the highest number of participants while the positive correlation group contained the lowest number of participants (see Table 2).

The second main finding concerns the effect that the different challenge-skills relationships have on flow. The three groups represent separate ways in which challenge and skills interact, and the results show that each one seems to have a different impact on the flow experience. This can be seen simply by observing the various mean values (in Table 3), not only for flow, but also for the rest of the variables (except for skills). We can observe that globally, the highest mean values correspond to the positive correlation group, followed by the non-significant correlation group, and the lowest belong to the negative correlation group.

As the flow at work is higher for the positive group than for the other two, we assume that the underlying mechanism behind this behavior pattern corresponds to Csikszentmihalyi's flow theory, more specifically his channel model. This model states that when the level of challenge and skills match either at a low or high level, the individual will more likely engage in a flow state. If challenge and skills do not match, the person may experience boredom or anxiety instead. We can speculate, based on the channel model, that individuals showing a positive challenge-skills relationship in a work context are more likely to experience flow than participants in the other two groups.

We were able to confirm this hypothesis by performing a regression analysis and a cusp modeling. The results showed that of the three, the positive correlation group was the best fit (see Tables 4-5 and Figure 4). This means that challenge and skill are good predictors of flow experience when they correlate in a positive way. However, we need to be cautious when claiming causality because previous research has stated that flow experience does not emerge exclusively from a challenge-skills balance. Flow scholars indicate that situational and personal moderators can boost or decrease the effect that the challenge-skills balance condition has on the engagement of the flow experience (Bricteux et al., 2017; Schiepe-Tiska & Engeser, 2012; Keller and Blomman, 2008).

The regression and cusp analysis also gave us interesting input on the non-significant correlation group. The coefficient of determination of this group was significant (see Tables 4-5). However, the indicators of the information criterion indicators revealed that the data did not adjust well to this model (see Figure 4). For this reason, in this group with non-significant correlation, there are hardly any points that appear in the fold of the model indicative of these abrupt changes. A similar situation occurs in the case of the negative correlation group: in these cases, no points appear within the fold of the model, which is reflected in the low fit values obtained by the nonlinear model in this group.

To better understand these results, we think that a third variable, such as the type of activity (e.g., intrinsic or extrinsic activity), would need to be added. This information would help us better understand the challenge-skills interplay of the individuals in this group. Unfortunately, this analysis cannot be carried out because we do not have the necessary resources to determine the nature of the activities done by participants. In our research, we were able to suggest a theory behind the positive correlation group, but none that could explain the underlying mechanisms of the challenge-skills relationship of the other two groups.

The third main finding of this paper concerns the outperform of the nonlinear modeling with respect to their linear counterparts. It is particularly interesting that this occurred more clearly in the group with a positive correlation between challenge and skills, a group that represents the original theory proposed by Csikszentmihalyi. In other words, when challenge and skills are positively related (e.g., higher challenge corresponds to higher skills), it is precisely when the experience of flow in the workplace emerges non-linearly, as a qualitative leap. Nonlinear modeling, through the catastrophe cusp model, captures this discontinuity in the emergence of flow very effectively. Due to the presence of such discontinuity, which linear models are unable to capture, nonlinear modeling yields superior goodness-of-fit indices. This result is not new, as there was already evidence of it in the works of Guastello et al. (1999), Ceja and Navarro (2009, 2011, 2012). However, it is now evident that this is especially the case when we consider a group of participants in which the condition of a positive relationship between challenge and skills, as originally proposed by the theory, is met.

Limitations and Future Research Lines

This research has certain limitations, the flow measure used is the first. Our research based the flow measurement on two –enjoyment and absorption– of Bakker's three most common elements of flow, which are interest, enjoyment, and absorption. Instead, we could evaluate the possibility of measuring this variable based on the six components of the flow experience discussed by Csikszentmihalyi. Consequently, in the flow diary we could replace the three items based on Bakker's theory for six items based on Csikszentmihalyi's theory: merging action and awareness, sense of control, autotelic experience, reduced self-consciousness, transformation of time. This would be an important recommendation for future research.

Another methodological limitation is the sample itself, because it is composed only of highly motivated and committed participants. The length and nature of the tasks of this research, completing the flow diary several times a day for several days, can be very demanding. Poorly motivated individuals may refuse to participate, and if they decide to participate, they may be prone to abandon the study in the first days of the application. It would be interesting to have a sample with participants with various levels of motivation and who experience more varied levels of flow.

Finally, it should be noted that once participants are grouped based on their correlation pattern, those data, which include multilevel and longitudinal information (i.e., registers nested within participants), have been considered as cross-sectional. It is true that there are multilevel analyses available to properly handle such data, but to our knowledge, a nonlinear equivalent and a catastrophe model have not yet been developed. The development of such models would undoubtedly be of great interest to the community.

Practical Implications

Important practical implications result from this research. We would like to focus on two things that we consider the most important. First, results confirm the fact that flow is an important experience at work. This is very promising for organizational psychologists and human resources professionals because it gives these professionals the opportunity to contribute to employees' well-being and productivity. Second, results also highlight the existence of intra-individual variations. When designing tasks and activities at work that can promote flow experience, employers should acknowledge the fact that the challenge-skills relationship will not be the same for all employees. The various ways in which these two variables relate to each other represent different patterns of behavior, and certain patterns might be more prone to experiencing flow than others. Therefore, activities must be adapted according to the employee's behavior pattern in terms of challenge and skills. For example, as we claim that individuals with a positive correlation pattern are more prone to experiencing flow than the other two patterns, when designing activities for this group, one should take flow conditions into account to help these individuals engage more easily in the optimal experience. When designing activities for the other two groups (negative and non-significant correlation), it would not be that relevant to consider flow conditions, because there might be other theories underlying these patterns of behavior. To propose some guidelines to recognize patterns of behavior and to suggest ways to adapt activities to each pattern of behavior, more research on the topic should be done.

Conclusion

This study has confirmed that not all participants experience the challenge-skills relationship in the same way. By classifying participants into distinct groups based on this challenge-skills relationship, we have found that when there is a positive relationship between challenge and skills, the occurrence of the flow experience is more likely to happen, as originally proposed in Csikszentmihalyi's theory. In the other groups of participants (with no significant relationship between challenge and skills or even a negative relationship), the experience of flow is also possible, but statistically less likely. Furthermore, in the group of participants who "follow the theory," nonlinear modeling also yields particularly suitable results, once again supporting Csikszentmihalyi's notion of flow as a discontinuous phenomenon with sudden onset. In conclusion, all these results emphasize the importance of continuing to study flow experiences as a nonergodic phenomenon (i.e., not homogeneous among participants) and as a nonlinear phenomenon (i.e., with disproportionate effects between causes and outcomes). We hope that colleagues interested in this intense motivational experience will heed this recommendation, as it can contribute to advancing the boundaries of our current knowledge of flow.

ACKNOWLEDGMENT

The authors thank Professors Sara Giovagnoli from the University of Bologna, Italy, and Leonor Cardoso from the University of Coimbra, Portugal, for their valuable suggestions for improving this research. We also extend our gratitude to the master students Julia Pöppelbaum and Karen Paredes, who initially worked with some of the data considered in this study.

Funding: JN received the financial support from the Spanish Ministry of Science and Innovation (PID2020-120148GB-I00 / AEI / 10.13039/501100011033).

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