

# Psychological and genetic characteristics and strategies of students' digital behavior in the context of the formation of the digital ecosystem

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**Abstract.** The objective of our study was to investigate the attributes of the cognitive, affective, and value-semantic domains, along with genetic predictors, that influence the digital behavior of young individuals. The study involved 91 people (33 males and 58 females) aged 18 to 25 years (Russian Federation). In order to measure digital behavior the questioner "Strategies of informational behavior" (SIP) was used. In order to study the cognitive, affective and value-semantic characteristics, the following tests were used: the Test of Life-Sense Orientations, the Buss-Durkee Hostility Inventory, the Gottschaldt Figures Test (a measure of embedded figures perception), and a method for assessing thinking style. Genotyping was used to examine polymorphisms of the COMT, DRD2, and BDNF genes. Our findings demonstrate statistically significant associations between constructive and destructive digital behaviors and specific facets of the participants' cognitive, affective, and value-semantic domains, as well as distinct aspects of dopaminergic system functionality.

## 1 Introduction

The widespread integration of Internet technologies into everyday life has a relatively short yet remarkably intricate history. Consequently, the study of psychological aspects related to Internet activity and its psychobiological foundations is a relatively new field. It is evident in today's context that individuals' orientation within the expansive digital realm encounters obstacles not only due to the sheer volume of content and "information noise," but also due to the peculiarities of its organization. Contemporary algorithms employed by social networks contribute to the fragmentation of the digital landscape. Certainly, there exist common elements within the information landscape, such as entertaining content and widely "promoted" events. However, even individuals who share the same social circles and engage in offline interactions (e.g., colleagues, friends, relatives) are exposed to distinct content within their online spheres. In such a scenario, to access truly diverse information, active searching becomes imperative. Failing this, algorithms will persistently "recommend" increasingly specialized content tailored to an individual's perceived "interests," further

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isolating them from the multifaceted reality. So, the individual's modes of interaction with the digital environment will play a pivotal role in determining the information they encounter and select on a daily basis.

In scientific literature, Internet activity is termed as "Internet use," "problematic Internet use," "cyber behavior," and more recently, "informational" or "digital behavior" [1, 2, 3, 4].

Psychological research mainly surrounds the differences between "digital behavior" and offline behavior [5]. Online forms of behavior encompass proficiency in technology, navigating digital spaces, assessing and using information effectively, sharing, promoting and managing online content. These behaviors, and offline ones, are shaped by cognitive, affective, motivational, and value-semantic features, influencing content perception and creation [1].

Behavioral genetics has linked specific gene polymorphisms to various behaviors and traits, as well as skills development, emotional responses, and Internet addiction [6, 7, 8]. For example, the COMT gene's A (Met) allele is associated with increased dopamine levels, stress vulnerability, and effective information processing. Carriers of the G (Val) allele have lower dopamine levels but exhibit stress resistance and improved executive functioning [9]. Studies of addiction to computer and/or online gaming have shown significant differences in the representation of alleles of the DRD2 dopamine D2 receptor (DRD2 Taq1A1) and Val158Met COMT gene alleles in the adolescent addicts compared with the control group [10].

The BDNF gene, encoding brain-derived neurotrophic factor, has been linked to generalized anxiety disorder [11] and mood disorders [12]. Studies have shown associations between the Met allele of the BDNF and COMT genes and negative emotional dispositions, anticipatory anxiety, cognitive deficits, and heightened attention-switching abilities [13, 14, 15, 16, 17, 18, 19].

In summary, despite increasing interest, a comprehensive theory on the psychological and genetic factors shaping digital behavior remains elusive. Our study aims to explore the cognitive, affective, and genetic aspects influencing digital behavior strategies in young individuals.

## **2 Methods**

A total of 91 participants (33 males, 58 females) between the ages of 18 and 25 years, all residing in the Russian Federation, were involved in this study. Data collection occurred through in-person interviews using structured questionnaires. All participants provided informed consent, were briefed on the study's objectives, and informed about the intended use and publication of the results.

To investigate digital behavior, we utilized the "Strategies of Informational Behavior" questionnaire [1], comprising 65 statements related to diverse Internet activities.

To assess cognitive, affective, and value-semantic characteristics, we administered the following psychological tests: Life-Meaning Orientation Test (D.A. Leont'ev, 1988) to gauge the overall level of life meaningfulness and explore life-meaning orientations; Buss-Durkee Hostility Inventory (A.A. Hvan, YU.A. Zajceva, YU.A. Kuznecova, 2005) to measure aggression levels, including behavioral and emotional aspects; Embedded Figures Test (Gottschaldt figures test; G. Uitkin, 1954) to examine individual differences in cognitive activity, specifically field dependence-field independence; Method for Measuring Thinking Style [20] to characterize individual thinking styles.

For molecular genetic analysis, we considered the genotypes of the COMT, DRD2, and BDNF genes within the dopaminergic system. These genes were selected based on documented associations in the literature with skill development, behavior regulation,

emotional responses (including aggressiveness and hostility), and the severity of Internet addiction.

Buccal epithelium samples were collected from participants immediately following psychological diagnostics, primarily in the morning, using disposable cotton swabs. These swabs were then placed in a transport medium and sent to a laboratory for genomic DNA isolation. DNA analysis was conducted using allele-specific polymerase chain reaction (PCR) with real-time detection for polymorphisms rs4860 of the COMT gene, rs6265 of the BDNF gene, and rs1800497 of the DRD2 gene. Genotyping took place at the Laboratory of Medical Genetics of the Rostov State Medical University of the Ministry of Health of Russia, Rostov-on-Don.

Data analysis involved standard statistical methods and the statistical data processing software "R" [21]. We employed the "leaps" package for regression model selection and the "sjPlot" package for constructing data tables.

The data analysis encompassed comparative analysis, multiple regression analysis, and regression model selection using all-subsets regression. Multiple regression analysis was chosen for its ability to examine the relationship between a quantitative dependent variable and multiple independent variables (both quantitative and qualitative). It allows for identifying which independent variables contribute the most to the variability of the dependent variable and selecting the most suitable models. Preliminary data checks verified the assumptions underlying multiple regression analysis, affirming the method's appropriateness for our study.

### 3 Results

In the initial stage, we employed principal component analysis to identify three components (RC1, RC2, and RC3) associated with digital behavior indicators [22]. This analysis allowed us to categorize various digital behavior strategies into broader constructs: constructive and destructive forms. Specifically,

*Active Constructive:* Participants actively utilized the Internet for recreational, communicative, and pragmatic purposes.

*Passive Constructive:* Users predominantly consumed online content as an information source.

*Active Destructive:* Participants employed the Internet to express aggressive or sexual impulses.

*Passive Destructive:* Users engaged with content featuring extremist, religious, or other elements, without creating their own.

These components (forms) served as dependent variables in the regression analysis, while psychodiagnostic data and subject genotypes were used as independent variables. We exclusively utilized the overall life meaningfulness indicator from the LSS method due to the strong intercorrelations among its scales, which could confound regression analysis.

Complete regression models were obtained encompassing all potential predictors. To handle the nominal variables representing genotypes, we created sets of dummy variables. The scheme involved selecting one genotype as the reference level (initial level) and establishing auxiliary variables for the remaining two genotypes. For instance, the A/A genotype served as the reference level for the COMT gene, and auxiliary variables were generated for the G/A and G/G genotypes, taking on a value of 1 if a subject possessed the respective genotype and 0 otherwise. Zero values for both auxiliary variables corresponded to the A/A genotype. The regression coefficient associated with an auxiliary variable represented the difference in dependent variable values between subjects with the reference level and those with the corresponding genotype, holding all other variables constant.

Subsequently, to simplify models and retain only significant variables, we reduced the number of predictors. We employed the all subsets regression method, as it considers all possible models, unlike the commonly used stepwise model selection, which may not guarantee the identification of the optimal model. We employed the adjusted multiple determination coefficient (corrected  $R^2$ ), accounting for model parameter count, as the criterion for selecting the best model.

Below is a description and comparison of the full and truncated models for each of the components. According to J. Cohen [23], a multiple determination coefficient ranging from 0.13 to 0.25 is moderate, and 0.26 and above is substantial. The removal of predictors in all cases led to an improvement in the characteristics of the models: a decrease in the standard error of residuals, an increase in the values of the multiple determination coefficient (CMD) and Fisher's F-statistic, and an improvement in its statistical significance.

**Table 1.** Full and truncated regression models for RC1 - active constructive form of digital behavior

Predictors	Full model			Truncated model		
	Coeff.	t	p-level	Coeff.	t	p-level
(Intercept)	0.22	0.22	0.823	0.21	0.31	0.754
BDNF (TG / G)	0.02	0.09	0.927			
COMT (TG / A)	-0.17	-0.41	0.680			
COMT (TG / G)	0.01	0.04	0.968			
DRD2 (TC / T)	-0.34	-1.37	0.176	-0.40	-1.85	0.068
DRD2 (TT / T)	0.88	1.57	0.122	0.75	1.55	0.126
Proactive thinking style	-0.02	-0.46	0.649			
Critical thinking style	-0.09	-2.60	<b>0.011</b>	-0.07	-2.55	<b>0.013</b>
Management thinking style	0.03	0.90	0.372			
Practical thinking style	0.01	0.26	0.796			
General indicator of the meaningfulness of life	0.00	0.18	0.856			
Field dependence-field independence	0.06	1.11	0.271	0.07	1.31	0.195
Physical aggression	-0.11	-2.07	<b>0.042</b>	-0.10	-2.09	<b>0.040</b>
Verbal aggression	0.15	2.77	<b>0.007</b>	0.15	3.15	<b>0.002</b>
Indirect aggression	-0.02	-0.36	0.721			

Negativism	0.12	2.60	<b>0.011</b>	0.11	2.79	<b>0.007</b>
Irritability	0.01	0.12	0.906			
Suspicion	-0.13	-2.24	<b>0.028</b>	-0.09	-2.36	<b>0.021</b>
Resentment	0.08	0.98	0.330			
Autoaggression (guilt)	0.13	2.11	<b>0.038</b>	0.16	3.02	<b>0.003</b>
Observations	91			91		
R <sup>2</sup> / R <sup>2</sup> adjusted	0.321 / 0.139			0.297 / 0.219		

When discussing the truncated RC1 model, we note the following observations (Table 1): The model's standard error of residuals is 0.9099, indicating the degree of dispersion of model residuals relative to the actual regression line. The adjusted coefficient of multiple determination (CMD) stands at 0.2188, denoting the proportion of the dependent variable's variance explained by this regression model. Fisher's F-test value and its significance assess how well the model as a whole fits the experimental data, testing the null hypothesis that all model coefficients are zero [24].

Table 1 reveals that predictors such as "Critical thinking style," "Physical aggression," "Verbal aggression," "Negativism," "Suspicion," and "Autoaggression" exhibit significance at the  $p < 0.05$  level. This significance allows us to reject the null hypothesis that these coefficients are zero, indicating a connection between these predictors and the dependent variable RC1. We employed the t-criterion for this assessment, with corresponding values provided in the table. The coefficients indicate how the dependent variable changes when the predictor's value increases by 1, while the values of other predictors remain constant [25].

Specifically, we find a direct relationship between RC1 and the scales of "Verbal aggression," "Negativism," and "Autoaggression," indicating that a preference for active constructive digital behavior is reliably associated with the active expression of feelings (including negative ones), without an intention to cause harm. Conversely, a decrease in critical thinking, along with the scales of "Physical aggression" and "Suspicion," leads to a decrease in RC1 values. In essence, users who favor the active constructive form of digital behavior tend to express their emotions actively, even if not necessarily harmful, while showing a diminished inclination to evaluate or verify information, personalities, or the activities of others.

We also note the relatively large coefficients linked to the presence of DRD2 C/T and T/T genotypes in subjects (-0.40 and 0.75, respectively). However, the limited statistical significance of these predictors prevents us from confidently establishing a relationship between these genotypes and RC1 levels. Further research could be needed to explore this aspect in more depth.

**Table 2.** Full and truncated regression models for RC2 - active destructive form of digital behavior

Predictors	Full model			Truncated model		
	Coeff.	t	p-level	Coeff.	t	p-level
(Intercept)	1.41	1.49	0.141	1.14	1.64	0.105
BDNF (TG / G)	0.10	0.47	0.637			
COMT (TG / A)	0.36	0.91	0.365			
COMT (TG / G)	0.18	0.75	0.453			
DRD2 (TC / T)	-0.09	-0.37	0.710	-0.06	-0.33	0.740
DRD2 (TT / T)	1.75	3.26	<b>0.002</b>	1.70	3.65	<b>&lt;0.001</b>
Proactive thinking style	-0.02	-0.74	0.459			
Critical thinking style	0.01	0.21	0.838			
Management thinking style	-0.03	-0.90	0.370	-0.04	-1.77	0.081
Practical thinking style	-0.03	-1.01	0.314	-0.02	-1.03	0.304
General indicator of the meaningfulness of life	0.00	0.00	0.998			
Field dependence-field independence	0.11	2.05	<b>0.044</b>	0.10	2.10	<b>0.039</b>
Physical aggression	0.13	2.59	<b>0.012</b>	0.10	2.45	<b>0.017</b>
Verbal aggression	-0.03	-0.53	0.601			
Indirect aggression	-0.01	-0.24	0.810			
Negativism	-0.03	-0.72	0.476			
Irritability	0.00	0.02	0.987			
Suspicion	0.08	1.49	0.140	0.07	1.59	0.115
Resentment	-0.15	-2.08	<b>0.041</b>	-0.14	-2.24	<b>0.028</b>
Autoaggression (guilt)	-0.07	-1.20	0.233	-0.07	-1.30	0.197
Observations	91			91		
R <sup>2</sup> / R <sup>2</sup> adjusted	0.367 / 0.198			0.344 / 0.271		

In relation to RC2 or an active destructive form of digital behavior, the predictors of the presence of the DRD2 T / T genotype, "Field dependence-field independence", "Physical aggression" and "Sensitivity" (Table 2) are significant at the level of  $p \leq 0.05$ . A direct relationship was found with all indicators, except for the last one. That is, the preference given behaviors are more pronounced among users of carriers of the T / T polymorphism of the DRD2 gene is reliably associated with the ability to resist the influence of background signs, a tendency to detail, less disposition to social contacts, active behavioral manifestations of aggression. Of interest is the nature of the relationship with the "Touchiness" indicator. This form of behavior implies the use of the Internet for the realization of aggressive impulses and / or sexual needs, while the feedback from the severity of the resentment indicates that such behavior has no real revenge or hatred. That is, such aggression is not directed at any specific object, it is not caused by resentment or a desire for "revenge". Most likely in this case, destructive manifestations either do not have a differentiated personal motivation and act only as a fixed pattern, or this means that aggression on the part of the subject in some way justifies the aggression of other people and does not cause a strong negative emotional reaction.

**Table 3.** Full and truncated regression models for RC3 - passive constructive form of digital behavior

Predictors	Full model			Truncated model		
	Coeff.	t	p-level	Coeff.	t	p-level
(Intercept)	-2.00	-2.02	<b>0.047</b>	-1.63	-2.09	<b>0.040</b>
BDNF (TG / G)	0.23	1.07	0.288	0.26	1.37	0.175
COMT (TG / A)	-0.03	-0.07	0.941			
COMT (TG / G)	0.16	0.66	0.514			
DRD2 (TC / T)	0.11	0.43	0.668			
DRD2 (TT / T)	0.34	0.61	0.542			
Proactive thinking style	0.06	1.68	0.097	0.05	1.70	0.093
Critical thinking style	0.00	0.13	0.894			
Management thinking style	0.06	1.83	0.072	0.05	1.99	<b>0.050</b>
Practical thinking style	0.01	0.18	0.857			
General indicator of the meaningfulness of life	-0.01	-2.23	<b>0.029</b>	-0.01	-2.51	<b>0.014</b>
Field dependence-field independence	0.04	0.77	0.445			

Physical aggression	-0.01	-0.18	0.857			
Verbal aggression	-0.01	-0.18	0.856			
Indirect aggression	0.10	1.72	0.090	0.09	2.02	<b>0.046</b>
Negativism	-0.05	-1.05	0.299			
Irritability	0.01	0.08	0.936			
Suspicion	0.05	0.88	0.384			
Resentment	-0.06	-0.71	0.477			
Autoaggression (guilt)	0.04	0.72	0.475	0.05	1.30	0.196
Observations	91			91		
R <sup>2</sup> / R <sup>2</sup> adjusted	0.270 / 0.074			0.234 / 0.179		

A passive constructive form of digital behavior (RC3) has significant predictors in the cognitive and emotional-personal spheres (Table 3). With the scales "Managerial style of thinking" and "Indirect aggression" RC3 found a direct relationship. One can also note a direct connection at the level of tendencies with the severity of the proactive type of thinking. Feedback was noted with the general indicator of the meaningfulness of life. Considering that the meaningfulness of life reflects the level of formation of the semantic sphere, the orientation of the future and satisfaction with the past and the present, the data indicate a low level of meaningfulness in the life of users who prefer a passive form of digital behavior. Perhaps it is the lack of a clear perspective or low satisfaction with current events that leads to a decrease in the desire for self-realization in the network and demotivates the production of content. The preference for this form of behavior is associated with focusing on a task or a specific function, communication in the network is also mainly "forced" or pragmatic in nature. Indirect aggression can manifest itself both in the very absence of behavior and in the rare demonstration of undifferentiated aggressive tendencies.

## 4 Discussion

In the presented study, psychological and genetic characteristics associated with various forms of digital behavior of young people were studied. The relationships between various forms of digital behavior with the features of the cognitive, affective, value-semantic sphere and polymorphisms of the catechol-O-methyltransferase (COMT) gene, the gene for the brain neurotrophic factor BDNF, and the DRD2 gene of the dopamine receptor D2 have been studied.

The connections identified between digital behavior, thinking styles, and the field dependence-field independence parameter are consistent with contemporary research on the link between cognitive aspects and online behavior, including constructive and destructive tendencies [26, 27, 28, 29].

Recent research has also delved into the personal determinants of online behavior. Studies have shown that both individual characteristics and elements of the value-semantic sphere are linked to problematic Internet use, online presence parameters, communication patterns, and self-presentation [30, 2, 31, 32].



Regarding the association with DRD2 gene polymorphisms, it is noteworthy that statistically significant effects were observed primarily in relation to the active "destructive" digital behavior form. This connection with problematic Internet use and aggressive behavior aligns with extensive psychogenetic research [33, 34, 35, 10]. The lack of significant relationships for the other two behavior forms can be attributed to sample characteristics, including the small size of some groups with rare allele combinations in the COMT, BDNF, and DRD2 genes, rendering them unsuitable for analysis.

In summary, our findings contribute to a deeper understanding of the psychological mechanisms underpinning digital behavior strategies [36] and shed light on their biological determinants. The results not only align with contemporary knowledge about the role of these genes in behavior but also provide unique insights into the interplay between genetics and digital behavior.

## 5 Conclusion

Based on our findings, we draw the following conclusions:

1. Various forms of digital behavior are significantly linked to specific cognitive and affective characteristics of users, their values and meanings.
2. Functioning of the dopaminergic system plays a notable role in shaping these behaviors.
3. Users who prefer an active constructive digital behavior tend to express their emotions actively, including negative ones. However, this behavior is not rooted in genuine intent to harm. Interestingly, it is associated with reduced critical thinking and a reduced inclination to evaluate or verify information, identities, or activities of others.
4. The use of the Internet to express aggressive impulses or fulfill sexual needs is more prevalent among carriers of the T/T polymorphism of the DRD2 gene. This behavior is associated with resistance to external influences, attention to detail, reduced inclination for social interactions, and active behavioral manifestations of aggression. It is important to note that this behavior is not driven by genuine vindictiveness or hatred.
5. Preferring passive constructive digital behavior is associated with decreased levels of life meaningfulness, a narrow focus on specific functions, and displays of undifferentiated aggressive tendencies.

The prospect of further research is seen in expanding the sample in order to cover a larger number of rare combinations of polymorphisms of the studied genes, as well as increasing the number of candidate genes in molecular genetic analysis. In addition, it seems promising to include in the subject of research the features of self-regulation, including the cognitive regulation of emotions.

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