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THE INFLUENCE OF FINANCIAL SATISFACTION, GENDER, AND LEVEL OF EDUCATION OF YOUNG PEOPLE ON PRESENT AND FUTURE ORIENTATION: AN ANALYSIS IN THE CONTEXT OF THE THEORY OF AUTHENTICITY AND SINGULARITY

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ABSTRACT

The article analyses the orientation towards the present and the future among two main groups: high school students and university students. Through data analysis and interpretation, the work focuses on understanding how time orientation plays a role in the theory of authenticity or singularity. Results have shown significant differences between high school students and university students, where university students exhibit a greater focus on the future, and high school students on the present. However, gender and satisfaction with financial situations were not found to be statistically significant for orientation towards the future or the present. In light of the theory of authenticity, the results suggest that time orientation and authenticity are not as closely related to gender and financial status as they are to the educational stage. We can conclude that high school students base their authenticity and singularity more on a hedonistic life centred on the present moment. The article rises questions about how different life aspects, such as educational level, can influence this dynamic and points to the need for further research.

KEY WORDS

orientation towards the present, orientation towards the future, authenticity, educational level, financial satisfaction

CLASSIFICATION

JEL: D91, I21, Z13

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INTRODUCTION

One of the challenges facing young people is the issue of planning for the future. The answer to the question of why lies in the present, which brings with it challenges in employment, housing, financing education, taking care of the family, as well as dreaming of shaping one's own future. The future, as such, is uncertain and represents a significant segment in the lives of all of us, but especially young people who are in the process of obtaining an education and choosing careers that will serve them in achieving financial (in)security. Young people, therefore, have to meet societal expectations of responsibly and effectively assuming lasting social roles, as well as their own expectations of how they will live and function in a given society in a way that will make them successful and satisfied members of that society [1; p.11].

The relationship between financial satisfaction and future planning can be analysed through the lens of theories of authenticity or singularity and present-oriented hedonism. In contemporary society, the heightened emphasis on authenticity, singularity, and orientation towards present hedonism has become pervasive, especially among young people who are susceptible to these trends due to their age, social and economic circumstances, and education. The question of how young people shape their life paths, aspirations, and identities in the context of these cultural and social trends becomes crucial. Concepts of authenticity and singularity in the modern context point to personal development, originality, uniqueness, and the pursuit of personal expression. On the other hand, present-oriented hedonism refers to a focus on immediate pleasure, often without consideration of long-term consequences. In Croatia, where changes in social dynamics and culture are also evident, there is a lack of comprehensive research focusing on young people and their relationship to these phenomena. It is necessary to explore whether there is a clear connection between an orientation towards present hedonism and the striving for authenticity or singularity among young people in Croatia, and how this orientation manifests in various aspects of their lives, such as education, financial situation, gender, or life choices.

Therefore, this study aims to examine the extent to which young people in Croatia focus their behavior on the present and to analyse whether it can be said that young people realize their authenticity and singularity based on behavior that is focused on the present. The study will particularly consider the relationship of young people to present hedonism and the consideration of the long-term consequences of their current actions, taking into account their satisfaction with their financial situation, gender, and the type of education they are currently pursuing (high school or higher education institution).

The purpose of the study is to explore to what extent young people in Croatia show an orientation towards present hedonism or the consideration of long-term consequences of their current behaviour, and to analyse how this focus is related to tendencies towards authenticity or singularity in their life choices. Additionally, the study seeks to explore whether there is a difference in considering the long-term consequences of current behavior based on financial satisfaction among young people and to compare how the orientation towards present hedonism and considering the long-term consequences of decisions manifest among high school students and college students, and to explore if there is a difference between them. Finally, the study aims to explore whether there is a difference in taking into account the long-term consequences of decisions among young people based on gender.

Given the existing research gap and the objectives of the study, the following research questions have been developed:

1) Are young people in Croatia more oriented towards present hedonism or the consideration of long-term consequences?
2) How is the focus of young people on the present and future related to tendencies towards authenticity or singularity in their life choices?
3) Is there a difference in the focus of young people on the present and future based on their satisfaction with their financial situation, gender, and type of education?

LITERATURE REVIEW AND PREVIOUS RESEARCH

FINANCIAL SATISFACTION

When considering the domain of *Personal Well-being*, it encompasses the overall life experience, satisfaction in various areas of life, trust in others and in institutions, and social support (having someone to rely on in case of need) [2]. If we were to specify the satisfaction in various life domains, it would include the financial situation, housing, work, commute time, living environment, etc. [2]. Financial satisfaction is defined as an internal feeling of well-being related to the finances at one's disposal [3]. The results of Eurostat's 2018 survey showed that Denmark is the most satisfied country in Europe regarding financial situation, followed by Sweden, Norway, and Finland. In contrast, Bulgaria is the least satisfied, followed by Serbia, Albania, and Kosovo. However, looking at other parameters like satisfaction with personal relationships, financial satisfaction does not align but diverges. As for Croatia, 8,1 % of respondents are very satisfied with their financial situation, 36.5% are satisfied, while 55,4 % are not satisfied at all in the total population.

Financial satisfaction has a positive impact not only on financial success [4] and making financial decisions [5] but also on overall life satisfaction [6, 7]. Financial satisfaction is primarily determined by financial capability [8], or the consumer's ability to perform a range of different financial activities for the purpose of achieving personal financial well-being [9] and, consequently, overall personal well-being [10]. Also, positive financial behaviour [11, 12] has a significant positive impact on financial satisfaction, manifested through financial activities such as budget management, tracking expenses, timely bill payment, and regular savings [13]. Furthermore, studies have shown that planning tendency has a significant positive impact on financial satisfaction as well as general well-being [14-16], and culture, which affects individuals, can explain differences in financial satisfaction at the national level [8]. Finally, a higher tolerance for risk and saving for emergencies have a positive impact on financial satisfaction, while on the other hand, significant negative impact comes from excessive spending and having debts [17].

As for gender, men have higher financial satisfaction, confirmed by numerous studies [18-20], especially those who have rational attitudes about finances, track their own expenses, and are capable of evaluating their own financial management [21]. In the context of age, financial satisfaction increases with age due to income growth and debt reduction, but changes in family structure that may affect changes in financial satisfaction at different ages should also be considered [22]. On the other hand, Fan and Babiarz [23] confirmed that financial satisfaction decreases after reaching its peak at a young age, while Owusu [24] confirmed that financial satisfaction does not depend on age. Considering the financial satisfaction of young people in Croatia, 12,76 % have stated that they are very satisfied with their financial situation, 46,22 % are satisfied, and 41,14 % are not satisfied at all [2]. This indicates that young people are more satisfied with their financial situation compared to the total population. The most significant predictor of financial satisfaction among young people is perceived behavioural control, or individual perception of one's control over the situation [25]. Also, according to Cao and Liu [26], the most significant influence on the financial satisfaction of young people is their

choice of sources of financial information, influenced by four factors of financial behaviour: impulse control, financial planning, financial motivation, and financial organisation.

PLANNING THE FUTURE

There are many ways to approach the future. Education, as a means of shaping the future of the youth, represents a significant life tool. However, even though today's generation is relatively more pessimistic about the individual benefits of education compared to the young population of 1999, it would be wrong to conclude that education and learning have become unattractive to today's Croatian youth [27; p.97]. According to research by Spajić Vrkaš and Potočnik [27], statistically significantly more students from rural areas chose schools they were interested in, compared to those from Zagreb and regional centres, where school choice was primarily dictated by academic achievement. Interestingly, among students who enrolled in gymnasium, the majority chose their school based on their parents' recommendation. The choice of education is influenced by various interests polarized between the value of a good salary and a secure job, and on the other hand, personal satisfaction with the chosen profession.

When young people are asked about their perception of circumstances important for success in Croatian society [28], for the year 2013, personal or family "connections" and acquaintances, cunning, "resourcefulness" and "shrewdness", luck, and favourable circumstances rank highest, followed by bribery and political suitability. On the other hand, acquired knowledge and skills, a university degree, professional responsibility, dedication, honesty, fairness, and proper treatment of others have lost importance in the eyes of the youth [28].

The future brings with it numerous fears: fear of job loss, debt bondage, over-indebtedness, climate change, sexually transmitted diseases, swine and bird flu, biological and computer viruses [29; p.132]. These are concerns that affect the youth and which they will probably face. Anthony Giddens discusses the concept of risk in the context of modernity. Risk pertains to dangers that are actively assessed in terms of possibilities [30; p.42]. He differentiates between two kinds of risks: external, coming from traditional or natural laws, and produced risks created by our increasing knowledge [30]. Produced risks affect various areas of individual lives, such as family, work, values, etc. Such risks lead to confusion, as every decision made is against a backdrop of contradictory and variable scientific and technological data [30; p.49].

The reflexivity of modern society consists in the fact that social practices are constantly examined and reshaped in light of incoming information, thus changing their character constitutively [31; p.38]. Reflexive modernization offers constant reflection and is connected to decisions and the risks they entail. Reflexive projection of personality may have negative consequences like narcissism, confusion, or feelings of meaninglessness and anxiety [32]. Research has shown that when it comes to gender, women reported lower average levels of risk-taking than men in all domains (driving, finance, recreation, work, healthcare, social risk) [33]. Also, men are more oriented toward planning the future than women are [34].

Talking about age, one of the basic demographic variables, we would undoubtedly agree that it significantly affects planning the future. The tendency to take risks generally decreases over the lifespan and is especially subject to change in young adulthood up to approximately 30 years and in older age from around 65 onwards [33]. According to researchers, these early and late phases of life will probably be marked by individual cognitive and biological changes, as well as significant life events like marriage or retirement. In other words, as we age, we are less willing to engage in risky situations and opt for safer choices. Financial planning is also more pronounced among young adults compared to adolescents, owing to their cognitive development [35].

Risk as a consequence of modernity encompasses a global spread of risk environments, while all mechanisms of eradication take control out of the hands of any individual [36]. Reactions to risk [36] include pragmatic acceptance, permanent optimism, cynical pessimism, and radical engagement. Each aims to free the individual from the burden of anxiety about the future. Besides Giddens, risk is also elaborated upon by Ulrich Beck. Beck is the creator of the term "risk society", which not only rejects traditional forms of life but also resists the side effects of successful modernization – uncertain biographies and hard-to-understand dangers that affect everyone and from which no one can adequately insure themselves [37; p.23]. Alongside risk, fear and (possible) threats start to dominate an individual's thoughts. Although constant threat determines our expectations, mentally occupies us, and guides our actions, it becomes a political force that changes the world [37]. In a risk society, the individual is forced to think about their own.

THEORIES OF AUTHENTICITY OR SINGULARITY AND PRESENT-DAY HEDONISM

To presume an outcome, certain knowledge is required. According to Salecl [38], there is a distinction between 'not knowing' (ignorance) and 'not acknowledging' (ignoring). Both pose a problem, yet they can sometimes be beneficial. Ignorance provides a natural buffer zone when we strive to understand who we are and what our place in the world could be. It marks a point where professional expertise ends and sets limits on what we can reasonably expect from people individually and what we can expect from the community [38; p.14]. In other words, ignorance gives us the right to excuse inaction on the grounds of not knowing, while providing comfort in our inability to act. On the other hand, ignoring, or "denial of the obvious", can be a survival-dependent strategy [38; p.14]. Ignoring is wiser and more manipulative, with the difference between the two being responsibility and innocence. In this age, ignorance is discouraged, even though anyone can find what they do not know on internet services and search engines. Concurrently, the concept of "Ikeaization" of society is related to modern times that do not allow ignorance and force society into fragmentation into all-powerful individuals. Ikea's image promotes a certain anti-sociality, emphasizing the value of productive but solitary work over community activity [39; p.492]. The "do-it-yourself" ideology expects the individual to learn many life skills: from organizing holidays, assembling Ikea furniture, installing new software on the phone to diagnosing their diseases.

In this way, young people are forced to rely on themselves even when they do not know what are they doing or what to do next. We are surrounded by various ways of creating the future and instructions that are often standardized. Here we come to Reckwitz [40], who sees how a late-modern individuals are not just accountable for themselves; they strive to be uniquely standout, beyond mere individual responsibility. This desire for authenticity manifests in the ways people strive to make sense of their lives and create a unique, personal identity. Individuals are increasingly considered unique and irreplaceable entities that must develop their own interests, talents, and passions. Such a society, which Reckwitz calls a society of singularity, focuses on creating uniqueness and singularity, rewarding qualitative differences, individuality, particularity, and extraordinariness [41; p.18].

How it came about, Reckwitz explains, is based on two key moments: the first is "the transformation of the capitalist economy from industrial mass production to cultural production", and the second is "the digital revolution of media technologies" [40; p.142]. Singularity thus refers to a "certain quality and cannot be reduced to quantitative properties, which places it outside the schemata of generality" [40; p.144]. Singularity is manifested in the fact that everyone is different in their own way and therefore they are mutually irreplaceable. What is especially abundant are experiences, excitement, surprises; it is not copied but recreated anew. As Reckwitz stated: "against the rationalism of mainstream modernity in the

culture of authenticity, the idea and conviction emerged that the subject – if freed from all constraints – strives for authenticity, self-realization, and self-expression" [40; p.148]. Such a society contrasts with industrial modernism, which was based on the reproduction of standards, normality, and uniformity and talked about the "power of the general" [41]. While individuals can now turn to authenticity as one way of dealing with the uncertainties that tomorrow brings, authenticity can provide a sense of control and uniqueness in a world often perceived as unstable and unpredictable. This concept can include entire atmospheres, various experiences such as driving, living, live performance, pleasure, beauty, education and participation in games [40]. One of the instruments is also social networks through which we can create our own profile and present ourselves to the public however we want, without precise, accurate, or inaccurate instructions. Therefore, singularity is not possessed, it is cultivated [40; p.151].

The other possible response to risks is present-day hedonism, which refers to an orientation towards current pleasure and satisfaction, instead of long-term planning and abstinence. This is particularly evident in consumer culture and the omnipresent need for instant gratification. Hedonism of the present can be associated with a tendency to avoid the long-term consequences of decisions, especially in the context of social risks. Studies [42] show that hedonistic orientation is significantly related to risk-taking, as people are less likely to consider the future implications of their choices. This tendency also correlates with a lack of social responsibility and a focus on individual well-being at the expense of others. Thus, hedonism can also serve as a survival strategy in times of uncertainty, but it can also lead to negative consequences such as unsustainable lifestyle choices and social irresponsibility.

RESEARCH METHODOLOGY

MEASURING INSTRUMENT

The survey questionnaire contained a total of 202 variables. For the purposes of this study, we used respondents' answers to the Consideration of Future Consequences (CFC) scale developed by Strathman, Gleicher, Boninger, and Edwards [43]. This measuring scale assesses the extent to which an individual considers the consequences of their current behaviour. The scale consists of 12 items, which are measured using a Likert-type scale where a value of 1 indicates strong agreement with the statement, and a rating of 7 indicates strong disagreement with the statement. The scale has two dimensions. The first dimension identifies individuals who think about the long-term consequences of their current actions, i.e., the future (CFC-Future Subscale). The second dimension identifies individuals focused on immediate consequences and needs, i.e., the present (CFC-Immediate Subscale).

In our study, the scale demonstrated a satisfactory level of reliability, tested by the coefficient of internal consistency ($\alpha = 0{,}692$). Before conducting factor analysis, we verified the adequacy of the data for analysis through the KMO index and Bartlett's test of sphericity. The KMO index is greater than 0,8 (KMO = 0,828), and Bartlett's test is statistically significant ($p < 0{,}01$), allowing us to proceed with factor analysis. Using the Principal Component Analysis (PCA) method, we abstracted two dimensions that together explain 49,82 % of the variance. After conducting varimax rotation, we abstracted two main components that align with the previous use of the CFC scale.

The items included in the first dimension relate to orientation towards solving current concerns or situations without much regard for long-term consequences. This dimension in the study represents a focus on the present, emphasizing short-term thinking. The items included in the second dimension emphasize thinking about the future and attempting to influence future outcomes through current decisions and behaviours. This dimension in the study represents a

focus on the future, highlighting long-term thinking. The research results show differences in orientation towards one or the other dimension based on gender, the financial situation of the student, and the type of education that the respondent was attending at the time of the survey (high school or higher education institution).

SAMPLE AND DATA COLLECTION PROCESS

A web survey was used for data collection in our study. The participants of the educational program "BUDI FIN – Be Financially Literate and Responsible" took part in the survey – an educational program on financial literacy for youth, http://www.budifin.hr. "BUDI FIN" was a free financial literacy workshop promoted in national newspapers, television, radio, and on social media. Youth interested in participating in the "BUDI FIN" program had to complete a survey online, a portion of which was used in this study. The survey was hosted on the educational program's "BUDI FIN" website. Accordingly, data were collected from a sample of volunteer students from various universities and high schools in the Republic of Croatia in 2019 and 2020. A total of 970 students participated in the survey. Out of the 970 respondents, 675 completed all the questions in the survey. Among them, 44,67 % were university students, and 55,48 % were high school students. Participants were aged between 15 and 25 years.

Given that participation in the survey was a condition for participating in the free financial literacy workshop, it should be considered that the sample may include young people who are, on average, more interested in financial topics. Therefore, the sample might be biased in this respect.

RESULTS AND DISCUSSION

In Table 1, the results are presented that show the respondents' answers to 12 statements that are part of the CFC scale. These statements from this scale measure an individual's focus on the present or the future. Also, Table 1 displays the average satisfaction of respondents with their own financial situation.

Respondents rated their current financial situation with an average score of 4,61 (SD = 1,374), suggesting general satisfaction with their current financial standing. As seen in Table 1, there is a strong orientation toward future thinking, with high mean scores on statements like "I think about how things could look in the future" (5,50, SD = 1,403) and "I think it's important to take warnings about negative outcomes seriously, even if they will only occur in the distant future" (5,71, SD = 1,301). This indicates that, on average, the youth in Croatia place great importance on long-term planning and considering future consequences.

Average scores related to a focus on current concerns or comfort are generally below 4. For example, "Everything I do is focused on resolving my current concerns because I think the future will resolve itself" has a mean of 3,36 (SD = 1,727). Young people in Croatia also show willingness to sacrifice current pleasure for future outcomes, with a mean score of 5,29 (SD = 1,391), indicating a long-term perspective in decision-making.

The results point towards a tendency for long-term thinking and planning among the youth in Croatia, with less emphasis on immediate concerns and comfort. On average, they are satisfied with their financial situation and are willing to sacrifice current pleasure for future goals.

Table 2 displays two dimensions (components) abstracted from the statements obtained on the CFC scale. After performing varimax rotation, two main components were abstracted with clearly corresponding items.

Table 1. Satisfaction with Own Financial Situation and Focus on the Present or Future (CFC Scale).

Item	Arithmetic mean	Standard deviation
How would you rate your current financial situation?	4,61	1,374
I think about how things might look in the future, and I try to influence that with my everyday behavior	5,50	1,403
I often choose behaviours to achieve an outcome that will probably only occur in the distant future.	4,98	1,535
Everything I do is focused on resolving my current concerns, because I think the future will sort itself out	3,36	1,727
Only the immediate outcomes of my behaviour influence me (outcomes that can be expected in the next few days or weeks)	3,46	1,615
My decisions and behaviour are mostly determined by my sense of comfort	4,29	1,590
I am willing to sacrifice immediate satisfaction or well-being to achieve some future outcomes	5,29	1,391
I think it's important to take warnings about negative outcomes seriously, even if they will only occur in the distant future	5,71	1,301
I think it is more important to choose behaviour that can have important consequences in the distant future than behaviour with less important consequences that will be felt in the nearer future	4,74	1,525
I generally avoid warnings about potential future problems because I think they will resolve themselves before escalating	2,97	1,553
I think it is often unnecessary to sacrifice the present moment because future problems can always be dealt with at a later time	3,28	1,568
My behaviour is focused only on resolving current concerns, because it seems to me that I will be able to solve future problems that may later arise	3,69	1,622
Given that my daily work has concrete outcomes, it is more important to me than behaviour whose consequences will be felt in the distant future	3,74	1,505

One dimension of the scale, consisting of 7 statements, can be termed the "Present Orientation" dimension, in accordance with the scale's construction, evaluation, and existing validity confirmation. In this dimension, high scores on statements like "Everything I do is focused on solving my current worries" (0,734) and "My behaviour is only influenced by immediate outcomes" (0,711) indicate a high orientation towards the present. This means that individuals who agree with these items are more focused on immediate goals and outcomes.

The second obtained dimension, which consists of five items, can be termed the "Future Orientation" dimension, again in line with the scale's construction, evaluation, and validity confirmation to date. Statements like "I think about how things might look in the future, and I try to influence that with my everyday behaviour" (0,744) and "I am willing to sacrifice immediate pleasure or well-being to achieve future outcomes" (0,748) show a high correlation with a future orientation. This means that individuals who agree with these items are more focused on long-term planning and future goals.

Table 2. Component Scores of Statements from the CFC Scale.

Statements from the CFC Scale	Dimension	
	Focus on the present	**Focus on the future**
I think about how things might look in the future, and I try to influence that with my everyday behaviour	–0,068	**0,744**
I often choose behaviours to achieve an outcome that will probably only occur in the distant future	0,051	**0,733**
Everything I do is focused on resolving my current concerns because I think the future will sort itself out	**0,734**	–0,057
Only the immediate outcomes of my behaviour influence me (outcomes that can be expected in the next few days or weeks)	**0,711**	0,086
My decisions and behaviour are mostly determined by my sense of comfort	**0,525**	0,135
I am willing to sacrifice immediate satisfaction or well-being to achieve some future outcomes	–0,067	**0,748**
I think it's important to take warnings about negative outcomes seriously, even if they will only occur in the distant future	–0,147	**0,724**
I think it is more important to choose behaviour that can have important consequences in the distant future than behaviour with less important consequences that will be felt in the nearer future	0,064	**0,579**
I generally avoid warnings about potential future problems because I think they will resolve themselves before escalating	**0,721**	–0,199
I think it is often unnecessary to sacrifice the present moment because future problems can always be dealt with at a later time	**0,708**	–0,207
My behaviour is focused only on resolving current concerns because it seems to me that I will be able to solve future problems that may later arise	**0,693**	–0,025
Given that my daily work has concrete outcomes, it is more important to me than behaviour whose consequences will be felt in the distant future.	**0,705**	–0,013

Table 3 presents the results of an analysis of differences in scores obtained from the principal components analysis and satisfaction with one's financial situation. Satisfaction with financial situation is expressed on a scale of 1 to 7, where a score of 1 indicates extreme dissatisfaction with one's financial situation, and a score of 7 indicates extreme satisfaction. For the purpose of analysis, we grouped personal satisfaction with financial situation into two categories. Respondents who rated their satisfaction with scores of 5, 6, or 7 were classified as individuals who are satisfied with their financial situation, whereas those who rated their satisfaction with scores of 1, 2, 3, or 4 were grouped into a category of individuals who are not satisfied with their financial situation.

Table 3. Orientation towards the Present and Future and Satisfaction with One's Financial Situation.

Dimension	How would you rate your current financial situation?	*N*	Arithmetic mean	Standard Deviation
Focus on the present	Satisfied (5,6 i 7)	359	–0,0147661	0,987
	Dissatisfied (1,2,3,4)	316	0,0167754	1,014
Focus on the future	Satisfied (5,6 i 7)	359	0,0314822	0,986
	Dissatisfied (1,2,3,4)	316	–0,0357661	1,015

The group of respondents who are satisfied with their current financial situation has an arithmetic mean of the component score of the dimension "focus on the present" of –0,014 and the standard deviation of 0,98. The group that is dissatisfied has an arithmetic mean of the component score of 0,016 and the SD of 1,014. The group of respondents who are satisfied with their financial situation has an arithmetic mean of 0,031 of the component score of the dimension "focus on the future" and the SD of 0,986. The group that is dissatisfied has an arithmetic mean of –0.035 and the SD of 1,015. There is a small difference between satisfied and dissatisfied individuals, with satisfied individuals showing a slight tendency toward a future orientation. However, after conducting a t-test, no statistically significant differences in focus on the present or future were confirmed between the group of respondents who are dissatisfied with their financial situation and the group that is satisfied.

In Table 4, the results of the analysis of differences in scores obtained by principal component analysis and the gender of the respondents are shown. Each dimension of the CFC scale was analysed for both genders.

Table 4. Focus on the present and future in relation to the gender of respondents.

Dimension	Sex	*N*	Arithmetic mean	Standard deviation
Focus on the present	Male	178	0,0269338	1,029
	Female	497	–0,0096463	0,990
Focus on the future	Male	178	–0,0794172	1,001
	Female	497	0,0284432	0,998

Male students have an arithmetic mean score in the dimension "focus on the present" of 0,026 and SD of 1,029. Female students have an arithmetic mean of –0,009 and an SD of 0,990 in the dimension "focus on the present". Scores in the dimension "focus on the future" among male students have the arithmetic mean of –0,079 and the standard deviation of 1,001. Among female students, the arithmetic mean score in the dimension "focus on the future" is 0,028, and the SD is 0,998. We can observe a tendency for male students to show slightly greater focus on the present moment compared to female students. However, after conducting a t-test, no statistically significant difference was found between female and male students in terms of focus on the future or present.

In Table 5, the results of the analysis of differences in scores obtained by principal component analysis between high school students and university students are shown.

The average score in the dimension "focus on the present" among high school students is 0,166, with the standard deviation of 1,027. The average component score in the dimension "focus on the present" among university students is 0,207, with a standard deviation of 0,925. After conducting a t-test, a statistically significant difference was found between these two groups of respondents ($t = 4{,}911$, $df = 673$, $p < 0{,}01$). The arithmetic mean score in the dimension "focus on the future" among university students is 0,003, with a standard deviation of 0,895. Among high school students, the arithmetic mean score in this dimension is –0,003, with a standard

Table 5. Differences in focus on the present and future between high school students and university students.

Dimension	High school or university	*N*	Arithmetic mean	Standaad Deviation
Focus on the present	High school**	374	0,1667444	1,027
	University**	301	–0,2071841	0,925
Focus on the future	High school	374	–0,0031375	1,078
	University	301	0,0038984	0,895

**significant at the level $p < 0,01$

deviation of 1,078. After conducting a t-test, no statistically significant difference was found between the arithmetic mean component scores in the dimension "focus on the future".

CONCLUSION

In this study, we analysed the focus on the present and future among high school and university students. We hypothesized that there would be differences in focus on the present or future between high school and university students, as well as in relation to their satisfaction with their financial situation and their gender. The theory of authenticity and singularity emphasizes the importance of self-confidence and honesty toward one's own beliefs, feelings, and values, rather than adhering to social norms and expectations. We expected that high school students, by living in the present moment and taking higher risks, would express their authenticity and collective identity. We used satisfaction with one's financial situation and gender as control variables. Differences between high school and university students turned out to be statistically significant. University students showed a greater focus on the future, while high school students showed a greater focus on the present. Therefore, we can confirm that a focus on the present is a form of expressing one's own authenticity among high school students. The result of our research, which indicates that adolescents in Croatia more frequently think about the future than do young people who are studying, is in line with research in some other countries [44]. As for satisfaction with one's financial situation and gender, despite initial assumptions, the analysis did not show statistically significant differences in the focus of young people in Croatia on the future or present based on these two variables. This suggests that these factors may not play an important role in shaping the temporal orientation of young individuals in Croatia. In conclusion, considering the theory of authenticity and singularity, the research results indicate that temporal orientation and authenticity are not so much related to gender and financial status as they are to the level of education and perhaps other socio-cultural or individual factors, which need to be explored in future research.

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CAUSES OF STUDENT SUCCESS IN SCHOOL

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ABSTRACT

The article presents the contribution of socio-demographic, socio-economic, employment status and level of education of parents/guardians to students' school success. The aim of this article is to discover the causes of school (un)success given the contribution of predictor variables. The predictor set of variables consists of four scales: socio-demographic status (total number of brothers, total number of sisters, marital status of parents, distance from home to school and number of members households), socio-economic status (total monthly income of parents/guardians, place to study in the house/apartment, possession of laptop/computer, constant internet access in the house/apartment and the way they come to school), employment status of parents/guardian and educated status of parent/guardian. In addition to the set of predictors, a criterion variable was used, which consists of three dimensions, namely school success at the end of the sixth, seventh and eighth grade of primary school. The results of the research confirm a statistically significant correlation between socio-demographic, socio-economic, employment status and the level of education of parents/guardians and school success of children, provided that socio-demographic status has a higher predictive power on students' school success. It was confirmed that students have a positive attitude about the importance of the grade as well as that they perceive that their parents have the same attitude.

KEY WORDS

school success, socio-economic status, socio-demographic status, employment status, level of education

CLASSIFICATION

JEL: C1, I2

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INTRODUCTION

In the school, evaluation/assessment of students' knowledge, skills, abilities and their application is carried out in the function of monitoring the overall progress during and at the end of the knowledge assessment period (continuous, quarterly, semi-annualand at the end of the year. For many docimologists, the question of valuation objectives is an essential question of assessment, i.e. evaluation of knowledge. This question arises [1] in the form of doubts about the justification of valuation procedures, whatever they may be, in education. The next step of these reflections is that each evaluation procedure contains an unpleasant moment of „pedagogical relationship". As an argument for this, it is stated that it is difficult to achieve that the roles of educators and evaluators are aligned in one person. It is also pointed out that this opposite, mismatch, is even more strongly manifested when the pedagogue should evaluate his students „in continuity" and finally assess which grade on a numerical or descriptive scale best represents the student's school performance. This, it is believed, is basically the fact that evaluation, evaluation, is one of the most difficult tasks. Students are supported by continuously evaluating the conditions that enable better learning. In a traditional class, the evaluation of a student's work is considered the final part of teaching during which the teacher gives the final judgment of how much the student knows, how much he can and what grade he/she has earned. Such a form of assessment that takes place at the end of the processing of a thematic unit and / or the educational period using tests, control tasks, knowledge tests and / oral tests and which is always expressed by numerical and / or descriptive assessment - is called summative assessment, most often present in the current school system. Research shows that summative assessment has very little or no positive effect on either student learning or teacher teaching quality as opposed to a combination of diagnostic and formative assessment [2]. When a student receives a low grade based on traditional, summative forms of assessment, it is most often included in the final sum of grades (entering the grade point average) even when the student has "corrected" the grade or improved his knowledge, which is often justified by "evaluating the student's effort" even though this is done without clear criteria. However, despite the ambiguity and inconvenience, the question of grading is nevertheless repeatedly presented as an indispensable task that pedagogues cannot refuse to perform. Although the previous aspects of grading and examples are extreme, and although the situations of final school success of students are not caused only by grading, nevertheless, in the overall reflections on the pedagogical function of assessment, the effect of the assessment on the developmental flows of the young personality should be taken into account. This aspect is particularly considered in the article through the analysis and measurement of the impact of additional factors, given that it has been confirmed that the socio-demographic status and socio-economic status of the family with a special focus on the number of household members and parental employment further reinforce the starting differences among students, complicating the process of achieving school success.

THEORETICAL FRAMEWORK

In practice, it is common for school success to be operationalized in different ways and equated with the notions of school performance, school competencies and abilities. When it comes to evaluating school success, it is usually reduced to forms of assessment, and it is accompanied by additional collection of information in order to encourage the progress of children from the current level of knowledge to reach expectations. School success also refers to educational outcomes, and outcomes on the purpose and goals of the subject in accordance with the expectations of students to understand and apply what they have learned.

Socio-demographic status means the social circumstances in which the child grows up, while socio-economic means the material and technical conditions of the family as a community.

REVIEW OF PREVIOUS RESEARCH

Some studies [3] use a concluding grade from individual subjects as well as general success, while others [4] use students' self-assessment of their own achievement. Although standardized tests are used as a measure of success in addition to concluding grades and general success, Keith's [5] research showed that there is a greater correlation between student characteristics and success when the criterion variable uses a final score rather than when standardized tests are used. Anaya [6] also states that a concluding grade is not the best indicator of success because it does not take into account students 'previous success. Also, the final grade is not a standardized measure, so it is difficult to compare grades obtained from different school subjects. Research also uses assessments that involve a combination of assessment measures by researchers, teachers and parents, and self-assessment and peer assessment measures [7]. Therefore, it would be good to use a combination of different measures of success, which relate to cognitive and metacognitive teaching strategies. The methodological advantage of using more success indicators improves the validity and reliability of measurements, but can also lead to an increase in errors in statistical inference, and it is necessary to take into account the use of appropriate statistical methods. Research shows that the demographic characteristics of the family as well as socio-economic status, family structure, marital status, specific characteristics of parents/guardians, family size, and family environment further complicate the overall process of school success because they directly affect students' starting positions [8-10]. According to [11] socioeconomic status is defined by family financial income, parental qualifications (highest educational attainment), and occupation-related status. Some research has shown that parents of middle economic status most often emphasize initiative and autonomy, while parents of lower economic status most often encourage conformism. This way of thinking reflects on the first jobs and work experience that students will have, the skills they will develop, and ultimately what jobs they will do when they grow up [12, 13]. The results of research by [14] point to the conclusion that children of parents who work in the field of health care most often want to continue their education in that field, in contrast to students whose parents did manual work. Some authors [15] define socioeconomic status as "a relative position within a social hierarchy depending on access to or availability of financial resources, power, and social prestige". This definition is related to the three-part operationalization, in which the most important predictors of educational success are examined family income and education and occupation of parents [16]. Socio-economic status is not operationalized in the same way in all surveys, as it includes several measures: parent education, income, parent employment, parent occupation, parent performance within occupations, their position in society. Nevertheless, the general conclusion is that income, parental education and their occupation together better represent socio-economic status than each of these measures separately. Research also shows that students living in better socio-economic conditions achieve better schooling success [17-20]. Socio-economic status has proven to be one of the strongest predictors of school success. The results of meta-analyzes showed that the correlation between socio-economic status and school success averaged around $r = 0,3$ [20, 21]. It was found that based on knowledge of socio-economic status, we can predict 10% of the variance in school success [22] and that this is the most consistent and stable indicator in relation to other variables. However, these studies also confirm that, in addition to the socioeconomic status variable, it is recommended to combine two or more indicators since most of the variance was explained through other factors, i.e. regression models: (1) parent education (meeting children with developmentally appropriate books, reading and interpretation of what was read), (2) cultural capital (possession of linguistic competencies and cultural preferences in the form of influencing the academic way of thinking and visiting museums, theatres with parents), (3) possession of cultural goods (making and owning works of art, home library of manuscripts, books and historical documents), (4) income of parents (economic power of the family through

the financial aspect: the possibility of buying equipment and materials, securing excursions, additional teaching resources). Other variables taken into account such as the characteristics of teachers, schools, teaching and principals have shown no significant contribution in explaining students' educational achievements.

When it comes to gender as a personal determinant of school success, research shows thatthe gender of the child plays an important role, so according to [23, 24] girls achieve better school performance compared to boys. Research suggests that parents are also more involved in girls 'school work than boys [25] and have higher expectations of school success than girls [26]. This contribution to parental involvement through an increased focus on girls' academic achievement sought through parental expectations under the influence of social norms related to gender role in education, and the importance of taking into account the context of families with beliefs, social context and cultural factors with regard to the climate that shapes families. Research conducted in Barking and Dagenem in East London showed a link between children's success in school and parental employment, and [27] conducted a survey among 620 children ages 13 to 15 to determine the link between family life and school success. The children filled out a questionnaire and kept a diary of home activities at home for a week, including a description of the time spent with each of the parents. After two years, the authors collected data on the success of the same children in school. Research has shown that several factors affect the overall success of children in school: the financial situation of the family, ambition in terms of education, mother's support and parental employment. Authors in [28] concludes that children achieve better success in school if both parents are employed, but that success is somewhat lower in children whose both parents work full time, while [29, 30] found that children of more educated parents (guardians) achieve better results in school on average. A study [31] found a significant correlation between the father's educational level, family income, and housing conditions and the student's success in school.

METHODOLOGICAL FRAMEWORK OF RESEARCH

METHOD OF WORK

In order to define a sufficiently focused subject area of research, for the purposes of this article we have singled out predictor variables by which we want to examine their contribution to student success in school. A predictor set of variables consistsfour scales: socio-demographic status (total number of brothers,total number of sisters, marital status of parents, distance from home to school and numberhousehold members), socio-economic status (total monthly income of parents/guardians, place to study at home/apartment, possession of laptop/computer, constant internet access in the house/apartment and the way they come to school),parental employment (parent/guardian employment status) and educated parent/guardian status. In addition to the set of predictors, a criterion variable was used, which consists of three dimensions, namely school success at the end of the sixth, seventh and eighth grade of primary school.

The aim of the research is to examine the causes of school (un)success given the contribution of predictor variables. For this purpose, three tasks were set aside. The *first task* was to examine the correlation between the socio-economic and socio-demographic status of parents/guardians and the school performance of students in the sixth, seventh and eighth grades. Two hypotheses were tested:

> **H_1:** It is assumed that there is a correlation between the socio-economic, socio-demographic status of parents and school student success.
>
> **H_2:** Socio-demographic status of the family has a greater power to contribute to student success than socio-economic.

The second task was to examine the attitudes of the student on the importance of assessment and their perception of parents' attitudes, taking into account the gender variable. One hypothesis was tested:

> **H_3:** It is to be assumed that students have a positive attitude about the importance of the grade as well as that they perceive that their parents have the same attitude, regardless of the gender of the students.

Quantitative – qualitative paradigm prevails in the research. Three research methods were applied in the research, namely descriptive, correlation and causal.

JASP0.16.1 statistical software was used for data processing, which includes other open source software components such as SPSS. SPSS served partial calculations of individual contributions of tested hypotheses. Taking into account the distribution of results, parametric statistics measures were used, and the characteristics of the stratified sample were explained by descriptive statistics measures.

RESEARCH INSTRUMENT

After obtaining the consent of parents and competent educational institutions, the created e-instrument "Causes of students' school success" was applied, which contains instructions on giving answers and expressing students' views. The reliability of predictor subscales was tested by calculating the Cronbach's Alpha coefficient, and was confirmed based on its value of 0,86. The subscales of individual subjects (0,97) and student successin the sixth, seventh and eighth grades (0,94) have a high level of reliability.

STATISTICAL SAMPLE

The research sample is stratified and includes 1252 primary school students (VI, VII and VIII grades), which largely exceeds the required statistical minimum.The research was conducted in the schools of Una-Sana Canton. The research is transversal and empirically based on character. Table 1 contains overview of the characteristics of the variables.

Table 1. Characteristics of the variable – level of education of parents.

Education	Mother		Father	
	Frequency	Percent	Frequency	Percent
No school	77	6,2	30	2,4
Elementary School	428	34,2	284	22,7
High school	554	44,2	715	57,1
University degree	75	6,0	85	6,8
College and more	118	9,4	138	11,0
Total	**1252**	**100,0**	**1252**	**100,0**

The characteristics of the sample show that more mothers (34,2%) than fathers (22,7%) have completed only primary school, while this relationship is reversed if we take into account high school. 6,2% of mothers and 2,4% of fathers have not finished primary school. Data for university degree and college of parents are approximately the same (15,4% and 17,8%).

According to Table 2, 78,8% of fathers in the sample were employed, as opposed to only 39,0% of mothers. Unemployed mothers from the survey sample are 56,6%, while fathers are 13,1%. This implies a higher employment rate of fathers, which can be understood as one of the consequences of the data from the previous table which shows the level of education of parents.

Additional analysis of summative assessment, Table 3, reveals that teachers in the eighth grade have a slightly milder assessment criteria M = 4,10, s = 0,9, than in the sixth (M = 4,04, s = 0,9) and seventh (M = 4,01, s = 0,9). Frequencies of Table 3 shows a slight growth trend in the

Table 2. Characteristics of the variable – working status of parents.

Work status	Mother		Father	
	Frequency	Percent	Frequency	Percent
Unemployed	709	56,6	164	13,1
Occasionally employed	68	5,4	93	7,4
In a permanent employment relationship	413	33,0	885	70,7
Employed and does not receive a salary	8	0,6	9	0,7
Retired	9	0,7	39	3,1
Other	45	3,6	62	4,9
Total	**1252**	**100,0**	**1252**	**100,0**

Table 3. Characteristics of the student success variable.

Grades	Eighth grade		Seventh grade		Sixth grade	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	9	0,7	7	0,6	3	0,2
2	46	3,7	50	4,0	65	5,2
3	271	21,6	335	26,8	312	24,9
4	417	33,3	397	31,7	372	29,7
5	509	40,7	463	37,0	500	39,9
Total	**1252**	**100,0**	**1252**	**100,0**	**1252**	**100,0**

number of students with very good and excellent results, while among students with sufficient and good results this trend is reversed, ie. in older grades they score better. The number of students with negative success is negligible (smaller than 1%).

In the analysis of student success by gender, Table 4, although the differences are negligible and range within statistical error, it can be observed that in sixth grade girls perform better than boys while in older grades boys perform better. The result obtained is that the boys in the eighth grade do not have negative grades unlike girls, we find it interesting to support future checks and research.

Table 4. Student success by gender and grade.

	Eighth grade		Seventh grade		Sixth grade	
	Male	Female	Male	Female	Male	Female
Valid	582	670	582	670	582	670
Missing	0	0	0	0	0	0
Mean	4,05	4,03	4,01	4,00	4,09	4,10
Std. Deviation	0,92	0,95	0,94	0,91	0,91	0,91
Minimum	2,0	1,0	1,0	1,0	1,0	1,0
Maximum	5,0	5,0	5,0	5,0	5,0	5,0

ANALYSIS AND DISCUSSION OF THE OBTAINED RESULTS

CORRELATION OF SOCIO-DEMOGRAPHIC, SOCIO-ECONOMIC, EMPLOYMENT STATUS AND LEVEL OF EDUCATION OF PARENTS/GUARDIANS WITH THE SCHOOL SUCCESS OF STUDENTS IN SIXTH, SEVENTH AND EIGHTH GRADE

Based on standard regression analysis, the magnitude of the contribution of perceived socio-demographic status, socio-economic status, employment status and level of education of parents/guardians to the school success of students in *sixth, seventh and eighth grade* was evaluated. All variables in the regression model were decomposed into the first principal component, and the factor scores were expressed in the form of regression scores. Based on the

correlation matrix for the set of variables included in the regression model, it was determined that all predictor variables statistically significantly correlate with the dimensions of school success of students in sixth, seventh and eighth grade. Although the registered correlations are statistically significant, it should be emphasized that the magnitude of the correlation is relatively modest. By testing the first hypothesis, we find that school success in the sixth, seventh and eighth grades of primary school is poorly correlated with variables: *total number of sisters, marital status of parents, number of household members, total monthly income, place to study at home/ apartment, computer/laptop , way of traveling from home to school, working status of mother, level of education of mother and father*, and correlation coefficients range from $r = –0,02$ to $r = –0,08$. *Father's working status, constant internet access to the house/apartment, distance from the house to the school and the total number of brothers* are variables whose correlation coefficients exceed the order of $r = 0,10$, which indicates a small but still *statistically significant correlation* with school success at the end of sixth, seventh and eighth grade. If we consider that the sample was explained by 70,7 % of employed fathers and 32,5 % of employed mothers, it seems clear why school success did not correlate with the sample of 32,5 % of employed mothers. The aforementioned data imply that the first hypothesis is accepted, with it we assumed *that there is a correlation between socio-economic, socio-demographic status of parents, employment status and level of education of parents / guardians and school performance of students*. A statistically significant difference shows that the observed variables with the school success of students best correlate the employment relationship of the father, and constant Internet access to the house/apartment, the distance from home to school and total number of brothers.

All variables that represent the starting positions operationalized by socio-demographic status, socio-economic status, employment status and level of education of parents/guardians are statistically significantly correlated with each other. As there is no distortion multicollinearity conditions followed the recommendation of leading authors in the field to include all variables in the regression model that do not share more than half of the common variance [32]. As no significant cases of multicollinearity disturbances have been registered in any of the four predictive models, the obtained models can be treated as reliable. A detailed overview of the diagnosis of collinearity is shown in Table 5.

Table 5. Multicollinear diagnostics: tolerance coefficients and variance increase factors for regression models of school performance assessment from sixth to eighth grade.

Model	**Collinearity Statistics**	
	Tolerance	**VIF**
(Constant)		
Total number of brothers	0,871	1,148
Total number of sisters	0,874	1,144
Marital status of parents	0,940	1,064
Distance from home to school	0,915	1,093
Number of members of your household	0,789	1,268
Total monthly income of parents/guardians	0,872	1,146
A place to study in the house/apartment	0,964	1,037
Owning a computer/laptop	0,969	1,032
Constant internet access in the house/ apartment	0,925	1,081
Way to come to school	0,958	1,044
Mother's working status	0,959	1,043
Father's working status	0,856	1,168
Mother's education	0,882	1,134
Father's education	0,880	1,136

The basic question regarding the relations of starting positions (operationalized through socio-demographic, socio-economic and work status of parents/guardians, and the level of education of parents/guardians) is how much these variables contribute to the possibility of predicting school success in sixth, seventh and eighth grade students. In order to answer the question, four successive models were created with the simultaneous use of predictor variables.

How is the average correlation (father's work status, constant internet access in the house/apartment, distance from home to school andtotal number of brothers) predictor variables with a criterion above the order of magnitude $r = 0{,}10$, and the remaining predictor variables with average correlations from $r = –0{,}02$ to $r = –0{,}08$ are a small amount of common variance, so the expected predictive potentials of the model are limited. A detailed overview of the overall efficiency of the model is shown in Table 6.

Table 6. General efficiency indicators of regression models: multiple correlation coefficients and multiple determinations. Dependent variable is the School Success. In table, R is a multiple correlation coefficient, R^2– multiple determination coefficient and ΔR^2 – corrected R^2.

Model	R	R^2	ΔR^2	Standard error of the estimate
Starting positions	0,307	0,094	0,083	2,51778
Socio-demographic status	0,214	0,046	0,042	2,57352
Socio-economic status	0,178	0,032	0,028	2,59263
Working status of parents/guardians	0,173	0,030	0,028	2,59197
Degree of education of parents/guardians	0,083	0,007	0,005	2,62223

The most efficient model was the regression solution for the score prediction model on the *socio-demographic status* dimension ($R = 0{,}046$), where 4,6% of the variance in school success was explained. The regression model that deals with the prediction of *socio-economic status* as an aspect of school success in sixth, seventh and eighth grade is less useful in prediction than the previous model ($R = 0{,}032$) and explained 3,2% of the variance in school success. The regression model that checks the prediction of school success from the aspect of the employment status of parents/guardians ($R = 0{,}030$), explained 3 % of the variance of school success. The level of education of parents proved to be the least useful regression solution in the prediction of school success. Although the model is statistically significant in practical terms it is extremely marginal ($R = 0{,}007$). The summarized results of the analysis of variance for all four models are shown in Table 7.

Table 7. Summative indicators of of variance for tested regression model (SS – sum of squares; df – degrees of freedom; MS – average squares; F – Fisher F ratio).

Model		SS	df	MS	F	Sig.
Socio-demographic status	Regression	396,28	5	79,26	11,97	0,00
	Residual	8252,25	1247	6,62		
	Total	8648,54	1252			
Socio-economic status	Regression	273,25	5	54,65	8,13	0,00
	Residual	8375,29	1247	6,72		
	Total	8648,54	1252			
Working status of parents/guardians	Regression	257,37	2	128,68	19,15	0,00
	Residual	8391,17	1250	2		
	Total	8648,54	1252	6,72		
Degree of education of parents/guardians	Regression	60,28	2	30,14	4,38	0,01
	Residual	8588,26	1250	6,88		
	Total	8648,54	1252			

Individual contribution of variables to the regression modelit was estimated via standardized regression coefficients β. The first predictive model (*socio-demographic status*) contributes

statistically significantly through four of the five variables, namely: total number of brothers (β = –0,136, t = –4,618, p < 0,05); total number of sisters (β = –0,095, t = –3,242, p < 0,05), marital status of parents (β = –0,062, t = 2,218, p < 0,05) and distance from home to school (β = –0,127, t = –4,531, p < 0,05). Through the second predictive model (*socio-economic status*) they contribute statistically significantly: the place for learning in the house/apartment (β = –0,063, t = –2,286, p < 0,05); having constant access to the Internet (β = –0,096, t = –3,393, p < 0,05) and the way they come to school (β = –0,060, t = –2,161, p < 0,05). From the third predictive model (*parent/guardian work status*), father's work status (β = 0,127, t = 4,353, p < 0,05) statistically significantly contributes to students' school success, while in the fourth predictive model it is the mother's level of education (β = 0,067, t = 2,322, p < 0,05). The results are shown in Table 8.

Table 8. Individual contributions of predictor variables from the set of starting positions to school success in sixth, seventh and eighth grade.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	**Std. Error**	***β***		
Socio-demographic status	(Constant)	12,80	0,44		29,04	0,00
	Total number of brothers	–0,43	0,09	–0,14	–4,61	0,00
	Total number of sisters	–0,23	0,07	–0,10	–3,24	0,00
	Marital status of parents	0,22	0,10	0,06	2,22	0,03
	Distance from home to school	–0,13	0,03	–0,13	–4,53	0,00
	Number of members of your household	0,10	0,06	0,05	1,68	0,09
Socio-economic status	Total monthly income of parents/guardians	0,01	0,04	0,01	0,21	0,83
	A place to study in the house/apartment	–0,19	0,08	–0,06	–2,29	0,02
	Owning a computer/laptop	–0,03	0,09	–0,01	–0,36	0,72
	Constant internet access in the house/apartment	–0,56	0,17	–0,01	–3,39	0,00
	Way to come to school	–0,12	0,06	–0,06	–2,16	0,03
Working status of parents/ guardians	Mother's working status	–0,04	0,04	–0,03	–0,98	0,33
	Father's working status	0,23	0,05	0,13	4,35	0,00
Degree of education of parents/ guardians	Mother's education	0,17	0,08	0,07	2,32	0,02
	Father's education	–0,12	0,07	–0,05	–1,70	0,09

Based on the obtained results, the second hypothesis that was extinguished is confirmed: "Socio-demographic status of the family has a greater power of contributing to the student's school success than socio-economic status".

STUDENTS' ATTITUDES ABOUT THE IMPORTANCE OF ASSESSMENT AND THEIR PERCEPTION OF PARENTS' ATTITUDES, TAKING INTO ACCOUNT THE GENDER VARIABLE

Table 9 shows that students attach great importance to their grades: 94,7% of them said that their grade was important or very important, while 5,3% of students said that their grade was irrelevant.

From Table 10 one can see that girls and boys equally attach importance to grades, ie. 94,1% boys and 95,2% girls.

Table 9. Students' attitudes about the importance of assessment.

Student attitudes	Frequency	Percent
It doesn't matter to me	66	5,3
It's important to me	**659**	**52,6**
It is very important to me	527	42,1
Total	1252	100,0

Table 10. Students' attitudes about the importance of assessment with regard to gender.

Gender	Student attitudes	Frequency	Percentage
Male	It doesn't matter to me	34	5,9
	It's important to me	**311**	**53,4**
	It is very important to me	237	40,7
	Total	582	100,0
Female	It doesn't matter to me	32	4,8
	It's important to me	**348**	**51,9**
	It is very important to me	290	43,3
	Total	670	100,0

After examining students' attitudes about the importance of grades, we further checked their perception of parental attitudes, taking into account the gender variable of parents. The results are shown in Table 11.

Table 11. Students' attitudes about the importance of assessment to their parents/guardians.

Students 'perception of parents' attitudes	Frequency	Percentage
It's important to mom and not to dad	**65**	**5,2**
It doesn't matter to them	23	1,8
Dad is important, and mom is not	15	1,2
It's important to them	505	40,3
It is very important to them	**644**	**51,5**
Total	1252	100,0

Half of the surveyed ninth grade students, more precisely 51,5% of them, think that their parents/guardians have a very important grade. As seen from Table 12, 91,8% of parents, according to students' attitudes, belong to the scale of answers that the grade is important and/or very important.

Girls and boys alike have a positive attitude that their parents care about or value the grade they receive; 92 % of girls and 91,6 % of boys have this attitude. In addition, 5 % of girls and boys

Table 12. Students' attitudes about the importance of assessment to their parents/guardians with regard to gender.

Students 'perception of parents' attitudes		Frequency	Percent
Female	It's important to mom and not to dad	**36**	**5,4**
	It doesn't matter to them	9	1,3
	Dad is important, and mom is not	9	1,3
	It's important to them	273	40,8
	It is very important to them	**343**	**51,2**
	Total	670	100,0
Male	It's important to mom and not to dad	**29**	**5,0**
	It doesn't matter to them	14	2,4
	Dad is important, and mom is not	6	1,0
	It's important to them	232	39,9
	It is very important to them	**301**	**51,7**
	Total	582	100,0

said that the grade they receive is more important to their mother, which we find useful to check, because we had a similar data for the category of mothers who did not finish primary school. We consider it useful to compare the attitudes of students and parents, i.e. to examine which category with regard to the level of education has a positive attitude towards education, how much it contributes to the positive attitude of students and how much it explains the achieved success of students. In accordance with the obtained findings, we confirm the third hypothesis "it is to assume that students have a positive attitude about the importance of assessment as well as to perceive that their parents have the same attitude, regardless of student gender".

CONCLUSION

By testing the first hypothesis, we confirmed that there is a correlation between socio-demographic, socio-economic, employment status and the level of education of parents/guardians and student success. Considering the relationship between the observed variables and the school performance of students, it was singled out that (1) the working relationship of the father, (2) permanent Internet access to the house / apartment, (3) distance from home to school and (4) the total number of brothers best correlate with the school performance of students, which confirms the first hypothesis.

In support of the second hypothesis tested, it was found that the first predictive model (socio-demographic status) contributes statistically significantly through four of the five variables, namely: total number of brothers, total number of sisters, marital status of parents and distance from home to school. The number of household members as the fifth variable has no predictive power in relation to the listed variables. The obtained results are in accordance with previous researches according to which [8-10] the demographic characteristics of the family such as family structure, marital status, specific characteristics of parents/guardians, family size, and the family environment further complicate the entire process of achieving school success, because they directly affect the starting positions of students. In our work, and in accordance with the results of earlier research, through the second predictive model (*socio-economic status*), it was found that they contribute statistically significantly: a place for learning in the home / apartment, possession of permanent Internet access and the way students come to school. These results can be linked to the results of the above-mentioned studies confirming that students living in better socio-economic conditions achieve better school performance [20, 21] and that the financial income of parents (economic power of the family through the financial aspect: the possibility of buying equipment and materials, securing excursions, additional teaching resources) statistically significantly contribute to the school success of students [16].

In our work, and in accordance with the results of previous research, through another predictive model (socio-economic status) it was found that they contribute statistically significantly: a place to study at home/apartment, having constant internet access and the way students come to school. From the third predictive model (parent/guardian work status), father work status contributes statistically significantly to students' school success, while other authors, such as [28], in their research conclude that children achieve better school performance if both parents are employed, but that success is somewhat lower in children whose both parents work full time, and research by the authors [27] conducted in Barking and Dagenem in East London which showed that several factors affect the overall success of children in school, among other things, is the employment of both parents. Based on the obtained results, we propose to conduct further research on the topic "on the reasons for the unpredictable power of the working status of mothers on student success". As the most important predictors of educational success, family income is examined, and the education and occupation of parents are stated [16]. Then, in a study for Australia [31], a significant correlation was found between the father's educational level,

family income, and housing conditions and student success in school, while [29, 30] found that children of more educated parents (guardians) achieve better results in school on average. The results of these studies are partly in line with the results of the fourth predictive model, which show that student success is conditioned by the level of education of the mother, but not the father.

Testing the third hypothesis confirmed the positive attitude of students about the importance of assessment as well as the perspective of parents in the same proportion „students have a positive attitude about the importance of assessment, they have the same attitude about the perception of their parents' attitudes. More precisely, half of the surveyed ninth grade students think that the grade they receive is very important to their parents/guardians. Both girls and boys stated that the grade they receive is more important to the mother than to the father. Available earlier research suggests that parents are more involved in the school work of girls than boys [25] and that they have higher expectations for girls' school performance [26] and that this contribution to the variable is linked to parental expectations under the influence of social norms related to gender role in education, which is why it is necessary to take into account the context of the conditions in which the family (beliefs, social context and cultural factors) lives to understand the results obtained with regard to the climate that shapes families.

Additional recommendations for further testing refer to the examination of the relations of the investigated predictors and school performance in the remaining grades of subject and classroom teaching in primary school, and the examination of other variables that speak in favor of the aforementioned constructive models in relation to school performance such as the correlation between adult beliefs and the importance of education.

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THE ATTITUDES OF STUDENTS TOWARD THE USE OF SMARTPHONES

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ABSTRACT

Objectives: The aim of the research was to examine the attitudes of students regarding the use of smartphones during the day and at night, their impact on the quality of sleep and the use of social networks and communication tools.

Methods: In the research, a survey questionnaire constructed for the needs of this research was used. It consisted of two independent and nine dependent variables. The research was conducted by placing a questionnaire on a Google form. 327 respondents, students studying in Croatia, took part in the research.

Findings: The results of the research show that respondents use their smartphones for an average of 3,16 hours a day; they visit the social network Instagram most often (54,1 %), and Snapchat the least (1,5 %). When communicating, most of them use WhatsApp (75,8 %), while Telegram is used by only one respondent (0,3 %). 84.1 % of respondents use their smartphone before going to sleep; almost 89 % of respondents say that their smartphone never wakes them up during the night.

Novelty: Mobile phones have become part of everyday life, especially among younger generations. The majority of communication takes place precisely through these devices, communicating through a handful of tools that are available.

KEY WORDS

tools for communication and collaboration, social networks, smartphone, students, health

CLASSIFICATION

JEL: I23, R20

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INTRODUCTION

Every day there are more and more users of social networks. They are popular with almost all age groups, especially young people, and are most often accessed via smartphones. According to data from the Statista agency [1], there were a total of 3.17 million users in Croatia in 2021, and it is predicted that the figure will grow significantly by 2025, when around 3.39 million users are predicted.

Social networks [2] were used by a total of 2.90 million users in Croatia in February 2022. The most visited social network was YouTube with a total of 2.90 million users, followed by the social network Facebook with 1.75 million users, Instagram with 1.45 million users, LinkedIn with 730 thousand users and Snapchat with a total of 550 thousand users.

Authors [3] state that young people today use technology in different ways, from writing messages to "tweeting", "chatting", playing online games and posting on various internet portals.

Considering the great popularity of social networks among young people, especially among the "Z" and "Alpha" generations, who could be said to have been "born with mobile phones in their hands". The "Z" generation, also called Gen Z, Homelanders, Centennials, iGeneration, post-millennials and zoomers, is a generation born in the late 90s and early 2000s, a generation that grew up in the iPhone age [4]. In contrast to the "Z" generation, the "Alpha" generation are members born (or those who will be born) between 2010 and 2025. The generation that first experienced remote classrooms, the generation that uses tablets, computers and ubiquitous streaming services from early childhood [5] the question arises as to how much social networks are used, for example, in educational process, and how much for the purpose of entertainment and free time. In their research authors [6] came to the conclusion that a very small percentage of young people use social networks for educational purposes. On a sample of 300 students at Prince Sattam bin Abdul Aziz University, the results were obtained that 97 % of respondents use social networks and only 1% of respondents use them for educational purposes. More than half of the respondents, 57% of them, stated that they consider themselves addicted to social networks. In a global survey conducted in 2021 [7], 33 % of respondents spend more than 3 hours a day on social networks, and the respondents stated that social networks had a negative impact on their social well-being. In 2022 [8], the average time spent on social networks was 147 minutes per day, which is ~~only~~ two minutes more than the year before.

Time spent on the Internet, considering the time spent for educational purposes and free time, is on the rise. Frequent use turns into daily activities that grow into a habit, and the habit can become risky and lead to addiction.

Some of the factors that can lead to Internet addiction [9] are individual and environmental. Individual factors refer to personality, behaviour, way of dealing with problems, ways of experiencing the world around you, etc., while environmental factors refer to the design of websites and video games that keep users online as long as possible.

In the world, there are more and more young people addicted to the Internet [10, 11], mobile phones [12, 13], fear of missing out (FOMO) [14, 15], social networks [16, 17] and the irrational fear of being left without them. Nomophobia [18, 19] is a term used to describe the anxiety disorder of fear of separation from mobile phones. In addition to nomophobia, phubbing, which indicates that the interlocutor is being neglected during the conversation due to the use of a smartphone, is increasingly being noticed.

Internet and social network users are sometimes aware that they spend too much time on social networks. The authors [20] of the research concluded that there is a strong connection between respondents who believe they spend too much time on social networks and their desire to stop doing so. A similar association was also found between being told by others that they spend too much time on social media and their beliefs about it. In total, 40 % of respondents underwent digital detoxification.

With digital detoxification, it is possible to engage in many other activities such as sports, meditation, reading, walking, socializing with peers, etc. For example [21] one of the techniques that can be used to reduce nomophobia is a technique called mindfulness. The results of their research showed that mindfulness has a positive effect on preventing nomophobia, the use of technology while driving, and dangerous driving behaviors that can lead to crashes. Furthermore, authors [22] recommend yoga and state that the problematic use of mobile phones really has an impact on physical and psycho-social health and can be considered as a basis for psycho-social disorders, and they believe that by practicing yoga, meditation techniques and breathing technique contributes to a healthy lifestyle, emotional stability and awareness. Thirty minutes of vigorous aerobic activity per day [23] can induce positive changes in students who are addicted to smartphones.

Excessive use of smartphones also affects other health segments, and one of them is precisely the problem with sleep, insufficient amount of sleep, sleep interruptions during the night, fatigue during the second day, etc. The hormone melatonin is responsible for the sleep cycle. Melatonin is synthesized [24] from tryptophan through serotonin and that the key enzyme in this process is called N-acetyl-transferase, which is activated at night, and mostly between 2 and 4 in the morning. Namely, the young often go to sleep with their mobile phones, the devices are often found in the immediate vicinity of the person (on the bed, next to the pillow, on the bedside table, etc.), and the question arises whether they have an impact on the quality of sleep, whether notifications wake them up during the night, whether they browse content on the Internet during the night, whether they fall asleep with some content on social networks in their mind, etc. A very high percentage of respondents (78%) in the Setta region of Morocco suffer from poor and insufficient sleep, especially those respondents who use a mobile phone right before going to sleep [25].

In a study [26] conducted among a population of 626 medical students in India, a total of more than half of the respondents (51.6 %) stated that they keep their mobile phones close to them while sleeping and 84.3 % of the respondents stated that they access social networks via mobile phone.

In a study [27] conducted on 123 medical students at the University Center located in the city of Maceió, state of Alagoas, Northeastern Brazil on their perception of sleep quality and academic achievements and the presence of symptoms related to circadian rhythm disorders before the pandemic and during the period in which the respondents participated in distance learning, such as sleepiness, sleep delay and reduced alertness. The obtained results showed that 100 % of respondents used screens continuously before going to sleep, 77.2 % stated that they had “bad” or “very poor” academic performance, which can be connected to the fact that 65.9 % of respondents could not maintain their productivity due to sleepiness during the day.

A study [28] conducted on a sample of 323 students at a public university in Sabah showed a significant relationship between sleep quality and academic success. The research results showed that the poorer the quality of sleep, the lower the academic success.

Considering the mentioned research results of the authors who researched the impact of mobile phones on students, the results of students studying in the Republic of Croatia on the use of smartphones will be presented in the practical part of the work.

METHODOLOGY

RESEARCH AIM

This research aimed to examine the attitudes and reflections of graduate and undergradute students studying in the Republic of Croatia regarding the use of smartphones during the day and night, its impact on the quality of sleep, and the use of social networks and communication tools.

MEASURING INSTRUMENT

The research used a measuring instrument designed for the needs of this research. The survey questionnaire was designed by the researchers. The questionnaire was not validated because it was a pilot study. After designing the survey questionnaire, it was submitted to the ethics committee of Juraj Dobrila University in Pula, where it was approved for implementation on February 2, 2022. The questionnaire consisted of a total of 23 variables, three of which were open-ended variables. For the purposes of this paper, a total of eleven variables were used. It consisted of two independent (gender and year of study) and the following nine dependent variables:

V_1: On average, how much do you use a smartphone per day?
V_2: Which social network do you most often visit using your smartphone?
V_3: Which tool do you use most often when communicating using a smartphone?
V_4: I use my smartphone right before going to sleep.
V_5: I turn off my smartphone at night.
V_6: The smartphone is in my immediate vicinity during the night.
V_7: Content that I access through my smartphone (for example YouTube and other social networks) helps me fall asleep.
V_8: Notifications on my smartphone wake me up during the night.
V_9: I use my smartphone too much.

The first three dependent variables were asked to the research participants in the form of questions, and they opted for one of the offered answers. The remaining six dependent variables are based on a Likert-type rating scale, where each statement is accompanied by a response scale (1 – never, 2 – rarely, 3 – sometimes, 4 – often, and 5 – very often) and the research participants choose one of the answers offered.

The research was conducted during the year 2022 through an online anonymous survey questionnaire placed on a Google form. The survey questionnaire was distributed via public e-mail lists. The questionnaire was available from February 2, 2022 to May 4, 2022. Respondents started filling out the questionnaire on February 2m 2022 at 18:24:25. In February, a total of 20.5 % of respondents answered the questionnaire, in March 74.01 %, in April 2.44 % and in May 3.05 % of respondents.

SAMPLE

The research was conducted on a sample of 327 respondents, undergraduate and graduate students studying in Croatia. A total of 69.1 % of full-time study respondents and 30.9 % of part-time study respondents participated in the survey.

The questionnaire did not ask about the age of the respondents because the aim was to determine their year of study. Students studying at universities and colleges in Croatia participated in the research. Given that it was an open-ended type of question where the respondents indicated the faculty and the place of study, the faculty was not clearly defined from some respondents' answers, because some respondents entered only the place of study or the university, and some did not answer that question at all. The research participants were informed about the aim and purpose of the research, they were given written instructions on how to fill out the questionnaire, anonymity was guaranteed, the possibility of giving up further answering, and it was explained to them that the data obtained from this research will be used exclusively for scientific purposes.

There were 23 (7 %) male and 304 (93 %) female respondents in the sample. The characteristics of the sample with regard to the year of study are shown in the Table 1.

In order to determine whether there are statistically significant differences in the distribution (normality) of the responses of research participants with regard to gender and year of study, the Kolmogorov-Smirnov test was applied, Table 2.

Table 1. Year of study of the research participants.

Year of study	Frequency	Percentage
First year	54	16.5
Second year	45	13.8
Third year	109	33.3
Fourth year	56	17.1
Fifth year	63	19.3
Total	327	100.0

Table 2. Tests of Normality. Lilliefors significance correction was applied within the Kolmogorov-Smirnov test.

Variable	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
V_1	0,219	327	0,000	0,891	327	0,000
V_4	0,380	327	0,000	0,682	327	0,000
V_5	0,335	327	0,000	0,696	327	0,000
V_6	0,359	327	0,000	0,682	327	0,000
V_7	0,200	327	0,000	0,847	327	0,000
V_8	0,409	327	0,000	0,607	327	0,000
V_9	0,266	327	0,000	0,823	327	0,000

Table 2 shows the results of testing the normality of the distribution of dependent variables. The Kolmogorov-Smirnov normality test was applied. The normality of the data distribution is shown to be statistically insignificant, that is, as a random deviation from normality, if the reliability value is greater than 0.05. As in our case the reliability values for all dependent variables amount to $p = 0.000$ and are less than 0.05, Sig. = 0.000 < 0.05, it is concluded that the assumption about the normality of the distribution of the obtained data is not confirmed and it is therefore rejected as such (which is quite common for large samples).

Table 3 shows the values of arithmetic means, standard deviations and skewness of all nine dependent variables. It is observed that the values of skewness for three dependent variables are negative (two of them are greater than one by modulus), which means that most of the obtained results are located to the right of the arithmetic means, among the higher values.

It can be seen from Table 3 that the skewness values for six dependent variables are positive (two of them greater than one), which means that most of the obtained results are to the left of the arithmetic means, among the smaller values.

Table 3. Measure of skewness.

Variable	Mean		Std. Deviation	Skewness	
	Statistic	Std. Error	Statistic	Statistic	Std. Error
V_1	3.16	0.054	0.972	0.242	0.135
V_2	2.24	0.092	1.659	0.994	0.135
V_3	2.47	0.064	1.153	2.431	0.135
V_4	4.43	0.048	0.872	–1.396	0.135
V_5	1.96	0.077	1.395	1.244	0.135
V_6	4.39	0.052	0.946	–1.699	0.135
V_7	2.57	0.081	1.472	0.413	0.135
V_8	1.47	0.047	0.853	2.097	0.135
V_9	3.98	0.059	1.059	–0.602	0.135
Valid *N* (listwise)	327		327	327	

RESULTS AND DISCUSSION

Processing of the data obtained from the research was done using the statistical package IBM SPSS Statistics 21.

The first item that the research participants answered to was related to the average time of daily use of a smartphone. The obtained data and calculated statistical values are shown in Table 4.

Table 4 shows that the largest number of research participants, 38.2 % of them, use their smartphone on average between three and eight hours a day. Comparing the expected (f_t = 65.4) and the observed values (frequencies), a very significant difference was found between them. Namely, the chi-square value is very high, it is χ^2 = 134.697 and it is statistically significant (p = 0.000 < 0.05). Such a high chi-square points to the conclusion that the responses of the research participants are statistically significantly differently distributed. The next item that the research participants answered to was related to visiting social networks using a smartphone. The obtained data are presented in Figure 1, while the calculated statistical indicators are in Table 5.

Figure 1 shows that the largest number of research participants visit the social network Instagram: 54.1 % of them, followed by the social network Facebook with 16.5 %, while the smallest number of respondents visit the social network Snapchat: 1.5 % of them.

Table 4. Data and statistical values for the dependent variable V_1.

Duration	**Less than 1 h**	**1-3 h**	**3-5 h**	**5-7 h**	**More than 7 h**	**Total**
Frequency	5	84	125	80	33	327
Percentage, %	1.5	25.7	38.2	24.5	10.1	100.0
Mean	3.16					–
Std. Deviation	0.972					–
Variance	0.944					–
χ^2	134.697*					–
df	4					
Asymp. Sig.	0,000					

*0 cells have expected frequencies less than 5. The minimum expected cell frequency is 65.4.

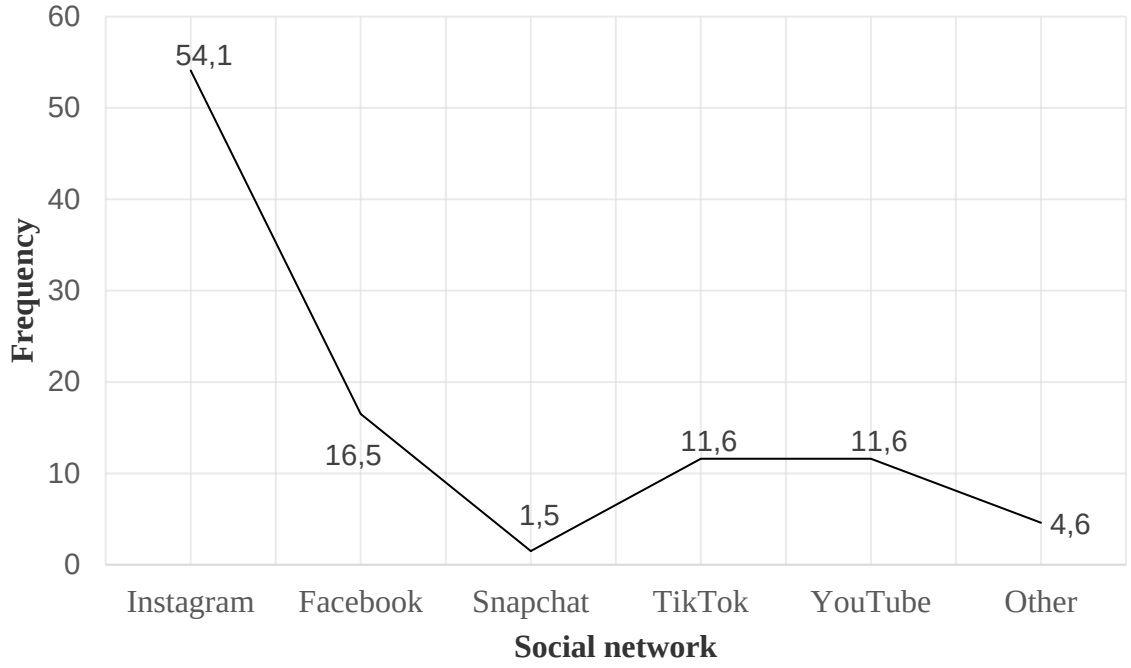

Figure 1. Graphic representation of data obtained with the dependent variable V_2.

Table 5. Data and statistical values for the dependent variable V_2.

Social Media Platform	Frequency	Percentage	Mean	Standard Deviation	Variance	χ^2 *df* Asymp. Sig.
Instagram – 1	177	54.1	2.24	1.659	2.753	358.927* 5 0.000
Facebook – 2	54	16.5				
Snapchat – 3	5	1.5				
TikTok – 4	38	11.6				
YouTube – 5	38	11.6				
Other – 6	15	4.6				
Total	327	100.0	–	–	–	–

*0 cells have expected frequencies less than 5. The minimum expected cell frequency is 54,5.

Table 5 shows the results of respondents about the social network they use the most. In the questionnaire, social networks are written in random order. Furthermore, Table 5 shows that the arithmetic mean for the dependent variable V_2 is $M = 2.24$, the standard deviation $SD = 1.659$, while the variance value is $V = 2.753$.

Regarding the dependent variable V_3, the research participants were asked to indicate how they communicate when using a smartphone. It was possible to opt for one of the offered methods: e-mail, WhatsApp, Viber, Zoom, Telegram or something else. More than 3/4 of respondents (of them: 75.8 %) use WhatsApp when communicating with a smartphone; only one respondent (in the percentage 3 %) uses Telegram. 8.6 % of research participants use some other form of communication. The following statistical values were obtained for this dependent variable: Mean $M = 2.47$, standard deviation $SD = 1.153$.

This was followed by a set of six dependent variables (from V_4 to V_9) that were given to the research participants to express their opinion on. The obtained data and calculated value statistics are presented in Table 6.

Table 6 shows that the highest arithmetic mean is associated with the dependent variable V_4 $M = 4.43$, which means that before going to sleep, a smartphone is used (V_4) by 84.1 % respondents: often 20.5% or very often 63.6% of them. The smallest arithmetic mean has the variable V_8.

Table 6. Obtained data and statistical values with dependent variables V_4, …, V_9 (1 – never, 2 – rarely, 3 – sometimes, 4 – often, and 5 – very often).

Statement	Never		Rarely		Some-times		Often		Very often		Statistical values			
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*M*	*SD*	*V*	χ^2 *df* / Asymp. Sig.
V_4	0	0.0	16	4.9	36	11.0	67	20.5	208	63.6	4.43	0.872	0.761	276.119* 3 / 0.000
V_5	190	58.1	56	17.1	23	7.0	20	6.1	38	11.6	1.96	1.395	1.946	309.223 4 / 0.000
V_6	7	2.1	11	3.4	32	9.8	75	22.9	202	61.8	4.39	0.946	0.895	401.180 4 / 0.000
V_7	112	34.3	66	20.3	50	15.3	48	14.7	51	15.6	2.57	1.472	2.166	44.636 4 / 0.000
V_8	229	70.0	61	18.7	24	7.3	8	2.4	5	1.5	1.47	0.853	0.728	541.914 4 / 0.000
V_9	3	0.9	29	8.9	81	24.8	72	22.0	142	43.4	3.98	1.059	1.122	173.902 4 / 0.000

M = 1.47 which means that almost 89 % of research participants claim that their smartphone never wakes them up during the night (70.0 %), or that it rarely wakes them up (18.7 %).

Furthermore, from Table 6, we observe that all chi-square values are very high and range from χ^2 = 44.636 (for the variable V_8) do χ^2 = 541.914 (for the variable V_8). Chi-squares indicate that the respondent's responses, by all dependent variables, from V_4 to V_9, are distributed statistically significantly differently. The skewness characteristics of each of the dependent variables are presented in Table 7. It can be noted that four skewness values are positive and two values are negative. With positive skewness values, most of the obtained results are to the left of the arithmetic mean, among the smaller values, while the results of negative asymmetries are located to the right of the arithmetic mean, i.e. among the larger values.

Table 7. The skewness of data obtained by the research for the variables V_4, …, V_9.

		Dependent variable					
		V_4	V_5	V_6	V_7	V_8	V_9
N	**Valid**	327	327	327	327	327	327
	Missing	0	0	0	0	0	0
Skewness		0.994	2.431	–1.396	1.244	–1.699	0.413
Std. Error of Skewness		0.135	0.135	0.135	0.135	0.135	0.135

The correlation values of the dependent variables V_4 to V_9 are presented in Table 8. It can be seen that six correlations are significant at the .01 level, and three of them have a negative sign. The highest correlation is between the variable V_6: The smartphone is in my immediate vicinity during the night and the variable V_8: Notifications on my smartphone wake me up during the night; it is a moderate correlation, an essential connection. The value of only one correlation is at the 5 % significance level and it has a negative sign. Other correlation values are not statistically significant.

Table 8. Correlation of dependent variables V_4, …, V_9.

		V_4	**V_5**	**V_6**	**V_7**	**V_8**	**V_9**
V_4	**Pearson Correlation**	**1**					
	Sig. (2-tailed)						
	N	327					
V_5	**Pearson Correlation**	–0,026	**1**				
	Sig. (2-tailed)	0,645					
	N	327	327				
V_6	**Pearson Correlation**	–0,156**	–0,080	**1**			
	Sig. (2-tailed)	0,005	0,147				
	N	327	327	327			
V_7	**Pearson Correlation**	0,074	0,010	–0,145**	**1**		
	Sig. (2-tailed)	0,180	0,859	0,009			
	N	327	327	327	327		
V_8	**Pearson Correlation**	–0,208**	0,067	0,445**	–0,111*	**1**	
	Sig. (2-tailed)	0,000	0,227	0,000	0,044		
	N	327	327	327	327	327	
V_9	**Pearson Correlation**	0,002	0,055	0,373**	–0,020	0,237**	**1**
	Sig. (2-tailed)	0,975	0,323	0,000	0,715	0,000	
	N	327	327	327	327	327	327

*significant at the 0.05 level (2-tailed)
**significant at the 0.01 level (2-tailed)

The conducted research has shown that all respondents use a mobile phone. On average, most respondents use it for three to five hours a day (38.2 %). The obtained information that a total of 10.1 % use it for more than seven hours is worrying. The smartphone has become ubiquitous in the everyday life of students. Frequent use of smartphones can affect the student's mental health and cause addiction to smartphones [29-30], the feeling of boredom and loneliness can cause aggression and addiction [31-32].

Considering the great popularity of social networks and tools for communication, students in this study most often visit the social network Instagram (54.1 %) and Facebook (16.5 %) and WhatsApp (75.8 %) as a tool for communication. Implications for some future research are to investigate how much time they spend on social networks and for what purposes and the possible impact (also) on their mental health.

Furthermore, in the research we were interested in how many respondents use their smartphone before going to sleep and whether the smartphone wakes them up during the night. The obtained data showed that 84.1 % of respondents do this, which could have negative implications for quality sleep, waking up during the night, lack of secretion of the very important hormone melatonin, and fatigue during the next day. Furthermore, a total of 89 % of respondents are not woken up by their smartphone during the night, but the data obtained that 7.3 % are woken up occasionally and 1.5 % very often is worrying. The authors [33-34] who studied the use of smartphones at night and their impact on insomnia concluded that they have negative health implications that can include daytime sleepiness, insomnia, poorer academic achievements and other unwanted consequences. In the research, the greatest connection was determined between the variable V6 (During the night, the smartphone is in my immediate vicinity), and the variable V8 (Notifications on my smartphone wake me up during the night).

CONCLUSIONS

The research shows the influence of smartphones on a sample of a total of graduate and undergraduate 327 students studying at one of the Universities and/or Polytechnics in the Republic of Croatia. We were interested in how much time students use a smartphone on average per day, which social network and communication tool they use the most, and whether they use their smartphone before going to sleep, whether they are woken up by sounds on their smartphone during the night, and whether they think they use their smartphone too much. Considering the many authors [35-37] who have researched the impact of smartphones on students' health, smartphone addiction [38], sleep-related problems [39-41] and the general impact on a person's mental health [42, 43], these studies have shown that excessive use of smartphones is generally not good for health.

What are all the possible reasons for excessive use of the smartphone, visiting social networks; is it boredom, the need to be on trend with the latest information, the number of likes, being seen, popularity, addiction to information, addiction to social networks, addiction to the phone and the inability to access information "immediately, at the moment and on demand" and the like are topics that have been studied and that open up new knowledge and new research of a multidisciplinary character and that require a "holistic" approach.

Lifelong multidisciplinary education about possible health consequences due to excessive use of smartphones is necessary at all levels of the educational process, and it would be wise to conduct it at least once a year.

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DIGITAL TRANSFORMATION OF CROATIAN NEWSPAPERS: ANALYZING EVOLVING PERSPECTIVES OF READERS OVER A FIVE-YEAR PERIOD*

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ABSTRACT

The digital transformation has revolutionized the media industry, reshaping the way news is consumed and challenging the dominance of traditional printed publications. As technology continues to advance at an unprecedented pace, it is crucial to examine the evolving landscape of news publishing and understand the preferences and behaviors of readers in the context of digital and printed newspaper formats. This research article presents a comparative analysis of reader opinions on a significant Croatian e-publication over a five-year period, aiming to explore the impact of digital transformation on readers` perceptions, engagement, and preferences between online and traditional printed content. By delving into the advantages, challenges, and trends associated with e-publications and printed editions, this study provides valuable insights into the dynamic relationship between readers and news publications in the digital era.

KEY WORDS

digital transformation, e-publication, newspaper, printed, readers

CLASSIFICATION

JEL: L82, L86

*In text, specific titles are suppressed with generic notation *Media and* MediaGroup.

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INTRODUCTION

In an era of rapidly advancing technology that has influenced our everyday life and shifting media consumption habits, the landscape of news publishing has undergone significant digital transformations. The complexity and diversity of today's media landscape provides many challenges for scholars studying online news consumption [1]. Traditional printed publications have long been a cornerstone of the industry, providing tangible and trusted sources of information. However, the rise of digital platforms and the advent of e-publications have revolutionized how readers access and engage with news content. This article examines and compares the dynamics between e-publications and traditional printed publications, focusing on a significant newspaper to understand the evolving preferences, advantages, and challenges associated with each format.

News media play a crucial role in providing people with diverse, informed, multifaceted perspectives on local regional and global political, economic, cultural, and other public issues [1]. The digital transformation has revolutionized the media industry, reshaping the way news is consumed and challenging the dominance of traditional printed publications [2-4]. With the proliferation of digital technologies and the widespread adoption of the internet, news consumption patterns have undergone a paradigm shift [1, 5]. The advent of online platforms and e-publications has enabled readers to access news content anytime, anywhere, and has introduced new possibilities for interactivity and engagement [6, 7].

In this new media landscape, traditional printed publications have faced significant challenges. The rise of digital platforms has resulted in declining readership and circulation numbers for print newspapers [8]. This shift can be attributed to the convenience, immediacy, and accessibility offered by digital news sources [9]. Furthermore, digital platforms provide opportunities for personalized content delivery and interactive features, enhancing the overall user experience [10, 11].

The digital transformation has also impacted the business models of organizations, that range from e-learning to news organizations [12]. As advertising revenue has shifted from print to online platforms, publishers have had to adapt and explore new monetization strategies, such as paywalls or subscription models [13, 14]. These changes reflect the evolving dynamics of the media industry and the necessity for publishers to find sustainable revenue streams in the digital age. In addition to the shifting revenue streams, the digital transformation has also brought about changes in the distribution and consumption of news content. With the rise of social media and mobile devices, news organizations have had to optimize their content for online platforms and adapt to shorter attention spans and on-the-go consumption habits of readers [15]. These platforms have become integral sources of news for many readers, offering real-time updates and fostering user-generated content [16]. Social media has an omnipresent impact and has become one of the main marketing tools [17]. This has led to the development of mobile apps and responsive web designs to enhance the user experience and ensure easy access to news content anytime, anywhere. Furthermore, the digital landscape has opened up opportunities for news organizations to engage directly with their audiences through interactive features, comments sections, and personalized content recommendations, fostering a more participatory and tailored news experience. The interactive nature of social media allows for greater audience engagement, as readers can actively participate in discussions and share news articles with their networks [18-20]. The rise of social media has changed the paradigm of information production and consumption, as they are now the preferred means of staying up to date with news and current affairs [20]. Ultimately, these transformations in business models, distribution, and consumption reflect the ongoing adjustments and innovations required to thrive in the digital era.

The digital transformation has brought about significant changes in the media industry, challenging the dominance of traditional printed publications. The convenience, interactivity, and personalized nature of digital news sources have reshaped news consumption patterns, resulting in declining readership for print newspapers. News organizations have had to adapt their business models to sustain profitability in the digital era. Moreover, the emergence of social media and mobile applications has further transformed the way news is disseminated and consumed, emphasizing the need for media organizations to adapt to these evolving platforms.

The increasingly intensive consumption of online news in recent decades has persistently endangered print media, as shown by several partial studies, such as Filistrucchi [21] who showed that the Internet had a negative financial impact on the largest Italian daily newspapers, or Mesquita [22] who showed that French newspapers cannot solve "the dilemma between free and paid content". World statistics show that in 2014 media content was used on average for 455 minutes a day [23], but only 16 minutes were devoted to reading daily newspapers (a decrease of 25,6 % in the period from 2010 to 2014), while magazines were read for 23 minutes a day (a decrease of 19 % in the period from 2010 to 2014). It interesting to notice that global consumption of media content in 2023, dropped for 30minutes to 455 minutes per day [24]. Legacy media like newspapers, "are becoming relatively less important as distributors of news even as they remain very important producers of news"; they seek a way out of financial difficulties by developing "new digital business models as their existing sources of revenue decline or stagnate" [25]. According to the latest EU statistics [26], 72 % of Internet users in the European Union now read their news online, and increasingly through social media instead of news websites. At the same time, interest in news was found to have fallen sharply worldwide, from 63 % of respondents in 2017 to 51 % in 2022 [27]. However, one has to take into account that there are significant differences between countries related to their level of development [28].

The goals of the article are twofold. First, the tables show the ten most read news websites according to Gemius for 2018 and 2023, to get a broad media picture of the popularity of e-publications in Croatia. Second, the results of the focus group discussion with readers of *Media-1*, as an example of e-publication that has introduced paywall, are presented.

The visiting rates of news websites in Croatia in 2018 were compared, and the results were compared with the visits in 2023. Two focus groups were created for the purpose of this research. The first focus group included readers of *Media-1* e-publication, and was held on April 23rd, 2018, in Zagreb, lasting 90 minutes. The second focus group, again with readers of *Media-1* e-publication, was held on February 2nd, 2023, via the Zoom application, lasting 90 minutes.

The participants of the focus groups were asked questions about the advantages of the e-publication compared to the printed edition and the reasons why some readers remained loyal to the paper edition. In particular, the aspects of price, speed, practicality and credibility of online content and the printed edition were investigated.

This article shows the differences in opinions of the users of *Media-1* e-publication towards free content and paywall, as well as the quality and reliability of newspaper articles in the period of five years (2018-2023). At the end of the 20th century, before the emergence of the first e-publications, *Media-1* was the most widely circulated newspaper in Croatia. The online edition of *Media-1* was launched on February 8, 1999 as one of the first e-publications of national daily newspapers in Croatia. In terms of timing, it was not an overly important event; until August 1999, there were only 6 % of Internet users in Croatia [29].

THE CHANGING LANDSCAPE OF ONLINE NEWS CONSUMPTION AND THE IMPACT ON PRINT MEDIA

The rise of digital platforms has not only replaced traditional intermediaries but also revolutionized business models. These platforms have become superpowers, encompassing omnichannel marketplaces that connect online and offline readers [30]. Moreover, they have transformed the linear supply chain pipeline into a dynamic network of interconnected producers and users within a complex ecosystem [31].

Bradshaw [32] lists the following characteristics of online journalism: people can consume it on any internet-connected device; it contains hyperlinks**,** multimedia and occurs in real time; the news is short and concise and can be read by skimming. Such characteristics of online content, as well as its immaterial nature, make the process of news production transparent and, by implication, free of charge. This may seem contradictory for modern generations who grew up in the digital age and mostly have the habit of shopping online [33], but it is in line with the general democratization of society. Attali [34] believes that hyper democracy includes "the mastery of time and meaning, costlessness, brotherhood, universal intelligence, 'good times', the common good". He expressly states that in the future "books and periodicals will be free", as well as music files and movies. According to his expectations, payment will be required only for live entertainment. But experience shows that free content and clickbait headlines "might be perceived as less credible and lower quality by readers" [35].

While some traditional news values, such as proximity, timeliness and impact have remained important in the digital age, other values, such as conflict and novelty, have become more salient due to the competitive pressure of the 24-hour news cycle and the need to attract and retain audiences in all to a more crowded media landscape [36]. One of the ways to win over the audience is to spread clickbait that "lures the reader to worthless content" [37], and completely "problematic information" [38] characterized by propaganda and disinformation. Wardle and Derakhshan [39] calls it "information disorder" characterized by disinformation (information that is false and intentionally created to harm a person, social group, organization, or country) and misinformation (information that is false but not created with the intention of causing harm). In such a situation, some readers remain loyal to print media, which they consider more reliable, and because of this, they are more willing to pay for online content.

Due to all that, it comes as no surprise that research reveals that trust in the media is at an all-time low. However, it is surprising that among younger adults between the ages of 18 and 25, traditional media channels are the most trusted, but at the same time the content from these channels is not considered problematic and journalists, as identifiable sources of news, are largely irrelevant in orienting the information behaviors of this user group with peers being more important influencers and providers of (links to) news [40].

TRENDS IN ONLINE NEWS CONSUMPTION IN CROATIA

This article compares news website visits in Croatia, focusing on data from two significant periods: May 2018 and May 2023. By examining these two timeframes, the study explores potential changes in user behaviour and engagement with online news sources over a five-year interval. The data used for the analysis is sourced from reputable web analytics platforms, ensuring the reliability and validity of the findings.

In May 2018, Croatia's media landscape might have been influenced by various factors, such as political events, social trends, and technological advancements. Comparing this with May 2023, which represents a more recent snapshot, will enable us to observe any shifts in news consumption patterns. By studying these variations, the research seeks to shed light on the evolution of the digital news ecosystem in the country.

PAYWALL IN CROATIA

Media-1 is the first news medium in Croatia to put up a paywall. The preparations for introducing the paywall, which was supposed to be a test model for the entire Croatian newspaper industry, took several months. The model was finally implemented on November 17th 2012 [41]. In the first phase, *Media-1* chose the paywall based on points. Each text had its own point value, which was subtracted from the initial, prepaid balance. The average value of the text was five points, while richer content, with more material or publications in the digital form, could have a higher value. In 2013, metered access was introduced. Namely, every subscriber of the printed edition of *Media-1* could contact the newsroom, which then activated a timed access service. After activating the subscription to the printed edition of *Media-1*, the subscriber could enjoy unlimited "Premium content" online. It should be said that *Media-1* was reluctant to publish the number of real users of the "Premium package" within the e-publication. Considering that all subscribers of the printed edition automatically had a subscription to the "Premium package", it was almost impossible to know the number of real users of the "Premium package". Editor-in-chief of the *Media-1* website, mentioned 10 000 subscribers of the "Premium package" in 2018, but this figure referred generally to "Premium package" users, not just to the people who were ready to pay, and who actually paid for access to the internet content [42].

Table 1. Introduction of paywall on the most visited news websites in Croatia.

Node	2018.	2023.	Payment type	Billing introduced
Media-2	No	No		
Media-3	No	Yes	Charging for certain content	2021
Media-4	No	Yes	Charging for certain content	2021
Media-1	Yes	Yes	Charging for certain content	2012-2019 and 2021
Media-5	No	Yes	Charging for certain content	2023
Media-6	No	No		
Media-7	No	No		
Media-8	No	No		
Media-9	No	No		
Media-10	No	Yes	Billing after 10 articles	2021

The other most read e-publications in 2018 did not charge for access to their online content. The paywall scheme began almost synchronously in 2021, after full free access to content was closed by *Media-1, Media-3, Media-4* and *Media-10*.

MEASURING THE VISITS TO E-PUBLICATIONS IN CROATIA IN 2018 AND 2023

This article provides data from the Gemius Audience agency (the Croatian branch of the company from Poland that has been operating since 2006). At the moment, these are the only relevant results, although e-publications and other online publications are under no obligation to participate in Gemius. Thus, for instance, *Media-15* permanently abandoned participation in the measurement within Gemius in 2015 [43]. The former MediaGroup-1 (today's MediaGroup-2) also left the Gemius Audience measurement system on several occasions.

On June 1, 2015, after two years of development, Ipsos Puls launched DotMetrics in Croatia, a project of Internet audience measurement. This, however, created some paradoxical data, so for example MediaGroup-3 and MediaGroup-2 announced in 2017 that they each had the most read e-publications in Croatia during the same period. The measurement for *Media-3* [44] is based on DotMetrics research, while that for *Media-4* [45], owned by MediaGroup-3 is based on Gemius Audience research. Some publications are not included in the 2018 report (primarily

Media-15 and *Media-3*) while the 2023 report does not include *Media-15*. Moreover, MediaGroup-2 publications have returned to the Gemius measurement.

Tables 2 and 3 show the most visited news websites in Croatian in May 2018 and 2023. The tables show the ten most read news websites according to Gemius for 2018 and 2023, to get a broad media picture of the popularity of e-publications in Croatia. The data for the years 2019, 2020, 2021, and 2022 is provided in the Appendix.

A comparison of the tables shows that in both 2018 and 2023 the same seven news websites are in the top ten e-publications, although there would be nine of them if *Media-3* and *Media-5* (MediaGroup-2 publications) had been included in the Gemius measurement in 2018, Table 2. The changes therefore refer to *Media-11, Media-12* and *Media-14* websites, which were included in the ten most read news websites in 2018, but in 2023 they were no longer included in the top ten. However, when it comes to *Media-11*, it should be pointed out that MediaGroup-4 television network stopped developing *Media-11* as a news website and directed its news content towards the television format and TV channel. In 2019, they took over *Media-6* from MediaGroup-6 and at the same time started developing *Media-13* news website, as a counterpart to *Media-2* news website owned by the competitor MediaGroup-5 television network. In the past five years, *Media-12* was merged to *Media-4* news website to achieve better results.

The top ten news websites in 2023 include the aforementioned *Media-3* (in the second place), *Media-5* (in the sixth place) and *Media-9* (in the eighth place).

In addition, there was an expected increase in the number of readers, that is, real users. Namely, there were 2 418 371 of them in 2018, and 2 855 756 in 2023, which is an increase of

Table 2. The most visited news websites in Croatia in May 2018.

News website	Real users	Page views	Visits
Media-4	1627 619	207 276 762	32 253 017
Media-2	1513 633	55 184 141	17 561 337
Media-1	1377 513	82 329 495	17 769 190
Media-7	1354 100	69 665 550	15 085 453
Media-11	1323 674	31 986 642	11 542 780
Media-6	1276 400	103 343 310	18 855 960
Media-12	830 767	6 335 585	3 418 475
Media-10	748 886	6 022 586	4 193 710
Media-14	731 799	4 673 825	2 509 646
Media-8	564 064	11 733 318	3 749 719

Table 3. The most visited news websites in Croatia in May 2023.

News website	Real users	Page views	Visits
Media-2	2 113 861	193 383 291	31 815 186
Media-3	1965 238	145 713 026	50 940 710
Media-4	1961 442	134 849 231	34 906 459
Media-1	1914 200	77 387 261	27 594 918
Media-6	1772 896	111 923 173	19 792 640
Media-5	1749 820	81 288 038	29 606 220
Media-7	1737 615	72 023 450	15 316 725
Media-9	1493 216	11 102 340	6 498 614
Media-10	1374 266	11 248 235	6 876 955
Media-8	1228 676	19 388 364	9 547 929

approximately 18 %. Perhaps a bigger increase could have been expected in that period because the Internet was by then fully affirmed as a relevant news medium in the world and in Croatia.

According to Gemius data, *Media-2* recorded a strong increase in the readers of e-publications, which went from 1513 533 real users in 2018 to 2 113 861 real users in 2023, which is an increase of almost 40 %. *Media-2* is the only news website among the five most read ones that still does not charge for its content, which possibly helped it to position itself as the leading news website in May 2023 (according to Gemius research). One of the reasons for its success is also the connection with the TV platform, i.e., with the MediaGroup-5 News Program (i.e., the central news program), which is still, according to Ipsos research (using the peoplemeter), the leading news program in Croatia. In May 2023, according to the same survey, *Media-3* was in the second place, but more detailed comparisons are not possible because that news website was not included in the 2018 measurement. It must also be taken into account that *Media-3* includes *Media-16* and *Media-17* websites, which means a bigger number of users. In 2021, *Media-3* introduced a partial paywall for its content – for research articles, comments and interviews, that is exclusive materials that are not available on other news websites. Informative articles and news remained freely accessible. *Media-3* does not publish data on the number of subscribers nor is it obligated to do so.

In 2018, the *Media-4* news website was in the first place, and in 2023 it fell to the third place of all most visited news websites. It should also be considered that in the meantime the *Media-12* website, which was in the top ten in 2018, was also added to it. Like most news websites that have decided to put up a paywall, *Media-4* also decided to partially disable free access to its content in 2021. During the five-year period, the number of visitors to the *Media-4* website grew by 20,5 %, slightly more than the average of internet users of media content in Croatia (18 %), but significantly less than the growth of the *Media-2* website (almost 40 %). The paywall scheme certainly played a big role in it, but there are obviously other factors as well (e.g., content) that led to the smaller increase in the number of readers compared to competing websites.

Only *Media-1* had a paywall scheme in both 2018 and 2023. Visits to *Media-1,* just like the visits to *Media-2*, increased in the five-year period by 39 %, which means that users obviously got used to the paywall on that platform.

Media-7, owned by MediaGroup-7, grew by 28 % in the five-year cycle. That internet website has no restrictions to accessing its content, but it was redesigned at the beginning of 2023. After such changes, there is usually a temporary drop in visits, so a certain time should pass to get a true picture of the readers' interest.

In 2021, the *Media-10* website recorded a significant increase in visits, as much as 84 % in five years. In the meantime, it also introduced a paywall, which could lead to the wrong conclusion that the paywall has no impact on visits. However, in this case, two factors influenced the positive results: in that period, the website profiled itself as distinctly 'journalistic', with many analyses and investigative reporting. Another factor in its popularity is the sale of another e-publication (*Media-6*) from the portfolio in that period, which means that the owner (MediaGroup-6) concentrated on the content and development of the *Media-10* news website.

Interestingly, *Media-8* website had the highest percentage growth in visits in the five-year period, as much as 117 %. It is important to say that *Media-8* does not have a paywall scheme.

CONCENTRATION ANALYSIS OF E-PUBLICATIONS IN CROATIA

Table 4 offers information regarding the concentration levels within the e-publication business in Croatia spanning the years 2018 to 2023. The measurement of concentration encompasses

various indicators, including the foremost e-publication, which is determined based on genuine users, page views, and visits. Additionally, the concentration is assessed by the market share of the leading entity, as well as the concentration ratios C2 and C4, and the Herfindahl-Hirschman Index (HHI). The calculations have been conducted using the total of 10 most visited e-publications as the proxy of the total market size. This approach has been used since the data of the size of the full market of e-publications visitors is unknown, and we have followed the practice of several previous research that also used the limited information about the market size [46]. Between the years 2018 and 2021, the e-publication that held the top position across all three categories, namely real users, page views, and visitors, was *Media-4*. However, a notable shift occurred between the years 2022 and 2023. *Media-2* emerged as the frontrunner in terms of actual users and page views, whilst *Media-3* claimed the top position in terms of visitors.

The market share of the leader experienced a marginal decline across all categories during the specified period, indicating a potential rise in market rivalry or diversification. In the year 2018, the online platform *Media-4* accounted for a 14 % proportion of authentic users, however this figure declined to 12 % for *Media-2* in 2023.

Table 4. Concentration indicators of top 10 e-publications in Croatia (2018-2023).

Concentration indicator	Year	Real users	Page views	Visits
Leading e-publication	2018	*Media-4*	*Media-4*	*Media-4*
	2019	*Media-4*	*Media-4*	*Media-4*
	2020	*Media-4*	*Media-4*	*Media-4*
	2021	*Media-4*	*Media-4*	*Media-4*
	2022	*Media-2*	*Media-4*	*Media-3*
	2023	*Media-2*	*Media-2*	*Media-3*
Leader's market share, %	2018	14 %	36 %	25 %
	2019	13 %	31 %	22 %
	2020	13 %	37 %	25 %
	2021	13 %	27 %	23 %
	2022	13 %	19 %	18 %
	2023	12 %	23 %	22 %
Concentration ratio C2, %	2018	28 %	54 %	40 %
	2019	26 %	48 %	43 %
	2020	26 %	53 % ↑	42 %
	2021	26 %	46 %	42 %
	2022	24 %	37 %	35 %
	2023	24 %	40 %	37 %
Concentration ratio C4, %	2018	52 %	80 %	68 %
	2019	49 %	71 %	67 %
	2020	50 %	80 %	71 %
	2021	50 %	79 %	69 %
	2022	47 %	66 %	62 %
	2023	46 %	68 %	63 %
HHI	2018	1099,28	2078,72	1508,29
	2019	1060,86	1758,24	1479,87
	2020	1071,93	2086,99	1509,39
	2021	1059,82	1770,22	1460,10
	2022	1036,84	1416,29	1304,08
	2023	1024,24	1462,62	1340,44

The concentration ratio C2 quantifies the collective market share of the two leading firms, whereas the concentration ratio C4 quantifies the collective market share of the four leading firms. Both ratios exhibited a fall over the observed time frame, so signifying a decrease in market concentration and implying an enhancement in market competitiveness.

The HHI is widely recognized as a standard metric for assessing market concentration. The calculation involves the process of squaring the market share of each firm participating in the market, followed by the summation of these squared values. In the context of market analysis, it is often accepted that a HHI value below 1500 indicates a competitive marketplace. Conversely, a HHI ranging from 1500 to 2 500 is indicative of moderate concentration, while an HHI over 2 500 signifies a high level of concentration. Between the years 2018 and 2023, there was a decline observed in the HHI across all categories, indicating a transition from a state of moderate concentration to a more competitive market environment.

FOCUS GROUP DISCUSSION WITH THE READERS OF *MEDIA-1* E-PUBLICATION IN 2018 AND 2023

METHODOLOGY

A focus group is a special group technique of conversation that aims to gain a deeper understanding of the researched phenomenon. It is carried out in a small group of participants who discuss a certain topic, with the guidance of an expert – moderator [47]. According to Tkalac Verčić et al. [48], after the detailed preparation of the content of the focus interview, it is necessary to inform the participants about the date and expected duration of the group interview. According to the same source the group interview is conducted in artificially created conditions, usually in the researcher's premises, which must be arranged in an appropriate manner. The entire procedure is recorded with a video camera and subsequently analyzed.

Since the early 1980s, the focus group method has been applied more intensively in market research, bringing a refreshment in the way it combines concepts and research results from different disciplines. It is most often used in marketing research - from planning the launch of new products to evaluating the quality or interest in new television shows before they are broadcast. Public relations in politics gave new impetus to this method, which enables a deeper insight into certain social problems from the voters' point of view and which allows for prior testing of various initiatives and messages [49].

Goals of the Research

The appearance of e-publications raised a new important question: how to make money from Internet content? The answer was seemingly simple, to charge for content by putting up a paywall, so that "content that is behind a paywall is only accessible to the online user if they provide credit card details and subscribe to the publication online" [50; pp.26-27]. *Media-1* was the first e-publication in Croatia to introduce a soft paywall for accessing content**,** on November 17th, 2012. With that in mind, this research was conducted to analyze the content quality, speed, economic viability and credibility of two different platforms of the same publisher.

The goals of the research were to discuss the topics presented in the following parts of the article, covering the topics presented in Figure 1.

Selection of respondents

Respondents were selected in two ways. The first selection was made from the existing pool of respondents that the market research agency *Promocija plus* uses as part of its own internet research panel. This group includes approximately 10 000 respondents from all over Croatia,

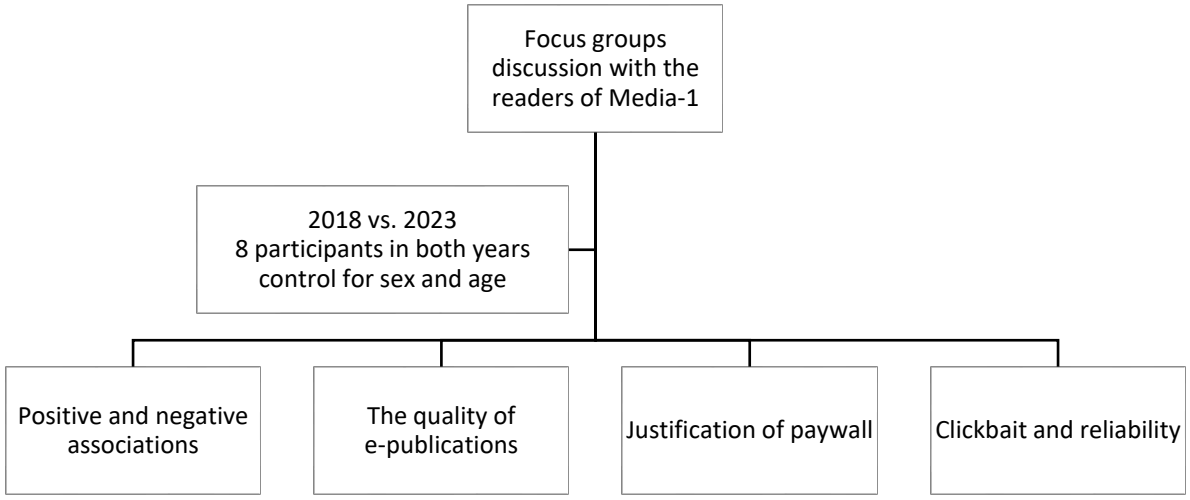

Figure 1. Overview of goals of the focus groups discussion with the readers of *Media-1*.

of different age and educational groups. The second focus group participants were selected from the pool of part-time external associates of the agency, which consists of approximately 2 100 people of different age and educational groups from all over Croatia.

In the first focus group consisting of eight readers of the *Media-1* e-publication, the primary selection criterion, and at the same time the basic principle of homogeneity of the group, was the fact that they were readers of the *Media-1* e-publication. For them, that publication was the primary channel of information considering all e-publications of daily newspapers in Croatia.

A similar criterion was used in the selection of the second focus group, with the only difference that it was held online, which also indicates the development of communication channels and the change in communication habits over five years.

The secondary selection criterion was an equal share of male and female respondents. Moreover, an effort was made to achieve a balance between younger respondents (from 18 to 39 years old) and older respondents (40 years old and older).

The structure of focus group participants in our research was as follows.

The first focus group (2018) included readers of the *Media-1* e-publication. It consisted of a total of eight people with the following demographic characteristics: all respondents were from Zagreb; there were four female and four male respondents; four respondents were aged 18 to 39 and four of them were aged 40 and over.

The second group was the online focus group (2023) which included readers of the *Media-1* e-publication. All respondents were from Zagreb; there were three female and five male respondents; four respondents were aged 18 to 39, and four of them were aged 40 and over.

Correct age representation is extremely important because the use of new technologies, in this case new media, is closely related to the age group of users.

The focus groups were analyzed separately. Below are the results of the focus group discussion with the readers of *Media-1* e-publication.

POSITIVE AND NEGATIVE ASSOCIATIONS OF NEWSPAPER E-PUBLICATIONS

The 2018 focus group had the following positive associations related to the newspaper e-publication: immediacy, free content, speed, convenience, large flow of information, better

information, constant availability of information and environmental friendliness (lesser use of paper). Positive associations mainly confirm the benefits that digital technologies generally bring to their users, not only when it comes to news and newspaper content. These positive associations highlighted by all group participants are speed, constant availability, and a large amount of information.

The following negative associations were highlighted: lack of trust, unreliable information, unverified information, fake news, excessive production of information, bombastic headlines, and empty texts, as well as utterly meaningless news. Two negative associations were singled out at the individual level: addiction to information and constant "copying" between news websites.

The 2023 focus group had the following positive associations related to the newspaper e-publication: easy availability, free content, timeliness, multimediality, possibility of feedback (i.e., leaving comments below articles), live news/breaking news, and a large amount of content in one place. The following negative associations were highlighted: frivolity, excess of yellow press content, paywalls, information that is less important than the information in the printed edition, a large number of orthographic mistakes (typos, grammatical and spelling mistakes, wrong noun cases), bombastic headlines and empty texts, the fact that news websites copy from each other, empty subtitles and clickbait headlines.

By comparing these two groups, it is clear that some characteristics of online content are constantly perceived positively, such as easy availability and timeliness, while hyperproduction and unreliability are perceived negatively. However, some new characteristics were also observed, such as an increase in the number of typos, copying articles from other news websites and clickbait headlines, all of which point to increased competition in which the lack of valuable news is compensated by increased production of 'worthless' content, which is then reflected in an increase in the number of errors.

THE QUALITY OF THE E-PUBLICATION AND THE PRINTED EDITION

In the 2018 focus group, respondents with the experience of reading the printed edition all agreed that the texts of the printed edition were of better quality. They are aware of the printed edition's tradition and quality, but they still feel the impact of technology in their everyday lives. These are their representative opinions:

> *"Somehow, the texts are better, cleaner, and, as we have already said, longer. In addition to all that, while I'm reading the e-publication, I'm also reading the comments that greatly influence my experience of the text."*

> *"E-publications are guided by the motto 'let's publish fast and have as many news items as possible' so there is no selectivity which is sometimes needed. However, a text which is to be printed, needs to be checked first and it therefore seems that only selected, better quality texts get to be printed."*

The 2023 focus group was given the task of comparing the texts of *Media-1* e-publication and printed publication. Participants who read the *Media-1* e-publication and the printed edition noticed significant differences in their content. They emphasize higher quality, more severe and longer texts as well as better sentence structure in the printed edition if compared to the texts in the e-publication.

> *"The printed texts seem more serious to me, and that's why I actually buy printed copies several times a year, I am interested in something that isn't in online editions. Specifically, you know, there is a text about something, and then I find it interesting to read."*

All this again points to a disproportion between the printed edition, which provides better texts but is not as timely, and the online edition which is faster and more interactive.

JUSTIFICATION OF PAYWALL IN E-PUBLICATIONS

The 2018 focus group seems reluctant to pay for access to online news content. The group does not seem to find any justification for the paywall in the e-publication because all news websites rely on advertising as a business model. As respondents say, many advertisers simply "bombard" readers with advertising and due to the existence of advertisements the paywall is not justified.

> *"For me, it's a matter of principle. You bombard me with ads, ads pop up on all sides, and now you want to charge me for content."*
>
> *"I wouldn't pay for it. Today everything is so accessible, I could certainly find the same content or some very similar content on the Internet easily."*
>
> *"If there was a paywall, regardless of its type, I don't think I would use that platform anymore, I would find another one."*

The introduction of a paywall, according to respondents, would definitely affect their current reading behavior by directing them to free news websites. The respondents state that the paywall would only be realistically justified on those internet sites which have no advertising at all, and which live off their readers' subscription.

> *"I know some news websites that are not well known and there are no advertisements there. If you want to read something there, you have to pay a monthly subscription. It's not like this – ads everywhere and they still expect you to pay."*

The group participants need a clear idea about which contents should have a justifiable paywall. Almost all of the participants in the group have yet to purchase content from newspaper e-publications. Only one participant stated that he bought books or music online. As for the attitude towards the price of printed daily newspapers, most believe it is too high and should be between EUR 0,53 and EUR 0,80. In 2018, the respondents considered the price of EUR 1,06 high. In other words, they thought that was the price which made them question their decision to continue buying the printed edition.

> *"Even these 1,06 EUR are too much, except on weekends when the editions are of better quality."*
>
> *"I would give 1,33 EUR just for the weekend edition, and 0,66 EUR during the week."*

They consider the price of EUR 1,33 as the psychological limit, after which they would stop buying newspapers or significantly reduce their purchases. After all, they emphasize that the price increase is conducive to the trend of decreasing circulation of newspapers. In conclusion, the respondents do not feel they need to pay for quality at all.

The 2023 focus group bases its reasons for choosing an e-publication (instead of a printed newspaper) on the already mentioned positive associations about e-publications: easy availability, timeliness, convenience, price (articles in the e-publication are mostly free, and the printed edition of the newspaper is paid for), ease of use and environmental friendliness. The following are two descriptions by the participants that summarize the arguments for the easy availability and environmental friendliness of e-publications and the problem of the price charged for printed editions:

> *"They are easily available, convenient and you can immediately see what is happening at every moment, and I also think, the price. How much? Now everything has become more expensive. I know when I was little, the newspaper would cost, I don't know, 0,53-0,66 EUR. Now there is no newspaper below*

> *1,33 EUR, it now costs two euros, and if you buy it every day or a couple of times a week, I mean, it makes no sense, and what am I supposed to do with the old copies? I mean, throw them in the trash."*

None of the focus group participants have paid for content so far, but they understand that it is someone's intellectual work, and that content has a price. One participant points out that she does not see a problem in paying for e-content, because if people can pay for a printed edition, they can also pay for articles in the e-publication.

> *"Well, I think, if you're already used to buying the printed edition, why not pay for the online edition as well, I mean, I don't see any difference, so if you want to buy the printed edition, you can afford it and pay for the online edition too, so maybe that's, if not cheaper, then it's more accessible, so yes. You have the option every day to browse the Internet instead of going to a newsstand and waste time, then you have to pay to buy it every day, and mostly there is old news in the printed newspaper, so ..."*

Since none of the participants paid for the content in the *Media-1* e-publication, the participants cannot assess whether some content is worth buying and what the quality of the articles is. One of the participants bought a subscription for the *Media-4* newspaper (EUR 7,96 yearly) as part of the Black Friday campaign.

The participants do not consider the paywall justified because they claim that our tastes are different and that someone may find a free article more interesting than a paid one. One participant does not even consider it logical to charge for specific e-contents, but rather suggests charging for the entire newspaper.

> *"I, for one, if I may say so, I don't consider it justified, because sometimes the articles that are twice as interesting to me are free, and some pointless ones are paid for, so it all depends, we're all different, we all read different articles, and now, in my opinion it's not justified, you'd better not give us a single article at all, but I don't know, say how much it costs a month so someone may pay for it, and not like this, you start reading and then you can't finish it because you have to pay ..."*

CLICKBAIT AND RELIABILITY OF E-PUBLICATIONS

In 2018, the focus group expressed lack of trust towards the Croatian media, mostly regarding the disconnection between headlines and texts, fake news, and covert advertising. The group was unanimous in this, but the participants were not feeling very strongly about this, because a certain degree of trust in the *Media-1* e-publication existed, nevertheless. They trust *Media 1* more than other newspapers, but even though there is trust, it exists only to a certain extent, especially when it comes to political topics. Here are the respondents' statements:

> *"If it is about political topics, unreserved acceptance of the articles is completely excluded. If the articles are about culture, cars or, for example, sports, then I believe them."*

> *"In Croatia, no media outlet is completely objective. Everyone is influenced by certain interests, but it is perhaps a little more objective compared to others."*

The trust in *Media-1* e-publication is based on the perception that *Media-1* is somewhat more objective and reliable than other news media. The reason for incomplete trust lies in the fact that the media are connected with power centers and advertisers.

As for clickbait headlines and accompanying texts that are loosely related to them or not related at all, everyone agrees that most headlines in the media are quite bombastic and that it is simply a strategy to lure readers. The respondents have experienced a bombastic headline coupled with

a text that has nothing to do with in the *Media-1* e-publication, but so far in a small number of cases. They believe that clickbait headlines do not describe what *Media-1* truly is as a news outlet; they believe that this practice is more common in other media outlets.

> *"It probably happens, I didn't notice anything that would be alarming."*
>
> *"This practice is not common in this newspaper."*

The attitudes of the group members about fake news are very similar, both in general and specifically regarding fake news in *Media-1*. They do not present specific examples, but state that fake news certainly exists, but it is not a frequent practice. One participant points out that *Media-1* does not have a problem with fake news, but rather with insufficiently reliable information that even the journalist is not 100 % sure about. Such a situation is most often recognized when there is no byline that accompanies an important news item, or the author's full name is hidden behind the initials or there is no information about the author of the newspaper article at all.

It is visible from the group participants' answers and the examples they cite that there is a certain lack of understanding of the difference between a sponsored article and fake news. Those who provide examples actually describe sponsored articles:

> *"I have recently read an article about allergies. So, I'm reading this article and it mentions some new research and institute this and that, and at the end of the text I see it's a paid ad."*
>
> *"A couple of years ago I read an article about bleeding gums and of course if offered a solution* – [title removed intentionally – op.ed.] *mouthwash, etc. So, nothing but buy our products."*

Covert advertising in general, at least in the way the participants perceive it, is not highlighted as a problem that appears often, including in the *Media-1* e-publication. Thematic areas in which covert advertising is mostly noticed include health, nutrition, and lifestyle. In addition, the participants have not noticed any content in e-publications that they would characterize as fake news. What bothers them most are misleading headlines which somehow hide the fact that the article is not neutral. All the participants of the focus group point out that in this case it is not a matter of trust in the texts published in e-publications and the printed edition *of Media-1*, because the texts are more or less the same, except that they vary in length; instead, it is a matter of greater seriousness perceived in the printed edition of the newspaper:

> *"I wouldn't say it's a matter of trust because the article is the same. It is a matter of seriousness of some kind. Unlike the printed edition, the online edition has ads which pop up around articles."*
>
> *"It's not a matter of trust, we just take it (the printed edition) more seriously. Information in the printed edition is more comprehensive and detailed."*

As for trust in the Croatian media, the focus group is unanimous in expressing reservations towards the Croatian media. The respondents do not automatically accept the texts they have read. Instead, they try to filter them.

> *"I also feel lack of trust, but there are media outlets that I trust more than others."*
>
> *"I don't trust Croatian media too much and I try to check certain information by comparison, what others write about the topic that I'm currently reading about."*

They trust *Media-1* more than other news media, but although trust exists, it is still expressed with a certain reserve, especially when it comes to Croatian politics. Some participants believe that lobby groups influence the content:

> *"When I compare it with other newspapers, I trust them the most."*
>
> *"Political texts are the most controversial."*

In the printed edition *of Media-1,* no one has perceived any news as fake news yet. However, most respondents do not perceive fake news in the competing media either, except for one respondent:

> *"It certainly doesn't have that, unlike some other, which has had numerous mistakes so far."*

When it comes to the printed edition of *Media-1*, no one has perceived any news or article as covert advertising. On the other hand, the respondents point out that this is a frequent and common practice in e-publications.

> *"I come across that every now and then in online publications."*
>
> *"Sometimes I have the impression that the text tries to sway me in a certain direction, but by no means that it was written by order, so to speak."*

No one can recall a single case, in any Croatian print media, of a bombastic headline followed by a text which was not related to that headline. They believe that such attitude toward readers is present almost exclusively on the Internet. In terms of trust, both in the e-publication and in the printed edition of *Media-1*, the participants of the discussion emphasize that the same authors and editors work in both types of publications, but they still explicitly express greater trust in the information of the printed edition, which, in their opinion, is more detailed and comprehensive than in the e-publication. The opposite opinion is expressed by only one participant who points out that for him, the type of platform is not a factor of trust or lack of trust.

In the 2023 focus group, one participant explains the negative association with clickbait with the following description:

> *"In online editions, they often have a clickbait article, and you won't really see that in the printed edition. I don't know, just read what someone thought about this or that, and you'll never guess who said what."*

One of the participants of the focus group describes the frivolity of the content as follows:

> *"I mean, compared to the printed edition, the online edition looks frivolous because it highlights the news that is usually skipped in the printed edition, at least I would skip it."*

As for clickbait headlines, i.e., the experience of sensational headlines followed by the text that has nothing to do with it, the participants experienced it in the *Media-1* e-publication, but they believe that such practice is more common in other media outlets:

> *"Take me for example, I read all the headlines first and then I decide if I'm going to read something or not, so it's the headline that will make me decide if I'm going to continue or not, so I mostly skim through everything that way, but I don't read everything in detail."*
>
> *"As I have already said, of course there is that, even quite a lot of it, but this newspaper is not famous for that if you ask me, I would even say it's the opposite."*

The participants noticed clickbait in the *Media-1* e-publication, but less often than in other e-publications. They did not notice bombastic headlines in the print edition.

> *"Well, honestly, in the printed edition, no ... I would just say that one of the good things about them is that there are not many texts or headlines that end with a question mark because as soon as I see a question mark in the headline, I know that the rest of the text is rubbish, and I won't even start to read that."*
>
> *"I mean, look. I noticed it in the online edition now that you mention it. I remember, I remember at the time of the biggest Corona virus panic, I don't know, in 2020, that*

it was famous for that trash, that I had to check it out, I knew it was wrong really, I knew it was wrong, but I had to check it in detail when they wrote about ..."

One of the participants noticed that some authors publish texts on topics and areas for which they are not educated enough.

The attitudes of the members of the group are very similar when it comes to the experience of fake news in *Media-1*. Some participants cannot remember specific examples:

"Yes, I agree, I have to say quite often, I can't remember the exact text and the headline, but I know sometimes that I read the headline and then I read the text and then ... What is that? Ha ha. It has nothing to do with anything, really. So yeah, quite often. Not really, I can't say it only, but others do it more let's say, so it's better than others, more serious."

It is clear from the answers of the group participants that they remember that there was covert advertising, but less than in other publishing houses. Only one participant remembered a weight loss product:

"Or a product for, for shopping. Yeah, weight loss, how to lose weight and suddenly the article ends, so you should buy this product to lose weight. I mean, really."

The participants of the focus group point out that they trust the printed edition of *Media-1* more because the articles are verified by editors, the information reaches the readers more slowly, and there is less probability of error than with the articles in the e-publication:

"I trust print a lot more."

"I mean, it's logical, printed news is checked and verified a lot more, so it's slower and therefore should be trusted more, right? Everything that is online, that is fast, leads to a greater possibility of error, right?"

CONCLUSION

The objective of this study was to conduct a longitudinal analysis of reader opinions concerning e-publications over five years. The research focused on comparing and contrasting the perspectives of two distinct cohorts of readers from *Media-1*, a prominent Croatian e-publication. The first cohort consisted of readers in 2018, while the second comprised readers from the same platform in 2023. Ultimately, this research aims to provide valuable insights into the dynamics of online news consumption in Croatia and contribute to a deeper understanding of the ever-changing media landscape.

The comparative analysis revealed consistent positive perceptions among readers regarding specific online content attributes, such as accessibility and timeliness. Concurrently, negative perceptions persisted concerning attributes like hyperproduction and unreliability. The study also identified emergent characteristics over time, including increased typographical errors, textual duplications from other news websites, and the prevalence of clickbait headlines. These developments are influenced by heightened market competition, wherein the proliferation of trivial content compensates for the scarcity of valuable news. Consequently, the pressure to publish promptly contributes to a rise in errors.

Persistent disparities are observed between printed and online editions. While the printed version is perceived to offer superior text quality, it needs to catch up in terms of speed and interactivity. Interestingly, respondents resist accepting paywalls, believing that paywalls manipulate them, albeit without clear understanding. This lack of distinction between native advertising and clickbait fuels criticism towards paywalls. Paradoxically, despite perceiving paid content as higher quality, focus group participants reject the implementation of paywalls.

This dichotomy between opinions and actions could be attributed to users' positive association with free content in Internet editions. Nevertheless, this study reveals that users associate free content with negative phenomena like fake news and clickbait.

Analysis of news website visits in Croatia indicates that e-publications offering free content experience faster growth than those implementing paywalls to restrict full access.

Concentration analysis has been conducted using the data of visitors of e-publications in Croatia. In brief, an observable transition in market dominance within the e-publication sector in Croatia has been noted between 2018 and 2023. This movement has been accompanied by a general decline in market concentration, indicating a potential rise in competitive forces or a broader range of market offerings.

This study highlights the importance of increasing efforts to raise awareness among online media consumers regarding the critical analysis of news value and journalistic practices. Encouraging individuals to engage in thoughtful reflection on media content is crucial. Incorporating media literacy education can significantly enhance their understanding of how the media influence public discourse and cater to the general interest. The authors of this article aspire for it to be a significant step in that direction, fostering a culture of media literacy and prompting further research in similar domains to advance knowledge in this field.

When evaluating the results of this research, the following limitations should be considered. First, the results of the focus group cannot be generalized to the entire population and as such, they cannot offer a quantitative answer about the phenomenon which is analyzed. This method provides certain qualitative answers to the question “why”. Second, the research focused to a limited number of e-publications, namely, to the most visited news sites, while in the same time, general publication is using social media and messaging platforms increasingly as the main source of news and relevant information. These two limitations pose at the same time the directions for the future research, that should be focused on the survey research on the larger sample of participants, considering not only newspaper websites, but also alternative sources of news and information, such as social media and messaging platforms. Future research should also consider the regional component and could analyze the development of e-publications in a wider geographical environment. Additionally, new technologies, that are becoming increasingly present, such as augmented reality [51] and big data [52], will also have a significant impact on the ways that the news are consumed, which also poses the fruitful area of future research of the media, but also of other industries related to technology.

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APPENDIX

Table 5. The most visited news websites in Croatia (2019-2022).

Year	News website	Real users	Page views	Visits
2019	Media-4	1964967	271135389	41283161
	Media-2	1831896	84617144	19879108
	Media-1	1692989	94921676	23893568
	Media-7	1678879	73990446	16703737
	Media-11	1608956	56186011	15304021
	Media-15	1606985	145773196	41055058
	Media-6	1532155	105376853	20248013
	Media-10	1048355	19072955	4193710
	Media-14	952942	5772984	3246790
	Media-12	859159	6694045	3829195
2020	Media-4	2015259	258656179	44902252
	Media-2	1962174	93783767	23967693
	Media-1	1952258	99746914	29567717
	Media-6	1862730	117036044	31603146
	Media-7	1731879	63676424	16446495
	Media-11	1662789	24253493	10186865
	Media-10	1229712	19505441	9436623
	Media-14	1187098	9449312	5963747
	Media-8	1080007	17518741	7764141
	Media-9	791228	4969352	2715502
2021	Media-4	2012613	182111643	42320373
	Media-2	1999260	110959859	24925082
	Media-1	1957858	111797399	35585121
	Media-6	1758305	123469360	24866322
	Media-7	1716196	69785585	19198235
	Media-11	1534745	29793847	11760068
	Media-9	1193259	10964013	7046703
	Media-14	1165328	8435503	5387279
	Media-10	1109635	10905313	8011194
	Media-18	997916	11597961	5529294
2022	Media-2	2193333	147512674	32162893
	Media-4	2059723	162880219	44975481
	Media-1	2024093	109614828	37668592
	Media-6	1947975	130790579	32889784
	Media-3	1917499	116032618	46711589
	Media-7	1700814	63870207	17293979
	Media-5	1673458	67524856	27847742
	Media-11	1437986	21531551	8979261
	Media-10	1222765	11410240	7808266
	Media-9	1205744	9982581	6307554

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PERCEPTION OF SOCIAL CONTROL OF MARIJUANA AMONG ZAGREB STUDENTS – FINDINGS ON GENDER DIMENSION

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ABSTRACT

The article presents the results regarding differences between attitudes of male and female students towards, as well as patterns of marijuana use among undergraduate and graduate students in Zagreb. Attitudes towards marijuana were examined within the framework of re-evaluating the analytical utility of Becker's mechanisms of social control – availability, secrecy, and morality. Through a survey conducted among Zagreb students, it was revealed that the differences in usage patterns between male and female students are negligible and align with findings from other studies indicating that the disappearance of gender differences is most pronounced among young adults. On the other hand, the perception of Becker's mechanisms of availability and morality between male and female students is expressed in terms of statistical significance, but with a limited impact – female students consider marijuana somewhat more available, but they are also slightly more committed to official, morality-based definitions of marijuana harm. Regarding the mechanism of secrecy, differences between male and female students were not identified, and students continue to perceive concealing marijuana use and its effects as important. As confirmed in other research, Becker's mechanism of availability proves to be poorly functional in the context of social control of marijuana, while the mechanism of secrecy remains analytically useful in conditions of marijuana illegality, regardless of its decriminalization in Croatia. The somewhat stronger expression of the morality mechanism in female students leaves room for exploring gender-biased aspects of social control.

KEY WORDS

marijuana use, students, gender differences, social control

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NTRODUCTION

Social control over marijuana use in Croatia is currently integrated within the framework of its decriminalization policy. The cultivation, processing, possession, and trade of marijuana are illegal, while the sanctioning for possession of small quantities for personal use must handed to misdemeanor proceedings [1, 2]. As a part of misdemeanor procedures, possession of marijuana for personal use is penalized with fines, typically around the legally prescribed minimum [3], occasional urine testing, and some forms of informal social control in cases involving minors. The use of marijuana for medical purposes is not prohibited but is only recognized in the treatment of the most severe illnesses [4, 5], and it entails the use of approved marijuana-based medications under medical supervision.

Despite the decriminalization of personal use, marijuana remains illegal in Croatia, and it is often portrayed as harmful and undesirable in public discourse. This is frequently emphasized with remarks about the increasing percentage of active ingredients in newer strains, marijuana dependence, dangers to mental health, and the widespread recreational use of the substance [6].

Sex and gender differences and their social implications regarding marijuana use in Croatia can be discerned from multiple studies and official drug reports. Most of these studies indicate that sex differences decrease among young adults (18-25 years old) who have tried, or those who occasionally or regularly use marijuana [7-9]. However, the differences remain relatively stable in the general population of Croatia [10-12]. Some studies have also explored and interpreted sex and gender differences in motivational aspects of marijuana (and other drug) use [13], family background, and through the application of other theoretical concepts [11]. Reduction in differences can be partially observed in terms of the broader normalization of marijuana use [6] – use prevalence in Croatia is slightly higher than the European average [14], it is visible in public spaces, and its social representation suggests a tolerable offense [6].

Essentially, these findings align with results from studies in some other countries. It appears that the gender gap is no longer as pronounced as it used to be, and its diminishing is increasingly evident in the rising lifetime prevalence of marijuana use among women. However, research findings suggest that men still lead not only in lifetime prevalence but also in frequency and quantity of substance use [15-18]. Men are more likely to consume marijuana in various ways and prefer more potent strains [19]. On the other hand, the reduction in the gap was indicated with the elaboration of the normalization thesis in the 1990s, according to which, for the context of drug use, gender is no longer a valid predictor with a tendency to further decline in importance for understanding drug use in the 21st century [20]. This has been repeatedly confirmed in subsequent studies [21-25] and studies highlighting the need for gender dimensions of marijuana and other drug use to move beyond examining differences between men and women in prevalence, attitudes, and opinions and to address questions emerging from gender studies themselves [18-19, 21, 26, 27].

Given that marijuana in Croatia is somewhat normalized but still illegal, existing studies have investigated the extent to which common mechanisms of social control of marijuana are functional in such circumstances. As part of research conducted among undergraduate and graduate students in Zagreb [6], we examined the obtained results regarding the gender dimension to determine if there are differences in the perception of mechanisms of social control of marijuana between male and female students. In addition to the perception of social control mechanisms, in order to enable a more precise elaboration on gender differences, results on the age of first consumption, frequency of use, reasons for use, user self-image, and preferred use environment were obtained.

In developing social control mechanisms, we relied on Becker's sequential model of deviance [28], which was developed precisely on marijuana users and whose analytical utility

has been questioned in recent studies and in times of global marijuana use normalization. Considering the stages through which a person develops into a marijuana user for pleasure, Becker indicated the importance of neutralizing mechanisms of social control, which manifest in hindering marijuana availability, suppressing its visibility in wider society, and morally discrediting both the use itself and its users. According to Becker, changes suggesting the success of neutralization occur simultaneously across all three mentioned mechanisms but vary in stages in the marijuana user's career, depending on whether they are beginners, occasional or regular users [28].

The hindrance of marijuana availability occurs through its prohibition and relegation to the realm of illegality, making supply more unstable and insecure. As with availability decrease, use becomes less stable and constant, this also involves the precaution of avoiding sanctions. Beginners and occasional users will rely significantly more on chance or acquaintances with other users, while regular users will focus on establishing a more stable connection with and will purchase marijuana from dealers as in any other commodity-cash transaction. On the other hand, concealing marijuana use allows users to avoid formal and informal sanctions, i.e., condemnation of such behavior by non-users. In cases of frequent use, this includes avoiding non-users themselves and directing daily activities toward the user group or subculture. Finally, neutralizing the mechanism of moral discredit of marijuana use involves rejecting the notion of use as an immoral and health-harming practice. Discarding prevailing stereotypes in drug use and rationalizing one's own activities are prerequisites for future use. The success of neutralization is reflected in the ability to interpret conventional notions about marijuana in terms of uninformed outsider views that are not resonant with user perceptions based on their own and wider user experience [28].

Through developments in the decades following Becker's original study, marijuana use has expanded both in terms of lifetime prevalence and the fragmentation of the user population. What is more, changes in the social context of marijuana use are evident in the rise of more tolerant social policies that vary from decriminalization to legalization in many countries in the 21st century. Recent studies often interpret the weakening influence of Becker's mechanisms of social control over marijuana use from the perspective of normalization theory [29-31] and place it in the realm of tolerable offenses [32]. For example, a study on marijuana use among Canadian students conducted shortly prior to its legalization by Hathaway shows that the question of availability and supply is mediated by informal friend networks, where reciprocity and sharing facilitate the use as a normalized and shared practice. However, some authors [33] point out that Becker's mechanisms at the beginning of the 21st century are more persistent than is commonly thought and express the persistence of the prohibitionist paradigm in drug policy [34].

In a study conducted among Zagreb students, the question of the perception of Becker's mechanisms of social control of marijuana use was at the forefront. In this paper, we examined these results through questioning prevailing findings in available studies on the gender dimension of marijuana and other drug use in Croatia [7-14] – in terms of frequency, different forms of prevalence, and motives for use. Two additional questions about the perception of one's own user status and the preferred use environment were included to provide some basic information about patterns of use.

METHODOLOGY

RESEARCH OBJECTIVES AND METHODS

As part of the research on patterns of marijuana consumption and the perception of social control among Zagreb students, determining gender differences is one of the focal points of

this study. Therefore, it was necessary to establish the frequency and motives of use, as well as the elements of marijuana use patterns mentioned in the introduction, with respect to gender. Subsequently, we tried to determine whether the obtained findings suggest statistically significant differences between male and female students. Finally, we wanted to explore to what extent theoretically formulated Becker's mechanisms of social control of marijuana use are applicable concerning any gender differences in their perception. The research questions can be summarized as follows:

RQ_1: Do the obtained findings on forms of frequency, motives, and selected patterns of marijuana use among Zagreb students show differences with respect to gender?

RQ_2: Are there differences in the perception of Becker's mechanisms of social control among male and female Zagreb students?

Regarding the first research question, a descriptive analysis was accompanied by an independent samples t-test. Concerning the second research question, the reliability of the constructed scales measuring the perception of availability, secrecy, morality/beliefs was first determined with the Cronbach alpha coefficient, followed by an independent samples t-test.

QUESTIONNAIRE

The questionnaire constructed for the research had three parts. The first part consisted of questions about the respondents' socio-demographic characteristics: gender, place of residence, field of study, number of household members at the place of residence, employment status, monthly budget, and parental education status. In the second part, for respondents who used marijuana at least once in their lives, elements of marijuana use were examined, with findings from previous Croatian studies - frequency and motives of use - supplemented by the perception of personal user status. Additionally, among students who have never used marijuana, the frequency of encounters with marijuana and potential motives for trying it were investigated. The third, final part of the questionnaire used for the analysis in this study focused on the perception of social control mechanisms directly aimed at preventing and discrediting marijuana use, according to Becker. These mechanisms include availability, secrecy, and morality, as elaborated in the introductory part of this article.

The scales measuring the perception of availability, secrecy, and morality contained statements about the relevant aspects of marijuana consumption (Table 1) and the procedure of their validation is already described in detail in another article [6]. Agreement and disagreement with the offered statements were expressed on a five-point scale – from "1 – strongly disagree" to "5 – strongly agree".

SAMPLE AND RESEARCH CONDUCT

The population covered by this research consists of Zagreb students – from the University of Zagreb, the Croatian Catholic University, private universities, and colleges. The research used a quota sample comprising 645 Zagreb undergraduate and graduate students. Quotas were determined based on gender and the field of study. Sample construction (and quota determination) was based on available data on the characteristics of the population of Zagreb students, participants in higher education programs in the city of Zagreb. As shown in Table 2, the sample consisted of 58,9 % female students and 38,3 % male students, with 2,8 % of students not identifying within the classical dichotomous division into men and women. Therefore, since this research sought to determine the possible existence of differences between genders, the mentioned 2,8 % ($N = 18$) of participants were excluded from the sample, resulting in a final sample of 627 Zagreb students.

In addition to gender, the quota sample also included the field of study. The distribution of students in the sample across various fields of study was as follows: 39,1 % in social sciences,

Table 1. Becker's mechanisms of social control.

	Statements	*N*	$\bar{x}$	SD
Availability (Cronbach α = 0,790)	Marijuana is relatively easy to obtain today.	645	4,21	0,961
	Usage of marijuana is not uncommon at social gatherings (parties, concerts, outings, weddings, etc.).	645	3,93	1,079
	It is not easy to obtain marijuana because it is illegal.	645	1,83	0,939
	Police actions make obtaining marijuana more difficult.	645	2,45	1,083
Secrecy (Cronbach α = 0,850)	If someone uses marijuana, it is better not to talk about it with colleagues at work.	645	3,55	1,127
	Marijuana consumers are wise not to let their broader environment find out.	645	3,42	1,086
	In certain situations, marijuana consumers must be careful not to be noticed.	645	3,83	1,039
	Marijuana consumers need to be careful not to let their parents find out.	645	3,29	1,049
Morality (Cronbach α = 0,808)	The current marijuana prohibition is morally justified.	645	2,90	1,271
	Statements about the harmful consequences of marijuana consumption are exaggerated.	645	2,94	1,184
	I trust psychiatrists and other experts when they talk about the harmfulness of marijuana.	645	3,39	1,157
	Consuming marijuana is an appropriate way to relax from stress.	645	2,90	1,152
	I consider most negative information about marijuana consumption that I heard in school to be accurate.	645	3,06	1,165
	Frequent marijuana consumption is an escape from reality.	645	3,73	1,157
	Ultimately, the law prohibits marijuana because its use can be harmful.	645	3,44	1,192
	It's not worth it for me to violate social norms.	645	3,07	1,119
	Occasional marijuana consumption is not harmful.	645	3,45	1,124

*The nuanced statements are not included in the final version of the questionnaire for greater internal consistency of the scales.

Table 2. The sample structure according to gender.

	F	%
Men	247	38,3
Women	380	58,9
Other	18	2,8
Total	**645**	**100,0**

29,9 % in technical sciences, 12,4 % in biotechnical and biomedical sciences, 9,3 % in humanities, and 9,3 % in natural sciences (the quotas for students from interdisciplinary and artistic fields were not defined due to their negligible numbers). Despite these quotas, the sample is non-probabilistic, i.e., convenient.

Moreover, the specificity of the sample, consisting exclusively of the student population, inevitably limits the generalizability of findings to a broader population, such as young adults in general. The student population is characterized by frequent redefinition of categories such as "desirable" and "undesirable", stemming from fundamental aspects of the student lifestyle.

Some authors [35-37] suggest that impending employment demands, dynamic changes in group environments, and greater susceptibility to external influences contribute to the non-crystallization of attitudes among students.

However, despite these acknowledged limitations, the sample composed of a student population can still be employed to test and identify the boundary conditions of the theory [37]. Considering the importance of changes in the group environment for dimensions such as availability, secrecy, and morality, along with the flexibility of attitudes and the need for frequent reassessment of conventional beliefs, specificities of the chosen sample are presumed to be plausible.

Finally, similar studies have established that the university serves as a social space conducive to researching the gender and drug use dimensions in an environment primarily adapted to young adults, some of whom do not use drugs [27, 30].

The data were collected using a combination of two survey completion techniques: Mobile Assisted Personal Interview (MAPI) and paper/pencil (PAPI). MAPI was the primary technique, with students accessing the survey on their smartphones or personal devices via a link or QR code in Google Forms format. In cases of technical difficulties during the MAPI technique, the PAPI method was employed, and researchers manually entered the data into the database. Surveys were distributed and completed at the beginning of lectures in collaboration with various professors at Zagreb faculties. The average duration for survey completion was 15 minutes, and students were informed about the purpose and objectives of the research before participating. Participation was voluntary, anonymous, and students could discontinue survey completion at any time. The data collected through the survey questionnaire were processed using the Statistical Package for the Social Sciences (SPSS) statistical software.

RESULTS

Addressing the first research question involved a descriptive analysis of specific marijuana use patterns among male and female Zagreb students. Regarding the prevalence of marijuana consumption, the data in Table 3 show that slightly more than half of male (54,7 %) and female (56,3 %) students reported having consumed marijuana at least once in their lives. A small percentage chose not to answer (1,6 %), and 43,7 % of males and 42,1 % of females stated they have never used marijuana. Consequently, 135 male students and 214 female students provided responses to further questions directly related to marijuana use, while other male (N = 108) and female (N = 160) students were asked about their future prospects of trying marijuana.

Table 3. Have you ever consumed marijuana in your life?

Answer	**Men**		**Women**		**Total**	
	f	**%**	***f***	**%**	***f***	**%**
Yes	135	54,7	214	56,3	349	55,7
No	108	43,7	160	42,1	268	42,7
I don't want to answer	4	1,6	6	1,6	10	1,6
Total	**247**	**100**	**380**	**100**	**627**	**100**

With regard to students who have consumed marijuana at least once, more than half of male students (51,1 %; f = 69) and female students (55,1 %; f = 118) identified socializing and recreation as the primary motivation for marijuana consumption. Meanwhile, 26,7 % of male students (f = 36) and 29,0 % of female students (f = 62) cited relaxation and stress relief as the main drivers for marijuana use.

Concerning the preferred social setting for marijuana consumption, a majority of both male (89,7 %; *f* = 121) and female students (90,6 %; *f* = 194) indicated a preference for consuming marijuana "with 1-2 friends" or "with a group of friends/acquaintances".

Among students who have never consumed marijuana in their lives, the prevailing reason is a lack of interest in trying it. Specifically, 82,4 % of male students (*f* = 89) and 76,3 % of female students (*f* = 122) expressed no desire to try marijuana. This indicates that a total of 78,7 % of surveyed male and female students who have never used marijuana have no interest in trying or consuming it. Moreover, the proportion of individuals expressing a desire to try marijuana (10,4 %) is slightly lower than of those who are uncertain about it (10,8 %).

Additionally, among male and female students who have never consumed marijuana in their lives, nearly one-fourth of the surveyed students (25,7 %) have never been in a situation where marijuana was consumed. This includes 27,8 % of male students and 24,4 % of female students. Combining this group with those who have been in such a situation only once, more than a third of surveyed male (38,9 %) and female (38,8 %) students have either never or only once found themselves in a situation involving marijuana consumption.

Regarding self-perception of user status among students who have tried marijuana once or occasionally and those who use it frequently (Table 4), almost half of male students (49,6 %) see themselves as non-users, while 45,3 % of female students share the same self-perception. Notably, 7,3 % of female students perceive themselves as frequent users, and a similar percentage applies to almost every tenth male student (9,6 %).

Table 4. How do you perceive your marijuana consumption?

Answer	**Men**		**Women**		**Total**	
	f	**%**	***f***	**%**	***f***	**%**
Regular user	13	9,6	16	7,5	29	8,3
Occasional user	55	40,7	101	47,2	156	44,7
Non-user	67	49,6	97	45,3	164	47,0
Total	**135**	**100**	**214**	**100**	**349**	**100**

Through a descriptive analysis, the frequency of marijuana consumption in various forms of prevalence was determined. Table 5 reveals that, in the last month, more than a third of respondents (35,8 %), including both female (35,1 %) and male (37,8 %) students, have consumed marijuana. In addition, at the time of the survey, every fifth participant (20,3 %) had used marijuana in the last week – 23,0 % of male and 18,7 % of female students. Nevertheless, it is notable that the proportion of male and female students who last consumed marijuana more than a year ago (compared to consumption in the last month) is almost equal.

Table 5. When was the last time you consumed marijuana?

Answer	**Men**		**Women**		**Total**	
	F	**%**	**F**	**%**	**F**	**%**
In the last week	31	23,0	40	18,7	71	20,3
In the last month	20	14,8	35	16,4	55	15,8
In the last year	28	20,7	55	25,7	83	23,8
Over a year ago	52	38,5	82	38,3	134	38,4
Not sure	4	3,0	2	0,9	6	1,7
Total	**135**	**100**	**214**	**100**	**349**	**100**

In order to determine whether the observed gender differences between male and female students are statistically significant, an independent samples t-test was conducted. The results indicated that, in none of the examined dimensions of use – consumption, perception of user

status, frequency, motives, and tendencies regarding consumption – there is not a statistically significant difference between male and female students in Zagreb.

To explore whether there are differences in the perception of Becker's social control mechanisms among male and female students in Zagreb, the internal consistency of the scales measuring the mentioned control mechanisms – availability, secrecy, and morality – was checked. For this purpose, the reliability analysis was performed for each of the scales based on the results obtained from the overall sample (N = 645). Through this procedure, certain items were excluded from the final version of the questionnaire (see Table 1), and the Cronbach's α coefficient for each of the final scales is presented in Table 6.

Table 6. Analysis of scale reliability.

	Cronbach α
Availability	0,790
Secrecy	0,850
Morality	0,808

In general, the descriptive analysis of the perception of marijuana availability (see Table 7) shows that 77,0 % of males (f = 190) and 87,9 % of females (f = 334) agree with the statement that obtaining marijuana is relatively easy nowadays. Therefore, approximately 4 out of 5 surveyed students (83,5 %; f = 524) believe that marijuana is very accessible today, meaning it is easily obtainable.

Table 7. Marijuana is relatively easy to obtain today.

Answer	**Men**		**Women**		**Total**	
	f	**%**	***f***	**%**	***f***	**%**
Strongly disagree	11	4,5	8	2,1	19	3,0
Disagree	10	4,0	1	0,3	11	1,8
Neither agree nor disagree	36	14,6	37	9,7	73	11,6
Agree	76	30,8	153	40,3	229	36,5
Strongly agree	114	46,2	181	47,6	295	47,0

Through a descriptive analysis of the perception of the moral justification of the current marijuana prohibition (see Table 8), a nearly even distribution was observed among female students regarding agreement or disagreement with the statement. That is, one-third of the surveyed female students agree (f = 128), another third disagree (f = 126), and the final third neither agree nor disagree (f = 126) that the current marijuana prohibition is morally justified. Concerning male students, the distribution is similar but with a higher proportion (39,7 %) expressing disagreement with the statement (f = 98). Therefore, the largest proportion (36,1 %) of all surveyed students believes that the current marijuana prohibition is not morally justified (f = 226). However, almost a third of their peers either think otherwise (31,9 %) or cannot align with either of these two positions (32,1 %).

Table 8. The current marijuana prohibition is morally justified.

Answer	**Men**		**Women**		**Total**	
	f	**%**	***f***	**%**	***f***	**%**
Strongly disagree	54	21,9	55	14,5	109	17,4
Disagree	44	17,8	73	19,2	117	18,7
Neither agree nor disagree	75	30,4	126	33,2	201	32,1
Agree	38	15,4	78	20,5	116	18,5
Strongly agree	36	14,6	48	12,6	84	13,4

In case of availability, the Cronbach's alpha coefficient of internal consistency is 0,790, and the final version of the scale consists of two items, with a possible result range from 2 to 10 –

a higher score implies a higher perception of availability. An independent samples t-test revealed a statistically significant difference ($t(625) = –2,763$; $p = 0,006$) in the perception of marijuana availability among Zagreb students, between men ($M = 7,91$; SD = 2,077) and women ($M = 8,34$; SD = 1,602), Table 9. Among women, availability as a social control mechanism is perceived as far less effective. In other words, compared to male students, female students consider marijuana to be more easily accessible. However, the difference in mean values equals –0,430 (95 % CI: –0,736 to –0,124) and is considered small (eta squared = 0,012).

Table 9. Comparison of availability perception

	Men (f = 247)		Women (f = 380)		t-test	P
	Mean	**SD**	**Mean**	**SD**		
Availability	7,91	2,077	8,34	1,602	–2,763	0,006*

*significant at the level $p < 0,01$

With regard to the morality mechanism (see Table 10), a high Cronbach alpha coefficient of internal consistency was obtained ($\alpha = 0,808$). In this regard, the final version of the scale consists of 5 items, allowing a range from 5 to 25. A higher score indicates greater inclination toward conventional beliefs and attitudes regarding marijuana use. Once again, a statistically significant difference was found between male and female students in Zagreb ($t(625) = –3,351$; $p = 0,001$), with a small effect size (difference equals –1,191 with 95 % CI: –1,889 to 0,493; eta squared = 0,017). Concerning statements reflecting conventional, institutionally grounded attitudes toward marijuana, women ($M = 16,93$; SD = 4,265) expressed a higher level of agreement than men ($M = 15,24$; SD = 4,477).

Table 10. Comparison of morality perception.

	Men (f = 247)		Women (f = 380)		t-test	P
	Mean	**SD**	**Mean**	**SD**		
Morality	15,24	4,477	16,93	4,265	–3,351	0,001*

*significant at the level $p < 0,01$

In the scale measuring the perception of secrecy, the highest Cronbach's alpha coefficient of internal consistency was identified ($\alpha = 0,850$). However, there was no statistically significant difference between female and male students in Zagreb (see Table 11).

Table 11. Comparison of secrecy perception

	Men (f = 247)		Women (f = 380)		t-test	P
	Mean	**SD**	**Mean**	**SD**		
Secrecy	13,96	3,662	14,23	3,179	–0,952	0,341

DISCUSSION

The presented results suggest a decrease in gender differences in marijuana use and its social control perception among undergraduate and graduate students in Zagreb. In the findings, there is little evidence of disparities, and where statistically significant, the impact size is small.

The findings on marijuana use align with results from research conducted in other countries, suggesting a reduction in gender disparities in the lifetime prevalence of use among young adults [20-25]. The findings on weekly, monthly, and yearly prevalence also indicate a lack of gender differences – where differences are identified, they are extremely small, unstable, and inconsistent. This holds true for students who have never consumed marijuana; gender differences are mild in terms of the desire to experiment and almost negligible when it comes to the absence of encounters in situations where marijuana is being consumed. Finally, gender differences are weakly expressed in terms of self-perception among users – in the case of regular users, men slightly outnumber women, and for occasional users, the difference is minimal.

The findings on the perception of Becker's mechanisms of social control suggest the existence of gender differences in the assessment of the mechanisms of availability and morality, with an absence of differences in the perception of the mechanism of secrecy. In questions related to the perception of the latter, it was revealed that students, in general, view concealing marijuana use as an important factor in neutralizing social control. In other words, concealing use from parents, colleagues, the broader social environment, etc., is considered important by more than two-thirds of the surveyed students, regardless of gender and user status. In this regard, Becker's mechanism of secrecy has proven to be a persistent and still relevant aspect of marijuana use.

On the other hand, female students perceive marijuana as more accessible and prevalent in group settings compared to their male counterparts. Conversely, male students tend to neutralize conventional, predominantly negative, and harmful stereotypes about marijuana more than female students. However, despite statistical significance, the impact size in both cases is small, suggesting caution in interpreting these differences.

The obtained findings partially stem from sample specificity, given that Croatian students represent a subset of young adults with prevailing liberal attitudes toward drug use [38]. While sharing liberal values and higher social awareness with their non-student peers, students are generally of higher social standing, residing in better conditions in larger urban centers. For an extended period, Croatian students have led in liberal drug attitudes, which resulted in their becing a distinct subset with higher psychoactive substance consumption, particularly marijuana [38].

Perhaps the most significant finding in the conducted research indicates that user status is a more critical predictor for assessing the mechanism of morality than gender affiliation [6]. This suggests a substantial extent of statistical difference, showing that non-users are more inclined towards official (school and psychiatric) definitions regarding the harmfulness of marijuana and the moral justifiability of its prohibition. Finally, the obtained results align with findings from other studies that indicate a reduction in gender differences in marijuana consumption among young adults [7, 21-25]. This is confirmed here, specifically in the gender dimension, regarding the assessment of the effectiveness of Becker's mechanisms of social control.

However, the presented results and derived conclusions should be viewed in light of their limitations. The dimensions of gender and sex in marijuana use and social control perception require more careful consideration and detailed exploration. The obtained results offer initial insights that need further supplementation with research grounded in a gender perspective. This applies to patterns of use, which should be complemented with knowledge about differences in preferences in how marijuana is mainly consumed, expected effects of use, preferences for specific usage environments, incorporation of use into personal identities, and more. In short, it is necessary to investigate to what extent these and other potential questions about usage patterns are gender-generated and whether they manifest through the acceptance or rejection of patriarchal values still prevalent in Croatian society [39]. Similarly, the obtained results on gender differences in the perception of Becker's social control mechanisms need close critical observation. For instance, the fact that, in the presented results, women perceive marijuana as more accessible than men does not provide information on whether they acquire it themselves or how easy it is for them to do so. Therefore, it remains to be determined how the more pronounced perception of accessibility observed here manifests in concrete ways, as other research indicates significant differences in how men and women obtain marijuana and how they perceive such situations [18, 19, 26, 27]. The same applies to the neutralization of the secrecy mechanism (experiences of concealing use from gender-biased aspects of social control of deviance) and morality (again, gender-biased judgments on the morality and harmfulness of marijuana use).

Finally, limitations extend to the sample, preventing generalizations to other young women and men, although results from other studies suggest trends of significant reduction in the lifetime

prevalence of marijuana use primarily among young adults but not among other adult men and women. Moreover, the study's participant population consists of undergraduate and graduate students in Zagreb, excluding students in other cities and universities. This leaves room to assume that local social, economic, and cultural specificities may manifest in different characteristics of student life.

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AN EXAMPLE OF THE CONSISTENCY ANALYSIS OF THE CLASSIFICATION OF TEXTUAL MATERIALS BY THE ANALYST AND USING THE NAÏVE BAYESIAN CLASSIFIER

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ABSTRACT

Sentiment analysis is a particular form of content analysis, and its application has become popular with the growth of Internet platforms where a wide range of content is generated. Today, various classifiers use for sentiment analysis, and in this article, we show an example of using a Naïve Bayesian classifier. The aim is to examine the consistency of classifying textual materials into a positive, negative or neutral tone by analysts and the Bayesian algorithm. The hypotheses are that there is an increase in the agreement between the two ways of classifying textual materials as (1) the complexity of the formulations and (2) the size of the learning datasets increases. Based on the results, both hypotheses were accepted, but only on certain groups of messages. Increasing the size of the learning datasets and increasing the complexity of the formulations helped the classification accuracy for messages in a positive tone, while the classification accuracy for messages in other tones was high and equal regardless of varying the parameters. Correlation analysis showed a high positive correlation between the outcomes the Bayesian algorithm classified and the tones the analyst determined (r = 0,816).

KEY WORDS

content analysis, sentiment analysis, naïve Bayes classifier

CLASSIFICATION

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INTRODUCTION

CONTENT ANALYSIS

Content analysis is one of the most widely used research methods in the social sciences. It is a process of studying and parsing verbal or non-verbal content to observe its characteristics and messages [1; p.258]. It is most often used in media research and has become especially popular with the growth and application of different types and means of Internet communication. Since a large part of internet-mediated communication is public, the opinions and information exchanged in this way have a potentially important role in shaping the public sphere. They are also a valuable source of data in social research. Finding and using an adequate way of analysing such data sources is a special challenge.

There are two basic types of content analysis: qualitative and quantitative content analysis [2; p.81]. Qualitative or non-frequency analysis is based on the subjective evaluation of the analysed content, where the most important is the existence or non-existence of specific properties (instead of the frequency of their occurrence). Quantitative analysis implies a systematic and objective procedure by which it is possible to find more precise indicators. The goal of quantitative content analysis is to determine the existence of specific properties and to express them quantitatively through the degree of their representation in the analysed content. The implementation of quantitative analysis includes several research phases: defining the subject of research; formation of aims and hypotheses; defining the research population; sample selection; definition of the unit of analysis; defining criteria for quantifying the unit of analysis; and defining a content unit and constructing an analytical matrix [3; p.172]. Defining the content unit implies the selection of criteria according to which the analysis is carried out. This phase is the most sensitive part of the analytical work. The criteria must be sensitive enough to identify essential characteristics of the content. They must also be adequate, simple, and unequivocal to ensure an objective analysis, i.e., the consistency and reliability of the analysis. Objectivity is achieved through constructing an analytical matrix, which includes a greater or lesser number of analytical criteria set in relation to the selected content, analysis procedure and method of data collection. To ensure objectivity, it is also necessary to ensure a larger number of analysts who must have a certain level of education and training for this type of analysis. It is required to conduct analyst training and use the same criteria to reduce subjectivity and increase objectivity [2; p.20]. Content analysis often requires understanding the context in which the content appears. Lack of context or insufficient understanding of the context can lead to misinterpretations or a lack of deeper understanding of the analysed contents [4; p.11]. Most researchers agree that by combining quantitative and qualitative content analysis, precision and objectivity can be achieved in measuring the observable features of the studied content, but also reveal their hidden dimensions and interrelationships [1; p.259].

SENTIMENT ANALYSIS

Sentiment analysis is a particular form of content analysis. Its application has become popular with the growth of internet platforms on which a wide range of content is generated [5; p.37]. The term “opinion mining” is also used for sentiment analysis because it is a method that deals with the analysis of people's opinions, sentiments, evaluations, assessments, attitudes, and emotions towards different products, services, organizations, individuals, events, topics, etc. It is based on finding statistical or linguistic patterns in the text that reveal an attitude about something or someone [6; p.5].

The most important indicators of sentiment analysis are sentiment words or opinion words [6; p.8]. The analysed words or textual information can be classified into two groups: facts and opinions. Facts refer to the transmission of objective data, while opinions express the author's sentiment.

Opinions are subjective expressions that describe the sentiment, assessment, or feelings that individuals have towards certain entities and their characteristics [7; p.20]. Sentiment is defined as an underlying feeling, attitude, evaluation, or emotion attached to an opinion. It can be summarized through three indicators: (1) "y" or the type of sentiment – determining whether it is an objective or subjective sentiment, (2) "o" or the orientation or polarity of the sentiment – positive, neutral, or negative, and (3) "i" or the intensity or strength of the sentiment – revealing whether the analysed unit is weakly, moderately, or strongly positive or negative. Polarities enable the detection of opinions, i.e., whether individuals express a positive, neutral, or negative sentiment (revealed through the adjectives, nouns, verbs, phrases, and idioms used) according to the analysed content. Neutral sentiment is categorized as an objective category of subjective analysis or, in other words, as an opinion or idea that does not have a clear tendency and cannot be classified as positive or negative sentiment [7; p.3].

Sentiment analysis can be conducted at different levels: (1) at the level of a specific document, whereby a conclusion whether the text of the entire document leaves a positive, neutral or negative sentiment is made with regard to the selected subject of research, (2) at the level of a sentence, whereby after the analysis of all sentences we decide whether each one documents a positive, neutral or negative sentiment, and (3) at the level of a feature, word or phrase, which includes the opinions or feelings of individuals that can be identified as positive, neutral or negative [8; p. 168].

There are several types of sentiment analysis (e.g., "aspect-based analysis", "intent-based analysis", "rule-based analysis", "lexicon-based analysis"), wherein the context of this article stands out "machine-learning analysis" as sentiment analysis in which manual data entry is not required because text input transforms into vector features [9; p.4]. This can be done in two ways: supervised and unsupervised. During machine learning in the supervised algorithm, the correct documents are given, which are positive and negative, and the algorithm learns and recognizes the difference based on this. In the unsupervised case, the algorithm finds a certain structure in the documents and divides them into two or more clusters. Unsupervised learning is more difficult to evaluate, while for supervised learning, criteria can be compared. The above is achieved through partitioning (dividing data into train and test sets), where one part of the data is used for learning and the other for validating what has been learned. A training set is a data set used to train a new classifier. The test set is a data set that is used to test the classifier on data that does not appear in the training set - it is used on unseen data [10; p.33]. In this case, it is best to do circular validation to reduce the bias when dividing the data into those two sets. The result of the classification is the mean value of the results of one group, and the more reliable the classification is, the more similar the results of each group are [11; p.9].

The advantages of sentiment analysis are that no dictionary is needed, and great precision is possible when classifying sentiments [11; p.12]. On the other hand, the limitations of sentiment analysis are the complexity of language and the use of sarcasm and irony, which can be difficult for computer algorithms [9; p.7]. Polarities can have different meanings depending on the context in which they are used. This problem is especially present while using conditional and interrogative sentences, but also when using sarcastic comments because, in this case, the polarity can have an opposite meaning than usual [12; p.47]. The problem is also the possibility of misinterpretation, which can lead to wrong and unreliable conclusions. Sentiment analysis often looks at the text from a collective perspective – it does not consider the context of individual users. That can lead to incorrect conclusions when it comes to the opinions of individuals. The quality of the conclusions also depends on the quality of the data used for analysis. Sentiment analysis most often focuses on the analysis of opinions rather than fact information by one or more persons [9; p.10]. Different individuals or groups may have different experiences, interests, and worldviews, and therefore it is necessary to provide a large amount of data for sentiment analysis to be valid [12; p.47].

Different classifiers used for sentiment analysis (e.g., decision tree, support vector machine, logistic regression, Naïve Bayes classifier) are mutually exclusive. This article will present an example of using the Naïve Bayes classifier. Its advantages are simplicity of implementation, efficiency and speed, robustness towards data forest, and tolerance of incomplete data. On the other hand, the disadvantages are sensitivity to the quality of learning data and less adaptability to complex and non-linear relationships [13; pp.49-55, 14; pp.3043-3049, 15; pp.153- 159, 16; pp.525-531].

THE USE OF NAÏVE BAYES CLASSIFIER IN SOCIAL RESEARCH

Recently, the possibility of using new statistical tools in social research has been discussed. In the methodological sense, research in the social sciences is faced with limited samples, imprecise measurements, and variables that are difficult to control. They rely on statistical conclusions, and their success depends primarily on their methods. Traditional statistical tools work well if: (1) the variables have a normal distribution, (2) there is no important prior knowledge or information about the variables used and analysed in the research, and (3) the number of data is relatively large in relation to the subject of research. If these prerequisites are not met, they become "weak" and difficult to apply tools that can lead to wrong conclusions. That is especially important for the social sciences, which face several problems: (1) the used variables rarely have a normal distribution, (2) the social sciences are interdisciplinary and numerous knowledge comes from other scientific disciplines, and (3) in some research it is not easy to satisfy a representative or sufficiently large sample because this usually requires high costs [17; pp.662-664].

The Naïve Bayes classifier is a statistical tool that overcomes the limitations of traditional statistical tools. It can be used to analyse various problems that cannot be analysed with the help of conventional statistical approaches but can also serve as a complement. Compared to traditional statistical tools, the Naïve Bayesian classifier is based on probability theory (it considers hypotheses and unknown effects). That means that it can be applied to different types of distribution, contains relevant prior information (uses previous evidence to solve problems), and can be applied to any sample size [18; p.4]. More precisely, the algorithm works on the principle of determining the probability that an individual text material, based on its specific parts, belongs to one of the predefined groups or classes. Textual materials must be separated into parts before classification using the Bayesian algorithm. These parts are called independent features and can appear as individual words or formulations in a text. When it is said that properties should be independent, it means that one word (or formulation) should not be conditioned by the presence of other words in the textual material and that all words are equally important. This assumption is often unrealistic, hence the name "naïve" Bayesian classifier, due to its oversimplification of the relationship between properties (words or formulations). Textual materials can be "cleaned" before disassembling them into independent features so that the algorithm can more clearly distinguish the unique properties of these materials. One way of "cleaning" is to remove punctuation marks from the text. To determine the probability of individual text materials belonging to a predetermined class, the Bayesian algorithm first needs to "learn" the characteristics of those texts within each class. It requires a learning dataset with already pre-classified text materials by class. The "learning" process takes place by observing how many times each word or formulation is repeated within a class, and based on this information, their conditional probability of appearing in a particular class is calculated. After the calculation, the probabilities obtained for each word or formulation are multiplied, which is repeated for each class. The value of the product determines the probability of the observed text material belonging to one of the classes.

In the recent literature, many examples exist of using the Naïve Bayesian classifier. We will mention some of them. Tago and Jin used Naïve Bayes in their research "Analyzing Influence of Emotional Tweets on User Relationships by Naïve Bayes Classification and Statistical

Tests" [19]. They investigated whether positive users construct their relationships actively. Words that were not in the dictionary were excluded. To solve their problem, the authors used the Naïve Bayes classification. They obtained almost the same result, and a significant difference was confirmed for the followee fluctuation, follower fluctuation, and mutual follow fluctuation. Naïve Bayes classification confirmed the results of their previous study that positive users connect with other users not one-sided but bilaterally. Chaabi et al. used Naïve Bayes in their research "Determination of Distant Learner's Sociological Profile Based on Fuzzy Logic and Naïve Bayes Techniques" [20]. Their research is based on automatic analysis of asynchronous textual conversations. Their analysis consists of four stages: recovery, filtering, lemmatization, and message classification. The Naïve Bayes has proved to be helpful in practice because it is suited to problems of message categorization and has the advantage of being efficient in terms of processing power in the absence of standardization of speech acts and for determining the social behaviours of learners. Shaziya used the Naïve Bayes model in her research "Prediction of Students Performance in Semester Exams Using Naïve Bayes Classifier" [21] to analyse the impact of education on improving students' performance. Data Mining was used to analyse vast amounts of data from many domains. The educational data mining area is being explored, and its impact in improving the quality of education. Ernawati et al. used Naïve Bayes in their research "Implementation of the Naïve Bayes Algorithm with Feature Selection using Genetic Algorithm for Sentiment Review Analysis of Fashion Online Companies" [22]. The authors concluded that the Bayes algorithm could improve accuracy based on provided data. The accuracy of the Naïve Bayes algorithm before using feature selection was 68,5 %, while the accuracy after using genetic algorithm feature selection was 87,5 %. Jing et al. used the Naïve Bayes model in their research, "Information credibility evaluation in online professional social network using tree augmented Naïve Bayes classifier" [23]. The authors proposed an approach using Tree Augmented Naïve Bayes Classifier and PageRank algorithm to evaluate the information credibility of the user profile in online professional social networks. Bayes Classifier was used to calculate the trustworthiness probability of a user's profile based on selected components in that profile and calculate the authority of user profile information by PageRank algorithm based on other users' recommendations and endorsements. The comparison between the two classification approaches shows that the integrated approach performs better than using only Bayes classifiers. In other words, the PageRank algorithm effectively improves the performance of the Bayes Classifier. Mihaljević used the Naïve Bayes model in his research "Analysis and Creation of Free Sentiment Analysis Programs" [24]. The author concluded that programs have mostly rich options for displaying results through tables or lists containing keywords of analysis, many charts, etc. However, most programs work only in English (there is insufficient support for other languages and sentiment analysis) and are still not accurate enough to replace human interpretation, especially while analysing idioms, sarcasm, and slang. Boulitsakis-Logothetis used the Naïve Bayes model in his research "Fairness-aware Naïve Bayes Classifier for Data with Multiple Sensitive Features" [25]. The author concluded that some considerations should be considered while using the Naïve Bayes model. First, the balance between statistical parity and the accuracy of the classifier should be pursued. The author also recommends further reading on the advantages and disadvantages of group fairness in general, as well as parity, so the users could decide whether to use Naïve Bayes in their research model. There are also some limitations of the Naïve Bayes model. The algorithm of Naïve Bayes does not automatically make a classification task fair when applied (it is only possible by doing extensive domain-specific investigation). Furthermore, the author also recommends reading sociological researchers where Naïve Bayes is used. Finally, he recommends identifying groups in the data using a set of observable qualities.

Despite its advantages, the Naïve Bayes classifier is still not used often enough in the social sciences for several reasons: (1) aversion to mathematics, (2) fear of writing computer syntax

(code), and (3) fear of leaving the comfort zone. However, due to the perceived advantages, scientists have developed several tools that could encourage its more frequent use, such as: replacing mathematical formulas with graphs (relationship trees), automatically generating syntax, and providing graphical visualization of models, results, and diagnostic tests [17; p.666]. Thus, the Naïve Bayesian classifier can give an understanding of certain phenomena studied by social sciences while ensuring the validity of statistical conclusions. This article aims to provide an example of classifying different textual materials by introducing a Naïve Bayesian classifier. This algorithm can help classify different textual materials in a shorter time and with fewer resources. It also gives analysts the possibility of additional verification of their conclusions about the category into which they have classified a text.

RESEARCH AIMS AND HYPOTHESES

In this article, the authors provide an example of an analysis of compatibility between two approaches in text classification: classification by the analyst and by using the naïve Bayesian classifier. The research aim is to examine the consistency of the classification of textual materials into positive, negative, or neutral tones by analysts and by using the Bayesian algorithm while varying (1) the complexity of the formulations (independent properties in each message) and (2) the size of the learning datasets on which the Bayesian algorithm can "learn" how to classify text. The hypotheses are that there is an increase in the agreement between the two ways of classifying textual materials as (1) the complexity of the formulations and (2) the size of the learning datasets increases.

METHODOLOGY

POPULATION

This article aimed to examine the tone of the textual materials on Forum.hr, a public online platform where users exchanged opinions about the Covid-19 pandemic. The data source consisted of the messages posted on the "Coronavirus" block of the "Society" sub-forum, which contained various topics related to the pandemic. The data were collected using a free online tool called Web Scraper, which enabled web scraping of the messages from the Internet. The following variables were extracted for each message: (1) the topic title, (2) the publication time, (3) the author's name, and (4) the message content. That information was entered into an analytical matrix in which each separate message (post) was considered a single unit of analysis. The data set comprised 112 314 messages from 2 583 authors and 169 topics, posted from March 2020 to May 2021.

Due to the large volume of data, the data set was reduced by applying a filter based on the presence of two keywords: vaccine/vaccination and/or headquarters (civil protection). These keywords were selected based on the assumption that they would elicit diverse opinions and tones among the forum users. The filtered data set included 3 277 messages from 590 authors and 98 topics. Two analysts manually coded these messages using three tone categories (positive, neutral, and negative). The inter-coder reliability was measured by Cohen's Kappa coefficient, which yielded a value of 0,801.

The Bayesian algorithm operates on the assumption of independence among the features in a text. Therefore, the first step of the analysis was to decompose all the downloaded messages (Figure 1 – step 1) into individual words. However, this assumption might not hold for more complex expressions (combinations of several words) that could also be considered independent features (the first part of the research objective). Unlike the Bayesian algorithm, human analysts consider the broader context and dependencies among the expressions in a text.

To approximate the human perspective, the messages were decomposed into independent features using one of five methods: unigrams, bigrams, trigrams, four-grams, and five-grams. For instance, the sentence: "I don't know what to think about the vaccine that everyone keeps talking about." was decomposed as follows: (1) "I"; "don't"; "know"; "what"; etc.; (2) "I don't"; "don't know"; "know what"; etc.; (3) "I don't know"; "know what to"; etc.; (4) "I don't know what"; "what to think about"; etc.; (5) "I don't know what to"; "to think about the vaccine"; etc. (Figure 1 – step 2). The five decomposition methods resulted in five separate databases containing the population of all the analysed messages decomposed according to different criteria. Three of these databases are illustrated in Figure 1 – step 2.

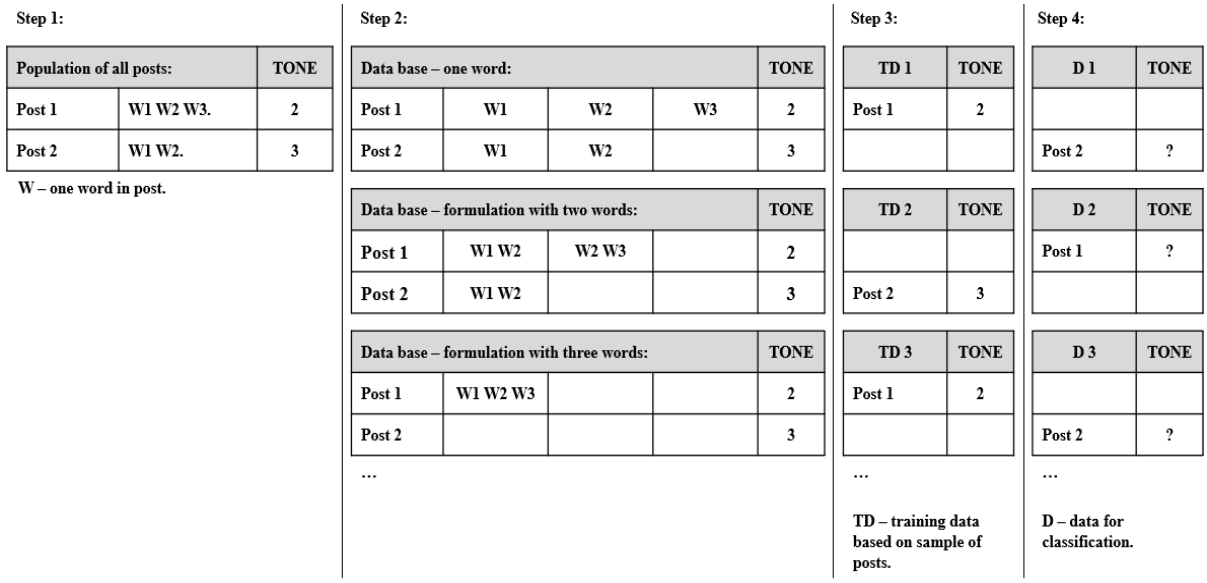

Figure 1. Scheme of the database preparation procedure for analysis.

DEFINING SAMPLES (LEARNING DATASETS)

The next step of the analysis was to define the training data sets for the Bayesian algorithm. The research aimed to test the agreement between the analyst's classification and the Bayesian algorithm's classification. Therefore, we decided to split the five previously described databases into smaller segments that would serve as the training data for the algorithm (Figure 1 – step 3). The messages in these segments were selected using a simple random sampling method but with different sample sizes to address the second part of the research objective. Specifically, nine samples were drawn from each of the five databases, ranging from 10 % to 90 % of the messages from the original databases (increasing by ten percentage points each time). Considering that we first created five databases with different levels of feature complexity and then created nine additional databases with different sample sizes from each of them using the sampling method, we obtained 45 data sets (training data sets) that served as inputs for the algorithm to "learn" how to distinguish messages based on their tone.

ANALYSIS AND PRESENTATION OF DATA

Human analysts and the Bayesian algorithm performed the tone classification of the textual materials using a combination of Excel (part of the Office 365 software package) and Rstudio (2023.03.0). The data were summarized using basic descriptive statistics, and the association between variables was measured using correlation analysis, namely, the contingency coefficient, which is appropriate for nominal-scale variables. The results were displayed in tables and graphs using line plots and contingency tables. The data analysis was conducted using the statistical program SPSS (v21).

RESULTS & DISCUSION

STATISTICS ON THE REPRESENTATION OF MESSAGES CLASSIFIED BY ANALYSTS

In the study, two analysts classified the 3 277 messages according to their tone: positive, neutral, or negative. The result was that the most common messages were of a neutral tone (71,3 %), followed by negatively toned messages with a share of 25,1 % of messages and positively toned messages with a share of 3,7 %. The fact that there is no equal representation of tones later in this article explains certain results.

STATISTICS ON THE REPRESENTATION OF MESSAGES CLASSIFIED USING THE BAYESIAN ALGORITHM

The classification of messages using the Bayesian algorithm took place in such a way that the conditional probability of its belonging to one of three tones (positive, neutral, negative) was calculated for each message. For example, if a message received the highest probability of a positive tone, it was also classified that way. However, in the classification process, there were also situations where individual messages were determined to have a zero per cent probability of belonging to any of the three tones or to have an equal probability of belonging to all tones. In these situations, it was not possible to determine how to classify the messages, and they were not included in the further analysis. As for the first results, Figure 2 shows the shares of classified messages using the Bayesian algorithm, regardless of the agreement of that classification with the analyst's classification. It can be seen that the shares of classified messages varied depending on the differences in (1) the complexity of word formulations and (2) the size of the learning datasets based on which the Bayesian algorithm learned to classify messages. For example, if the success of the classification is observed concerning the criterion of the share of messages for which the algorithm was able to determine their tone, the most successful scenario occurred on the learning datasets of the largest size (right side of Figure 2). However, there is a more pronounced difference between different scenarios if they are also observed concerning the formulation complexity parameter. More specifically, by "learning" on a learning dataset consisting of 90 % of all messages divided into three-word formulations, the algorithm classified as much as 84 % of all messages. Also, it is visible that the proportion of messages for which the algorithm succeeded in setting the tone increased continuously as the learning datasets increased, but again except for the classification modality in which the Bayesian algorithm learned on five-word formulations. Although these results still do not correspond directly to the set research aims, they indicate that the success of using the Bayesian algorithm is conditioned concerning the two observed parameters.

The following figures show even more evident patterns in changes in the share of classified messages. Results in Figures 3 to 5 are visibly similar to that in Figure 2, but the shares of messages are divided by individual tones. Several general conclusions can be drawn by comparing all three figures in parallel. Before interpreting the results in figures, an example of reading the results can be taken with modality in which the algorithm learned to classify messages on the smallest learning datasets (left side) and only based on one word (full black line). Shares of messages are as follows: neutral tone – 48,4 % (Figure 3), negative tone – 51,1 % (Figure 4), and positive tone – 0,5 % (Figure 5). Cumulatively, it is 100 % of the messages concerning the previously described classification modality.

Returning to the general conclusions, the first concerns the modality in which the algorithm learned to classify messages based on a single word only (solid black line). This classification method is the least dependent on the size of the learning dataset. In other words, no significant changes were recorded in the shares of classified messages by increasing the size of the learning datasets. Secondly, classification modalities in which the algorithm learned based on more complex formulations (two or more words) showed a greater dependence on the size of the learning datasets.

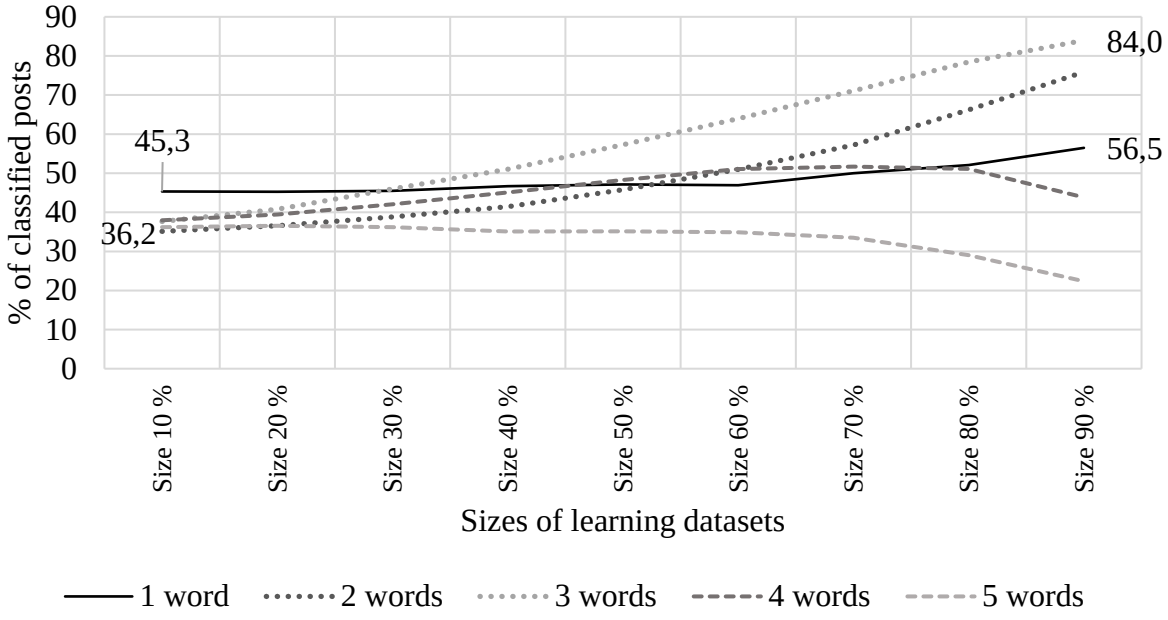

Figure 2. The percentage of all classified posts regarding the complexity of the formulations and the size of the learning datasets.

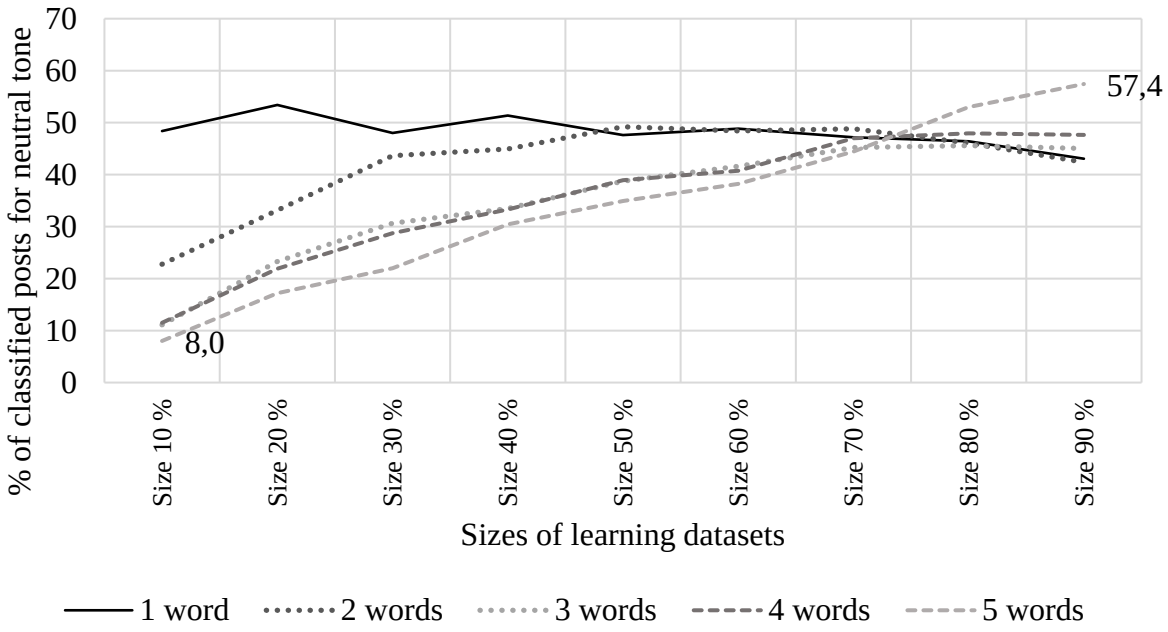

Figure 3. The percentage of classified posts regarding the complexity of the formulations and the size of the learning datasets (neutral tone).

More specifically, for neutral and negative tones, a stable increase in the share of classified messages was recorded by increasing the size of learning datasets, while in parallel, a continuous decrease in the share of positively toned messages was recorded. Thirdly, by increasing the size of learning datasets, proportions of messages per tone increasingly began to reach proportions of tones determined by analysts and which were described in previous sections. Based on the results presented so far, it can be concluded that more evident patterns are obtained for the description of changes in the share of classified messages if they are not viewed as a whole but by individual tones.

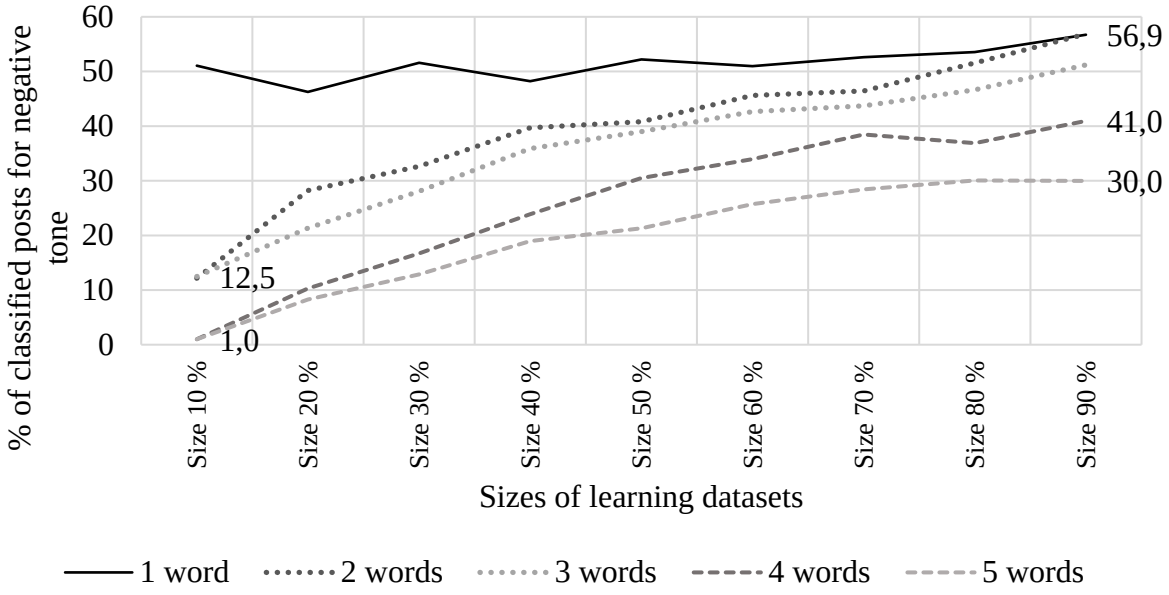

Figure 4. The percentage of classified posts regarding the complexity of the formulations and the size of the learning datasets (negative tone).

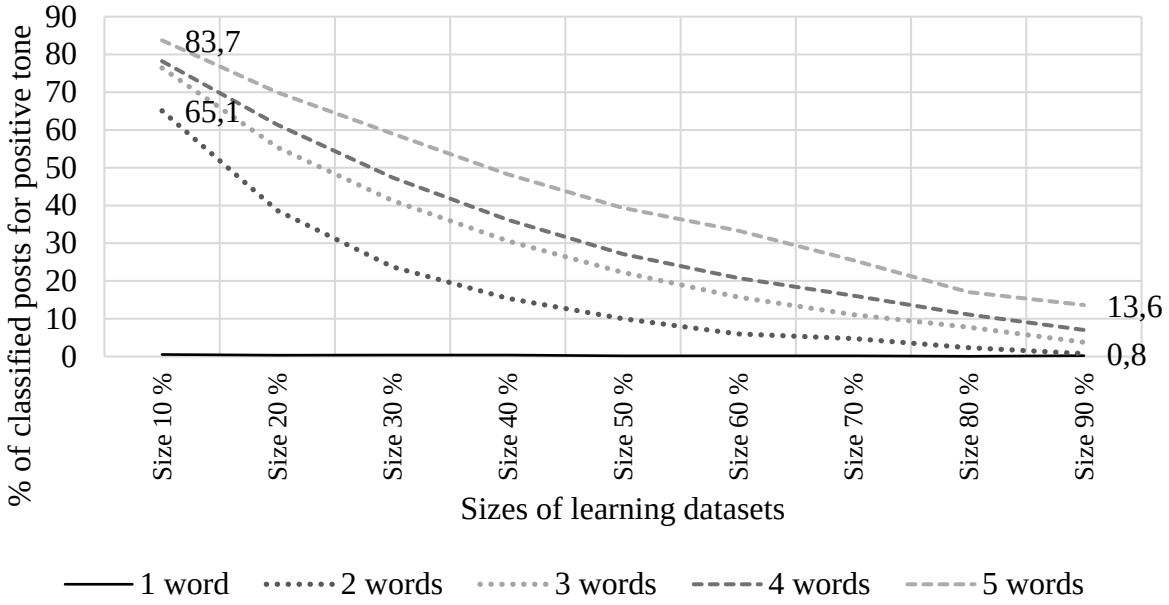

Figure 5. The percentage of classified posts regarding the complexity of the formulations and the size of the learning datasets (positive tone).

By observing Figures 3 to 5, a fourth conclusion can be drawn. There is a certain level of consistency in changes in the share of classified messages, observing these changes concerning different database sizes and formulation complexity (45 classification modalities). To gain a more detailed insight into described conclusion, the following tables show correlations between classifications made with different sizes of learning datasets (Table 1) and different levels of complexity of formulations (Table 2). It can be seen in Table 1 that the results of message classification become more and more similar as the learning datasets increase. For example, the two modalities with the most similar classification results are those that contain 70 % and 80 % of the total number of messages. Similar conclusions can be drawn by observing Table 2. It can be seen that the strongest correlations are between those classifications that were based on more complex formulations (lower right part of Table 2).

Table 1. Correlations between different size learning datasets.

	Sizes of learning datasets								
	Size 10 %	**Size 20 %**	**Size 30 %**	**Size 40 %**	**Size 50 %**	**Size 60 %**	**Size 70 %**	**Size 80 %**	**Size 90 %**
Size 10 %	1,000	0,554	0,531	0,492	0,474	0,452	0,431	0,387	0,370
Size 20 %		1,000	0,559	0,543	0,543	0,518	0,506	0,481	0,450
Size 30 %			1,000	0,580	0,582	0,582	0,563	0,529	0,510
Size 40 %				1,000	0,602	0,600	0,595	0,583	0,540
Size 50 %					1,000	0,605	0,625	0,592	0,560
Size 60 %						1,000	0,626	0,625	0,590
Size 70 %							1,000	0,627	0,590
Size 80 %								1,000	0,621
Size 90 %									1,000

Table 2. Correlations between learning datasets with different levels of complexity of formulations.

	Complexity of formulations				
	1 word	**2 words**	**3 words**	**4 words**	**5 words**
1 word	1,000	0,700	0,644	0,616	0,619
2 words		1,000	0,744	0,688	0,638
3 words			1,000	0,783	0,720
4 words				1,000	0,768
5 words					1,000

CONCORDANCE OF ANALYST-MADE CLASSIFICATION WITH BAYESIAN CLASSIFICATION

So far, results about the share of messages classified by the Bayesian algorithm have been presented. However, it has not been observed whether this classification agrees with the analyst's classification. In this part, this factor is also taken into account to be able to answer the research hypotheses. Figure 6 shows the differences between these shares. But before interpreting the results, it is necessary to explain the meaning of individual numerical values in the graph. If we recall that the Bayesian algorithm could learn how to classify messages based on 45 different learning datasets, individual values in Figure 6 represent the average or median value of the share of classified messages from those sets. For example, the value 50,7 % is interpreted as the proportion of messages for a neutral tone, which is obtained as the average of all proportions in the 45 datasets for that tone. Similarly, the value 33,0 % represents the average proportion of classified messages for that same tone but, in this case, only correctly classified messages. Figure 6 shows that the shares of correctly classified messages using the

Bayesian algorithm are lower than the share of the total number of classified messages regardless of tone. The biggest difference between the described shares was recorded for the positive tone. In that tone, the share of correctly classified messages is lower by 64 % compared to the share of the total number of classified messages. The smallest differences between shares of classified and correctly classified messages are for those in neutral tone.

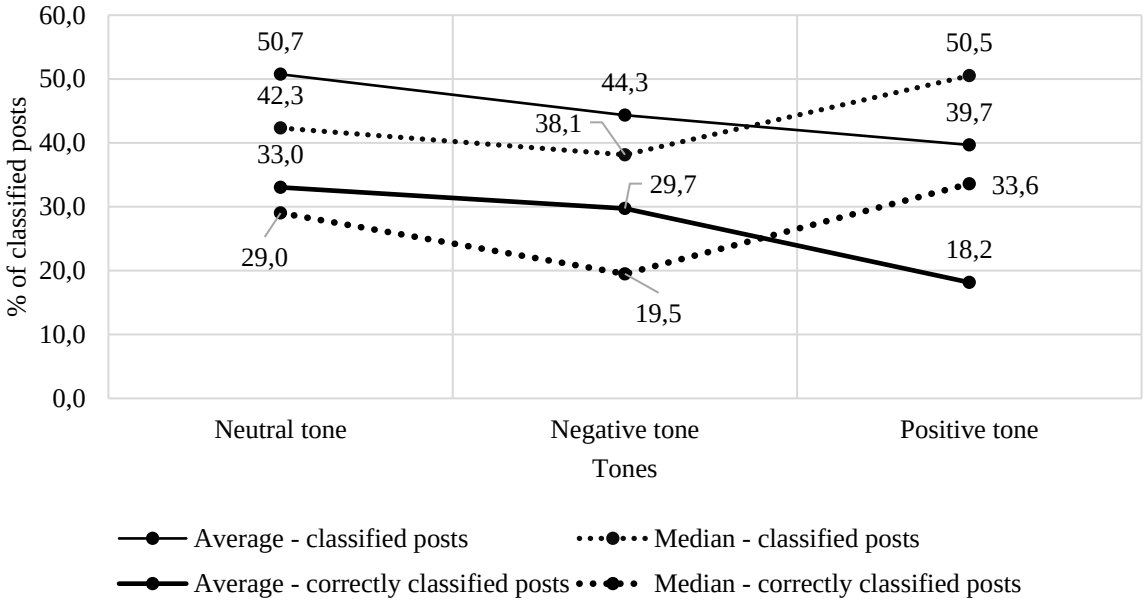

Figure 6. Percentage of classified and correctly classified posts in regards to their tone.

Finally, more detailed results exist about the share of correctly classified messages depending on different classification modalities (Figures 7 to 9). First, the shares of correctly classified messages in different classification modalities are more similar than the shares of the total number of classified messages (Figures 3 to 5). The exception is the shares of messages classified in a positive tone (Figure 9), which are similar only on larger learning datasets (right side of the display). Second, messages in neutral and positive tones remained relatively robust to changes in the size of the learning datasets (Figures 7 to 8). More specifically, no significant changes were recorded in the shares of these messages as the set sizes increased. The same conclusions are not valid for positively toned messages (Figure 9), where a decrease in their shares was recorded by increasing the size of the sets. Thirdly, the shares of messages classified in different tones follow the ratios of tones determined by the analysts for the same messages relatively well. For example, in the modality in which the algorithm learned on the largest learning dataset and five-word formulations, the following results were obtained compared to what was determined by the analysts: (1) neutral-toned messages are underrepresented by only 9,7 percentage points, (2) negatively toned messages are more prevalent by 11,4 percentage points, and (3) positive messages are underrepresented by 1,9 percentage points. Following on, correlation analysis indicated a high positive correlation (r = 0,816) between all variables describing the shares of tones classified by the analyst and the algorithm.

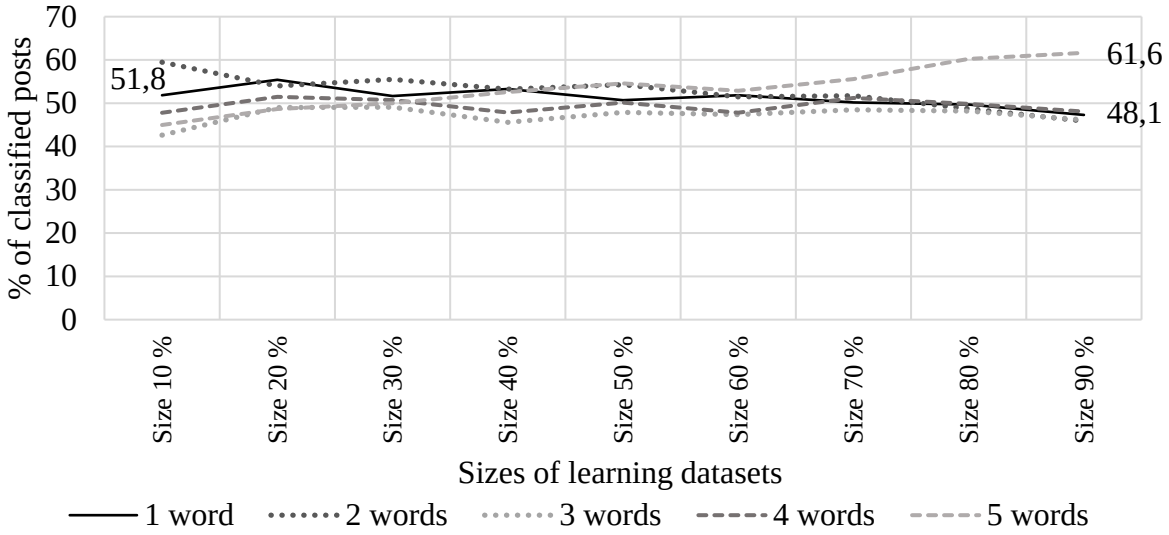

Figure 7. The percentage of correctly classified posts regarding the complexity of the formulations and the size of the learning datasets (neutral tone).

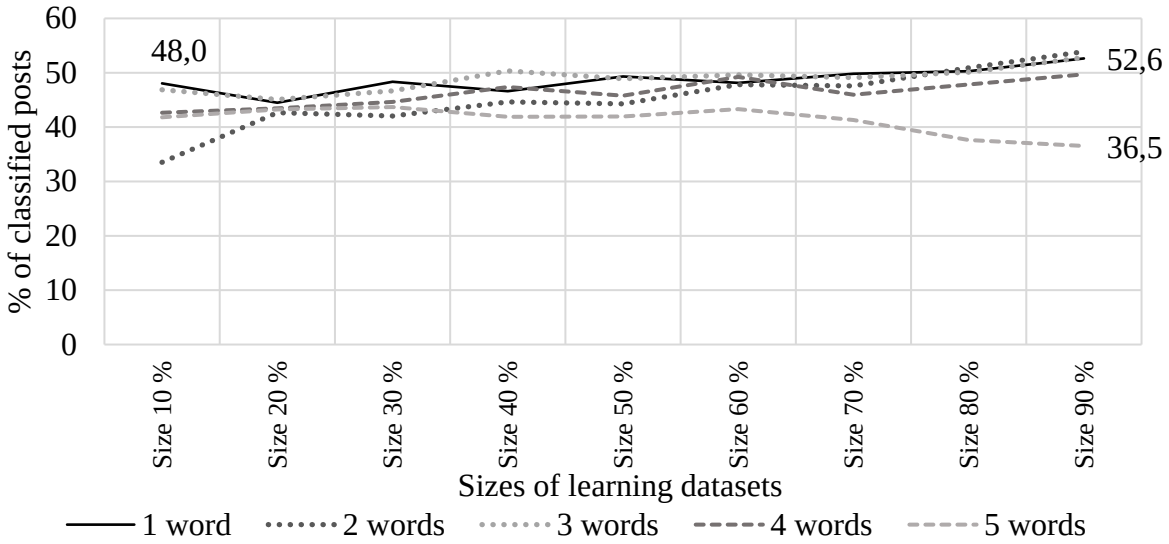

Figure 8. The percentage of correctly classified posts regarding the complexity of the formulations and the size of the learning datasets (negative tone).

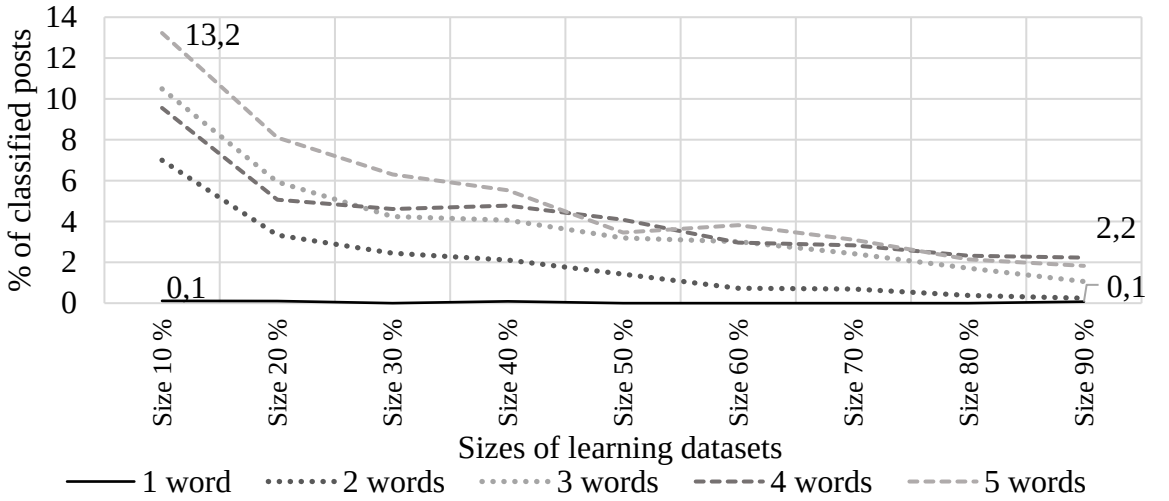

Figure 9. The percentage of correctly classified posts regarding the complexity of the formulations and the size of the learning datasets (positive tone).

CONCLUSION

This article aimed to examine the consistency of the classification of textual materials into positive, negative or neutral tones by analysts and using the Bayesian algorithm. In doing so, two parameters were varied based on which the algorithm learned how to classify messages: (1) complexity of formulations, and (2) size of learning datasets. The results first show data on the representation of messages in relation to the tone assigned to them by the analyst. Out of 3 277 messages, most of them are classified in a neutral tone (71,3 %), followed by messages in a negative tone (25,1 %), while the fewest messages are in a positive tone (3,7 %). The database of tone-specific messages served as the starting point for the application of the Naïve Bayesian classifier. Learning datasets of different sizes and with different levels of complexity of word formulations were obtained from it. For example, the simplest dataset contained only 10 % of the messages from the original database, and the Bayesian algorithm learned how to classify messages based on individual words. In contrast, the most complex dataset contained 90 % of the messages from the original database, and the algorithm learned how to classify based on five-word formulations. Based on all combinations, 45 different learning datasets were created.

After the application of the Bayesian algorithm, it was shown that there are more pronounced differences in the representation and variation of classified messages by tones if the shares of "all" classified messages are compared, regardless of the accuracy of that classification (the first group) and the share of "correctly" classified messages (second group). It turned out that the representation of classified messages from the first group, looking at them by tone, varied greatly depending on the size of the learning datasets and the complexity of the formulations. This conclusion is valid for messages for all three tones (Figures 3 to 5). The representation of messages from the second group showed a much lower level of variation compared to the previously described parameters, and this conclusion is especially valid for messages that were toned as neutral or negative (Figures 7 and 8). More precisely, the analysis showed that correctly classified messages in a neutral tone were represented by about 50 % of all messages in all classification modalities, and negatively toned messages were also represented to a similar extent. In other words, no significant changes were recorded for the described shares by varying the size of the learning datasets or the complexity of the formulations. The share of correctly classified neutrally toned messages proved to be the most stable in relation to various statistical indicators (median and arithmetic mean) (Figure 6), but this should not be surprising if we refer to the theoretical part of the article, which states how neutral sentiment is categorized as an objective category of subjective analysis. Furthermore, as for correctly classified messages in a positive tone, it was shown that their representation changed depending on the previously described parameters. More precisely, the share of these messages began to approach the share determined by the analyst (up to 3,7 %) only when the learning datasets began to increase and when the Bayesian algorithm learned to classify based on more complex formulations (Figure 9).

Based on these results, both research hypotheses can be accepted, but only on certain groups of messages. Increasing the size of the learning datasets and increasing the complexity of the formulations helped the classification accuracy for messages in a positive tone, while the classification accuracy for messages in other tones was high and equal regardless of varying the parameters. Also, the correlation analysis showed a high positive correlation between the outcomes classified using the Bayesian algorithm and the tones determined by the analyst (r = 0,816). Considering the potential reasons for the recorded differences between classes (tones), positively toned messages were represented by less than 5 % of all messages, which could have influenced their greater susceptibility to varying parameters. One of the factors that can influence the success of the classification using the Bayesian algorithm is the "quality" of independent properties in the textual materials. In classification classes with a smaller number

of textual materials, various specificities or irregularities in the text can come to the fore much more easily, ultimately affecting the algorithm's classification power. In the introductory part of the article, it was pointed out that different polarities can have different meanings depending on their context in textual material. In other words, analysts may find themselves in the problem of applying equally objective and consistent text classification criteria for all types of specific tones, which cannot be ruled out as a scenario that also happened in our analysis of individual forum posts. Nevertheless, looking at most of the posts we classified, the Bayesian algorithm confirmed our conclusions, which demonstrated the potential of applying that algorithm as an additional help or confirmation of the conclusions that analysts make by applying the classical approach to the classification of textual material.

In the end, two potential directions for further research arise from the above, which concern the issue of determining the adequate relative size of individual classes in learning datasets and the adequate quality of independent features in the observed text materials.

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OPTIMAL STRATEGIES FOR VIRUS PROPAGATION

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ABSTRACT

This article explores a number of questions regarding optimal strategies evolved by viruses upon entry into a vertebrate host. The infected cell life cycle consists of a non-productively infected stage in which it is producing virions but not releasing them and of a productively infected stage in which it is just releasing virions. The study explores why the infected cell cycle should be so delineated, something which is akin to a classic "bang-bang control" or all-or-none principle. The times spent in each of these stages represent a viral strategy to optimize peak viral load. Increasing the time spent in the non-productively infected phase (τ_1) would lead to a concomitant increase in peak viremia. However increasing this time would also invite a more vigorous response from Cytotoxic T-Lymphocytes. Simultaneously, if there is a vigorous antibody response, then we might expect τ_1 to be high, in order that the virus builds up its population and conversely if there is a weak antibody response, τ_1 might be small. These trade-offs are explored using a mathematical model of virus propagation using Ordinary Differential Equations. The study raises questions about whether common viruses have actually settled into an optimum, the role for reliability and whether experimental infections of hosts with non-endemic strains could help elicit answers about viral progression.

KEY WORDS

viral dynamics, optimization, bang-bang control, viral strategies, optimal control theory

CLASSIFICATION

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INTRODUCTION

A normal cell upon infection goes through a life cycle characterized by 2 phases: a stage in which it is producing virions but not releasing it (non-productively infected stage) and a stage in which it is releasing virions into the outside environment (productively infected stage). Hence there is a delay between infection and release of virions. In whatever follows, we denote the time spent in the non-productively infected stage as τ_1 and the time spent in the productively infected stage as τ_2. The time in τ_1 is spent in viral penetration, uncoating of viral core, transcription and assembly.

The number of virions produced over the entire infected cell life cycle is directly proportional to $\tau_1 + \tau_2$. It is asked whether the virus might be trying to maximize this quantity in order to optimize "virulence" (a quantity which shall be concretized shortly). The question of why there need be 2 distinct phases and not just one where virion production and release occur simultaneously, also cries out for explanation. Such forms of delineation are called "bang-bang control" or the all-or-none principle and are characterized by a phase of proliferation and then terminal differentiation, and are frequently encountered in optimal biological systems [1].

If the total length of the infected cell lifetime is a measure of "virulence", we can then set a theoretical upper bound on it and then compare it with its actual value from field measurements. This would give us a qualitative understanding of "how far" the virus can still go in optimizing itself e.g. it can be used to determine if the avianinfluenza virus is already as virulent as it can be or is it still sub-optimal.

The rest of the article is organized as follows: Section 2 discusses arguments for optimization in biological systems and Section 3 introduces the principle of "bang-bang control". The hypotheses and questions are posed in Section 4 and Section 5 outlines the mathematical model. Section 6 contains the results and discussions and concluding remarks are presented in Section 7.

OPTIMISATION IN A BIOLOGICAL SYSTEM

Before commencing with the mathematical analysis we state what our modeling philosophy will be and give some justification for employing such an approach. First of all, there is certainly no a priori reason why virus propagation – or any other biological system – should operate in an "optimal" fashion. Indeed there is a substantive issue as to whether the notion of "optimality" can be given an operational meaning for many biological systems. Typically, an organism or a virus is forced to cope with a number of competing influences so that an improvement in one direction involves a sacrifice in another. Thus optimality must be interpreted in a broader sense as a "best compromise" solution. Beyond this consideration, however, there are at least two major reasons why a particular biological system might not be performing its function in the most expeditious fashion. First, despite the fact that one tends to think of natural selection as an inherently optimizing process, improvements on existing mechanisms generally proceed by small modifications of existing structures. Thus, there is ample opportunity for the system to become trapped in "local" maxima; there may be "nearby" structures with higher fitness but to reach them may require a temporary, but fatal, decrease in overall fitness. Second, while the system may be constantly improving, evolution is a slow and erratic process so that any system we examine may not have had time to optimize under existing selective pressures. Both of the objections may be partially circumvented by restricting attention to systems which appear to have been evolutionarily static for a long time. The mammalian immune system and viruses surely fulfil this criterion.

A virus typically only wants to proliferate in a host only so much as to ensure transmission to another host (an exception is the Ebola virus which kills its host so fast as to prevent

propagation to another host). Hence it is trying to optimize the basic reproductive ratio R_0 in epidemic models. In vector-borne pathogens, the peak viremia in blood serum is a very good determinant of R_0 [2]. Hence, we assume that the virus is trying to optimize the peak viral load in blood serum (P_v).

BANG-BANG CONTROL

In a seminal paper [1], Perelson et al. examined the mammalian immune system and looked at optimal strategies for B-cell proliferation and differentiation. They used control theoretic principles to analyze the minimum time taken by the immune system to eliminate a fixed amount of antigen in the shortest span of time. The problem briefly stated is as follows: given an initial population of B-cells (which secrete antibodies at a modest rate, proliferate into B-cells or differentiate into plasma cells) and plasma cells (which secrete antibodies at a very high rate but do not proliferate), how do you apportion the total population between B-cells and plasma cells? Does the optimal strategy involve proliferation of B-cells followed by differentiation into plasma cells? Or does it involve simultaneous B-cell proliferation and differentiation? The authors showed using optimal control theory that the optimal strategy for B-cells is to go through a stage of proliferation (to build up their population) and then differentiate into plasma cells. Such a control is called “bang-bang” or all-or-none. It is not immediately evident or intuitive that a strategy of simultaneous B-cell proliferation and differentiation is not optimal.

A parallel is drawn between that work and the problem at hand here, where the infected cell also goes through a phase of production of virions followed by a phase of virion release. The reasons for “bang-bang control” in the infected cell system and its implications are explored in the following sections.

HYPOTHESES AND QUESTIONS

This section explores some of the hypotheses proposed and frames some questions. There are two hypotheses about the non-productively infected stage of the infected cell:

HYPOTHESIS .

The virus is not trying to optimize the duration of the non-productive infected stage (τ_1). Hence this time is exactly equal to the time required for viral penetration, uncoating of viral core, transcription and assembly. The interpretation is that as soon as the first complete virions is assembled, the infected cell immediately proceeds to release the virion i.e. it switches to the next phase of productive infection. The obvious disadvantage of this strategy is that the amount of virions produced would be reduced, compared to an approach in which τ_1 is increased. Clearly this strategy is sub-optimal and we do not explore it further.

HYPOTHESIS 2

The virus is trying to optimize peak viral load and hence viral production. However it cannot increase the duration of the productive infected stage (τ_2). This is so because there are physiological limits imposed by the area and strength of the cell wall, which will constrain the duration of virion release. After a threshold, the cell wall will simply fall apart. It can only increase the duration of the non-productive infected stage (τ_1).

Hypothesis 2a

Having a high τ_1 would imply an increased virion release count. However, this would come at the cost of increased susceptibility to lysis by Cytotoxic T-Lymphocytes (CTLs). A lower τ_1 would reduce the susceptibility to CTL mediated lysis at the expense of a reduced virion count.

Hypothesis 2b

The virus might optimize itself such that it bursts early in the face of a weak antibody response. Conversely, it could burst later (after building up a pool of virions) when confronted with a vigorous antibody response.

There are two attributed research questions:

RQ₁: Why cannot τ1 increase indefinitely?
RQ₁: Why is the optimal control "bang-bang"?

MATHEMATICAL FORMULATION

A standard mathematical model of virus propagation adapted from Baccam et al. [3] is constructed to test the hypothesis. Ordinary Differential Equations (ODEs) are used to represent populations of virus, infected cells and normal cells. The equations are as follows:

$$\frac{\mathrm{d}T}{\mathrm{d}t} = -\beta TV,$$
$$\frac{\mathrm{d}I_1}{\mathrm{d}t} = \beta TV - kI_1 - \omega_{CTL} I_1,$$
$$\frac{\mathrm{d}I_2}{\mathrm{d}t} = kI_1 - \delta I_2,$$
$$\frac{\mathrm{d}V}{\mathrm{d}t} = pI_2 - cV,$$

where T is target cell population, I_1 – non-productively infected cell population, I_2 – productively infected cell population, V – virus population, β – rate constant of infection, k – rate of death of non-productively infected cells, δ – rate of death of productively infected cells, ω_{CTL} = rate of CTL-mediated lysis of non-productively infected cells, p – number of virions produced per productively infected cell per time step and c – rate of clearance of free virus particles.

We also get $\tau_1 = 1/k$ and $\tau_2 = 1/\delta$.

In this simple ODE model, the population of target cells (normal and uninfected cells) are represented by the variable T. They are also lost due to infection, which is represented by the term $-\beta \cdot T \cdot V$. The non-productively infected cells (I_1) are supplied by the loss from the target-cell pool and die at a rate proportional to their number density with constant of proportionality k. They are also lysed by (Cytotoxic T-Lymphocytes) CTLs at a rate proportional to their density and with a constant of proportionality of ω_{CTL}. Productively infected cells (I_2) are replenished from the non-productive pool and die at a rate proportional to their density and with a constant of proportionality of δ. New virions (V) are produced by infected cells at the rate $p \cdot I_2$ and virions are lost at a rate proportional to the virus concentration with constant of proportionality c (representing antibody-mediated virion clearance).

The variation in ω_{CTL} has been modelled in a time-dependent fashion. Namely it is made to mimic the clonal expansion of a pool of effector CTLs after day 4.

$$\omega_{CTL} = \begin{cases} 0, & t < 4, \\ \Omega \cdot \exp[\theta(t-4)], & t \geq 4. \end{cases}$$

The model was parameterized from a study of experimental infection of Influenza A virus in humans [3]. The model was implemented in the Berkeley Madonna package [14] and the code is freely available for download [15]. The model parameters are shown in Table 1.

Table 1. Estimated parameter values from Baccam et al. [3].

Parameter	β, ml/(TCID$_{50}$·day)	δ, day^{-1}	p, ml/(TCID$_{50}$·day)	k, day^{-1}	c, day^{-1}	T_0	V_0, TCID$_{50}$/ml
Value	$4{,}9 \cdot 10^{-5}$	4,2	$2{,}8 \cdot 10^{-2}$	3,9	4,3	$4 \cdot 10^{8}$	$4{,}3 \cdot 10^{-2}$

RESULTS AND DISCUSSION

The model as outlined in the previous section, thus parameterized, was used to test the hypothesis.

TEST OF HYPOTHESIS 2A

Restating, having a high τ_1 would imply an increased virion release count with cost of an increased susceptibility to lysis by Cytotoxic T-Lymphocytes (CTLs). A lower τ_1 would reduce the susceptibility to CTL mediated lysis at the expense of a reduced virion count.

As a result, we observed that the optimal strategy was to increase τ_1 till a threshold (in this particular case it was found to be just less than 4 days). Incidentally, day 4 is also the time at which CTL action is initiated. Hence, the optimal strategy for the virus is to continue the non-productively infected phase till just before CTL initiation. Till CTL action is initiated, the virus will continue to build its population. Increasing τ_1 beyond 4 days would lead to loss of produced virions due to CTL-mediated infected cell lysis. Any decrease below 4 days would reduce the total virus production and hence peak viremia. Hence the optimal control is "bang-bang", Figure 1. Bang-bang control strategies have also been known to be optimal in other biological systems like differentiation of B-cells and production of plant seeds [1]. Note that due to the use of a continuous ODE system (which mimics biology more closely) as opposed to a delay-differential equation, some infected cells do burst earlier than day 4.

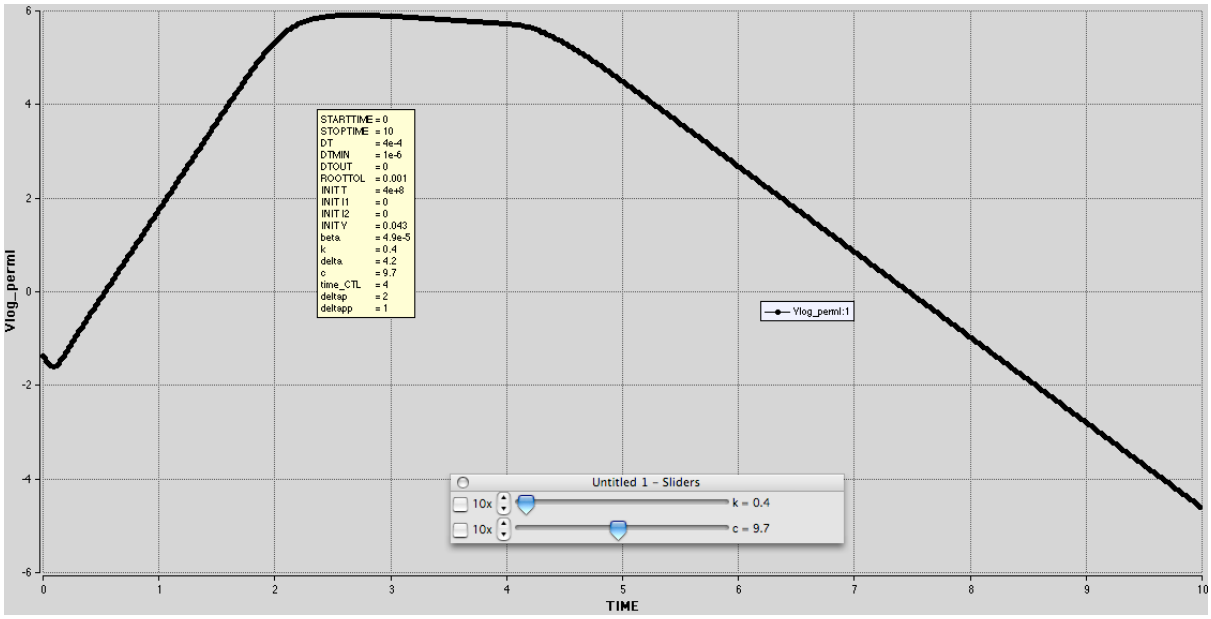

Figure 1. Predicted plot of logged viremia ($\log_{10}$TCID$_{50}$/ml) versus time in days for Hypothesis 2a.

TEST OF HYPOTHESIS 2B

Restating, the virus might optimize itself such that it bursts early in the face of a weak antibody response. Conversely, it could burst later (after building up a pool of virions) when confronted with a vigorous antibody response.

Result: The antibody response was varied by manipulation of the virion clearance term c in the ODE system. It was found that the optimal strategy remained conserved under variations in the antibody response i.e. the optimal strategy for the virus was always to burst at $\tau_1 = 4$ days. We can reason about this in the following manner: increasing τ_1 beyond 4 days would lead to loss of produced virions due to CTL-mediated infected cell lysis and any decrease below 4 days would reduce the total virus production and hence peak viremia. Hence antibody response has no effect on τ_1 – a fact that is perhaps not intuitively obvious.

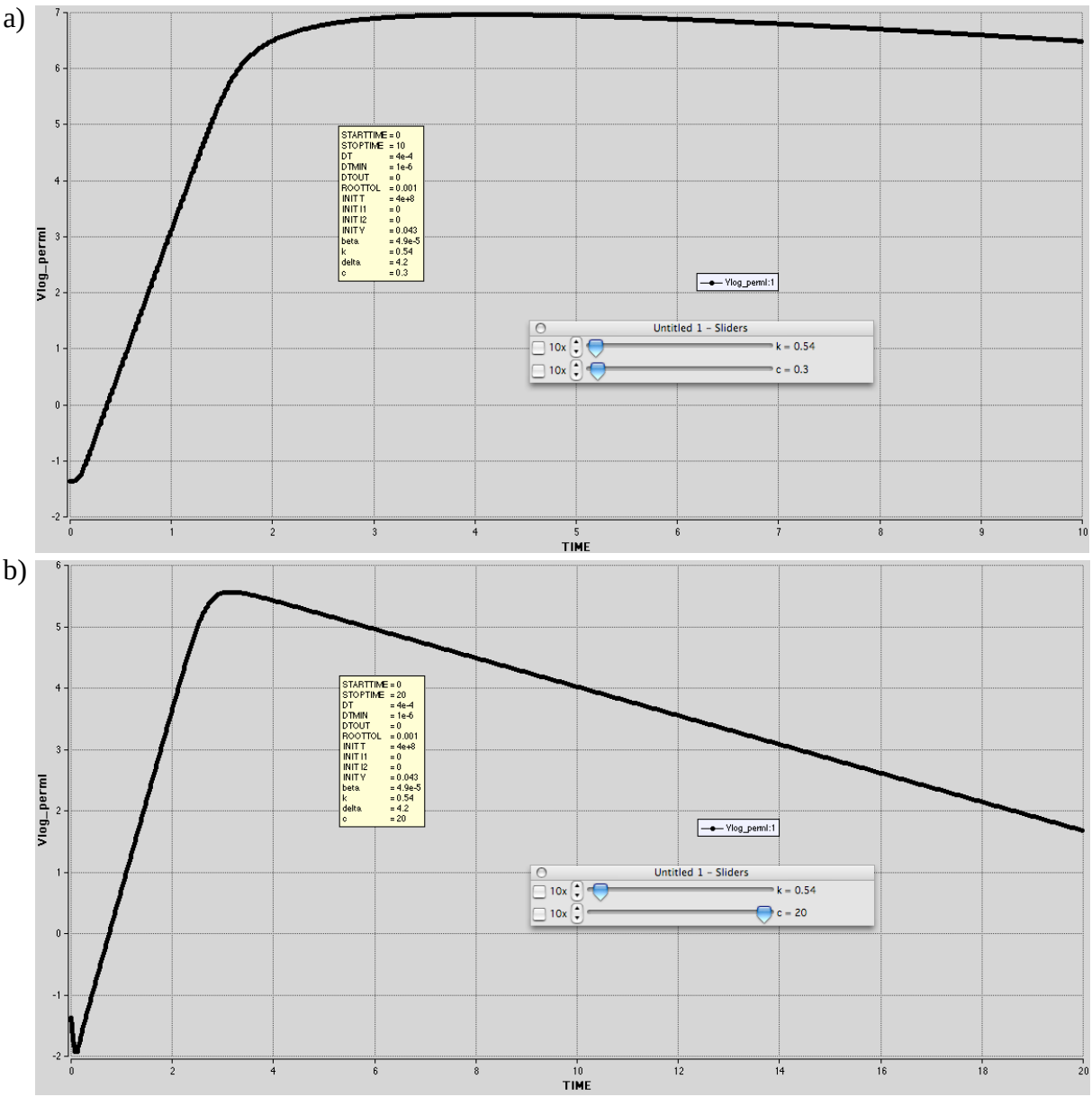

Figure 2. Predicted plot of logged viremia ($log_{10}TCID_{50}$/ml) versus time in days for Hypothesis 2b, a) low antibody response with τ_1 = 4 days, b) high antibody response with τ_1 = 4 days. The optimal strategy remains the same (burst just before time to CTL initiation).

WHY CANNOT τ_1 INCREASE INDEFINITELY?

From the preceding discussion, it becomes evident that if τ_1 were to increase indefinitely beyond the time to CTL initiation, then there would be a concomitant decrease in virion output due to CTL-mediated infected cell lysis. Hence the time to CTL initiation sets an upper bound on τ_1.

WHY IS THE OPTIMAL CONTROL "BANG-BANG"?

Due to physiological limits on cell wall integrity, the time spent in the productively infected phase (τ_1) must be limited. Any attempt to increase it beyond a threshold would merely cause the whole cell wall to break down. Hence, in order to increase virus production, the only "recourse" the virus has is to increase the time spent in the non-productively infected phase and build up the virus population until onset of CTLs. This naturally gives rise to 2 delineated phases ("bang-bang control"). Any intermediate graded response i.e. virion production occurring simultaneously with release is essentially equivalent to the productively infected

phase and since the time that can be spent in it is severely limited, we see that it is a sub-optimal strategy. Such strategies are also optimal in diverse biological systems ranging from differentiation of B-cells in the immune system to allocation of energy to seeds in plants [1].

CONCLUSIONS

This work visits virus proliferation from an optimization viewpoint. A few basic assumptions are made: a) the time spent in the productively infected phase is constant and cannot be subjected to optimization beyond a threshold, and b) the virus is trying to optimize virion production and hence peak viremia. Starting from these assumptions, it is posited that the optimal strategy for virus proliferation is to delay burst till onset of Cytotoxic T-Lymphocytes. This so called "bang-bang control" or all-or-none principle is exhibited in many other biological systems like ant colonies and annual plants [1]. However, optimization may not be the only principle at work. In fact, considerations of reliability may be invoked to explain the presence of long-lived latently infected cells (e.g. HIV). These long-lived cells evade detection by CTLs and ensure a prolonged viremia in hosts.

Another conclusion, which is not intuitively obvious, is the fact that the optimal strategy of allocating the maximum time in the non-productively infected phase remains invariant even in the face of a varying antibody response. This strategy is insensitive to the humoral response and depends only on the time to CTL initiation.

The total length of the infected cell lifetime is a measure of "virulence", and a theoretical upper bound has been set on it. Comparing this value to the actual value from field measurements would give us a qualitative understanding of "how far" the virus can still go in optimizing itself e.g. it can be used to determine if the avian-influenza virus is already as virulent as it can be or is it still sub-optimal. In the case of the Influenza A virus from the Baccam et al. study [3], the theoretical upper bound on τ_1 is around 4 days, whereas the observed is around 12 hours, suggesting that the virus is still operating sub-optimally and still has scope to improve by mutating itself. Insights like these could be crucial for bio-surveillance efforts and help inform strategies to cope with future pandemics caused by virus mutations.

Lastly, it is instructive to note that experimental infections of hosts with non-endemic strains (viral strains that have not co-evolved with the host and hence are not operating in an optimal manner) could affect experiment outcome. This would elicit a lower than normal viral response, since the viral strategy would now be characterized by Hypothesis 1 i.e. the time spent in the productively infected phase (τ_1) would just constitute the time required for viral penetration, uncoating of viral core, transcription and assembly and no more.

Clearly more work needs to be done to verify these arguments and an extensive analytical treatment of these arguments coupled with more experimental work will be the subject of future work. The current work highlights the significance of simple mathematical and dynamical models that reveal insights into biological processes as has been done previously in immunology and cell biology [4-13].

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CROWDFUNDING SUCCESS PREDICTION USING PROJECT TITLE IMAGE AND CONVOLUTIONAL NEURAL NETWORK

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ABSTRACT

Prediction of crowdfunding success is a challenging problem that has great importance for project creators and platforms. Although meta features, e.g., number of updates or backers, are widely used for success prediction, they are limited to time period after project posting where project creators cannot adapt their profiles. Because of that, ability to predict campaign success in pre-posting phase would significantly improve chance for project success. According to the theory, mostly used methods in this situation are those based on text features, while methods based on the influence of image modality on project success are rare. Due to this, in this article we propose deep learning-based method for crowdfunding success prediction in pre-posting phase using project title image. Experimental results show that image modality could be used for campaign success prediction. Proposed method obtains results comparable to competing methods from literature, but using only one image per campaign and no derived features. It is also shown that deeper convolutional neural network achieves better prediction performance.

KEY WORDS

crowdfunding, success prediction, project title image, deep learning

CLASSIFICATION

JEL: O31

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INTRODUCTION

The global crowdfunding market in 2020 was valued at 12,27 billion U.S. dollars [1] and consist of reward-based crowdfunding, equity – based crowdfunding, donation – based crowdfunding and real estate crowdfunding [2]. Crowdfunding success prediction, especially in phase before project posting, is a challenging task that has great importance for project creators as well as for crowdfunding platforms. Reliable prediction would allow project creators to revise campaign profile in timely manner and maximize chance for success, while crowdfunding platforms could emphasize projects having higher probability to reach their goal. Existing approaches for success prediction mainly exploit dynamic meta-data after the project is posted. In pre-posting phase focus is put on profile text, that is mainly project description. Although visual content carries more information content than text, influence of campaign images on final outcome has not been extensively studied.

Deep learning, as subset of machine learning, has been successfully applied in different areas like object detection in images [3], medical imaging [4], natural language processing [5], finance and banking [6] etc. Deep learning models consist of multiple processing layers that reveals hidden structures in high-dimensional data. Each added layer represents input data on more abstract level that is suitable for detection or classification tasks. Convolutional neural network (CNN) is deep learning architecture that has made breakthrough in image and video processing showing strong performance in image classification task.

In this article we propose method for crowdfunding success prediction based on project title image and convolutional neural network. Image dataset is collected by scraping project title images from Kickstarter platform. Using this dataset, we have trained CNN-based classifier that predicts whether project is successful or not using only project title image as input. Experimental results show that proposed method achieves state of the art results meaning that even single project title image has predictive potential that could be considered for success prediction, especially in synergy with textual and meta features. Different from other approaches in literature, we predict project success using automatically extracted CNN features of title image only. In this way we avoid manual selection of image features used for classification. We performed comparison of 3 widely used CNN architectures showing that deeper network achieves better results.

LITERATURE REVIEW

Methods for crowdfunding success prediction mostly utilizes machine learning techniques. Greenberg et al. [7] have trained decision tree classifier for project success prediction using meta features (project goals, sentence count, project duration etc.) where they achieved 68% accuracy. In [8] novel text analytics framework for crowdfunding success prediction is introduced. Authors developed model for extraction of topical features from project descriptions which are then combined with numerical features and used as an input of different classifiers. Evaluation showed that in prediction performance decision tree classifier outperforms SVM, backpropagation neural network and extreme learning machine. It is important to note that research was conducted on two popular crowdfunding websites (Dreamore and Zhongchou). Li et al. [9] applied censored regression for crowdfunding success prediction and showed that addition of temporal features obtained after project launch significantly improves prediction performance.

Little work has been done regarding influence of visual content on crowdfunding success. In [10] authors proposed multimodal representation of campaign including text, images and metadata. Textual features include: title, summary, project description and risks/challenges. Visual representation of single campaign consists of all jpg images from campaign website, while

metadata include campaign category and project goal. These features are combined in 3 branch CNN architecture to predict project success. Bottom branch encodes text using Bag of Words (BoW) with Term Frequency-Inverse Document Frequency method (TF-IDF). Middle branch encodes campaign visual content utililizing ImageNet pre-trained 16-layer VGG model as feature extractor for each image in single profile. Final feature map for profile is created by stacking VGG features of single images. Top branch encodes metafeatures with fully connected neural network. Performance of success prediction with project images only is also investigated and it is shown that visual modality has significant contribution to campaign success, but to lesser extent than textual information.

Zhang et al. [11] combined textual and image modalities to predict crowdfunding campaign outcome for GoFundMe platform. Part of project features are crawled directly from websites (launch date, description, location, title cover image, category, current amount, goal amount etc.), while rest of features are derived (fundraisers location population, image quality, number of faces in images etc.). Different from [10], image content is not represented directly with CNN features, but with aesthetic and technical quality scores for title image as well as features derived from face recognition (number of faces, gender, beauty smile level, emotion, age). Image quality features are obtained with CNN model pretrained with ImageNet dataset and fine-tuned for classification of visual quality. Deep learning based face recognition platform Face++ is used to get facial features. Textual information is encoded using Linguistic Inquiry and Word Count (LIWC) features which are then fused with image features and classified using random forest classifier. Results showed that for projects belonging to 3 categories (Competitions & Pageants, Community & Neighbors, and Weddings & Honeymoons) and having goal between $ 8 000 and $ 40 000 image quality score, when fused with basic and text LIWC features, significantly improves classification performance. Interestingly, using image quality as single feature gives best classification result for this project group. It is also shown that for projects in other categories image quality does not influence on crowdfunding success. In [12] a machine learning approach is employed to recognize faces and facial expressions in profile images. It is found that appearance of smiling faces gives 5 % increase of funding amount, while presence of creator's face negatively influences on it.

DATA AND METODOLOGY

Training and testing of proposed method have been performed on image dataset scraped from Kickstarter. More precisely, we used dataset in csv format available at Webrobots [13] containing campaigns in the period from June 2010 to February 2021. Links to campaign cover images are extracted from csv files and download was performed with script written in Python. Cover images for projects with states canceled, suspended and live were filtered out what finally gives 54 563 images for successful campaigns and 33 159 images for failed campaigns. Dataset is split in 3 parts: training, validation and testing dataset.

Overview of proposed method for crowdfunding success prediction is shown in Figure 1.

Campaign profile image is used as input of CNN that was previously trained on ImageNet [14] dataset that is widely used in visual object recognition research. Images are annotated as one of 1000 categories from ImageNet Large Scale Recognition Challenge (ILSVRC). Here we

Table 1. Sizes of datasets used for training, validation and testing.

Dataset	Number of images		
	Success	**Fail**	**Total**
Training	31 500	17 161	48 661
Validation	3 214	1786	5 000
Testing	19 849	14 212	34 061

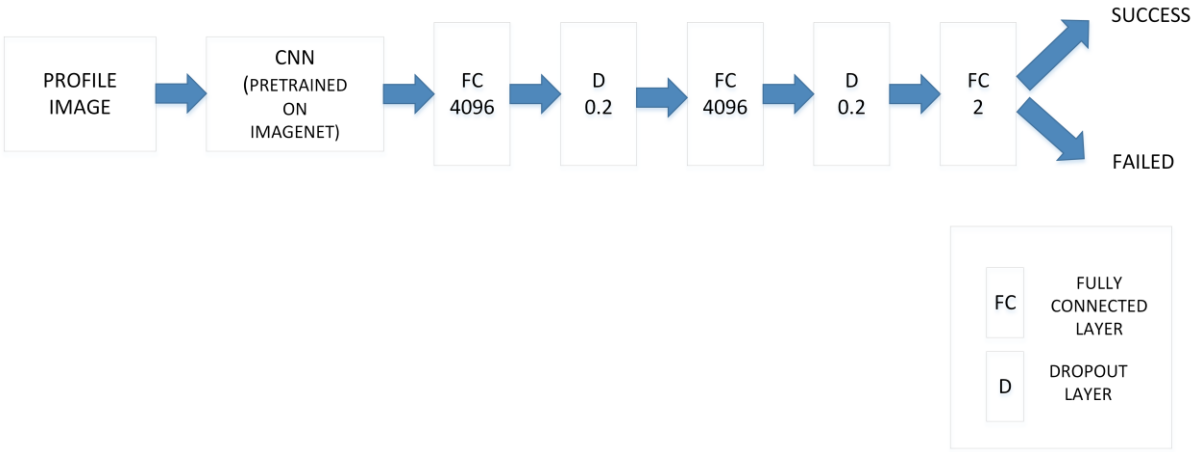

Figure 1. Overview of proposed method for crowdfunding success prediction.

tested 3 CNN architectures widely used in computer vison tasks: 16-layer VGG model [15], ResNet 50 [16] and DenseNet121 [17]. Top classification layer is removed from CNN and 2 fully connected layers with 4 096 channels are added followed by 2 sigmoid activated outputs representing campaign success or failure In this way transfer learning approach is realized where pretrained CNN acts as feature extractor followed by fully connected classifier. During training CNN weights are frozen and only weights from fully connected classifier are updated. In this way visual features learned from ImageNet dataset are repurposed for task of classification of campaign title image on success or failure classes. Since training the CNN from the scratch requires significant hardware resources and large training dataset, transfer learning allows us to perform training faster and with limited number of training images. We hypothesize that CNN features learnt on ImageNet dataset can be exploited for crowdfunding success prediction, although connection between project image content and project success/failure is far from straightforward and it is more complex than classification of image into classes like “horse”, “car”, “tree” etc.

VGG architecture consists of convolutional layers that use 3×3 kernels giving relatively small receptive field. Max pooling layers downsamples feature maps by factor 2. VGG network is shown in Figure 2.

Increasing the CNN depth by adding more convolutional layers enables extraction of high level features that help network to learn complex mapping between input (profile image) and output (success or failure). Problem here is that simple stacking more layers leads to accuracy degradation. This can be handled by ResNet architecture [16] where residual mapping is fitted instead of direct mapping between input and output. Residual block shown in Figure 3 learns residual mapping $F(x) = H(x) - x$, where x is input and $H(x)$ is original mapping. Huang et al. [17] proposed DenseNet architecture where all layers with same feature size are connected with each other. Each layer receives inputs from all preceding layers and passes its feature maps to all subsequent layers. If x_l is feature map of l^{th} layer and $x_0, x_1, \dots, x_{l-1}$ are feature maps of all preceeding layers with same size, then

$$x_l = H_l([x_0, x_1, \dots, x_{l-1}]), \quad (1)$$

where $[x_0, x_1, \dots, x_{l-1}]$ represents concatenation of feature maps and H_l is non-linear transformation of layer l composed of and batch normalization (BN), rectified linear units (ReLU) and convolutional operations. Since concatenation is viable only for feature maps of the same size, there is no pooling operation in function H_l which is important part that enables features downsampling in CNN. Therefore, network is divided in dense blocks (H_l) and transition layers between them that performs convolution and pooling, Figure 4.

Figure 2. VGG architecture.

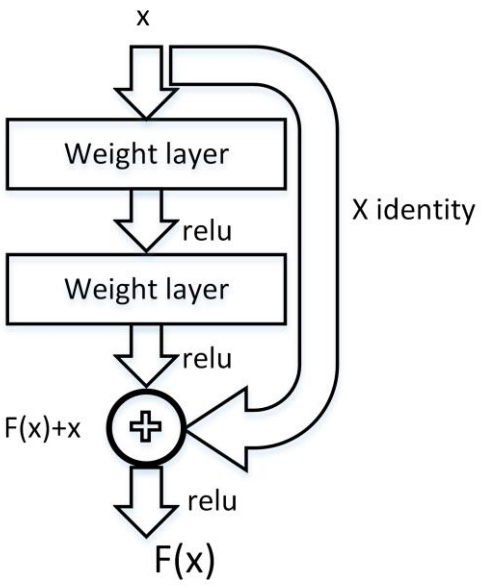

Figure 3. ResNet architecture.

Since we deal with binary classification problem, binary cross-entropy is chosen as loss function:

$$L = -\sum_{k=1}^{N}[\delta(y_k = 1)\log p_k + \delta(y_k = 0)\log(1 - p_k)], \quad (2)$$

where δ is indicator function having value 1 when prediction corresponds to ground truth (otherwise it has value 0), $p_k \epsilon [0, 1]$ is estimated probability for class with label 1 that is obtained as output of last dense layer with sigmoid activation.

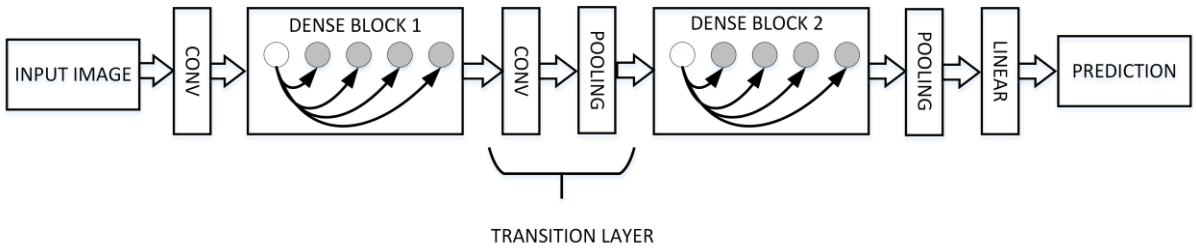

Figure 4. DenseNet architecture with 2 dense blocks.

RESULTS AND DISCUSSION

For performance evaluation and comparison with competing methods we have used following metrics: Accuracy, Recall, Precision, F-score and AUC@ROC. Accuracy is defined as:

$$Accuracy = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions}. \quad (1)$$

If binary classification is considered, accuracy can be calculated with

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}, \quad (2)$$

where TP refers to the number of true positive cases, TN is number of true negative, FP is number of false positive and FN is number of false negative outputs. Recall is the measure that reveals proportion of true positives that are detected correctly:

$$Recall = \frac{TP}{TP+FN}. \quad (3)$$

Precision shows what proportion of positive identification is actually correct, that is proportion of false positive outputs:

$$Precision = \frac{TN}{TN+FP}. \quad (4)$$

F-score is the measure defined as

$$F - score = 2\frac{Precision*Recall}{Preision+Recall}. \quad (5)$$

This can be interpreted as weighted average of precision and recall.

Receiver operating characteristics (ROC) curve plots relation of true positive rate and false positive rate. Area under curve (AUC) is defined as area under ROC curve describing how classification performs over range of all classification thresholds. Training is performed using Python and Keras library with TensorFlow backend. We used SGD optimizer and learning rate set to 1e-4 for 20 epochs. Batch size was 8 and early stopping is employed if validation loss did not decrease for 6 epochs.

Table 2. Results of success prediction for different CNN architectures.

Classifier		Accuracy	Precision	Recall	F-score	AUC
VGGNet16		0,6139	0,6141	0,9083	0,7328	0,6452
ResNet50		0,6431	0,6545	0,8212	0,7284	0,6803
DenseNet121		0,6502	0,6568	0,8373	0,7361	0,6890

Table 2 shows success prediction performance for VGGNet, ResNet and DenseNet classifier. It can be seen that DenseNet arhitecture achieves highest accuracy, precision F-score and AUC. ResNet predictor performs slightly worse for all measures. VGGNet architecture gives lowest accuracy, precision and AUC, but it has highest recall among proposed methods. This indicates that it can predict success of campaign (true positive case) with high reliability, while low precision means that classifier gives less reliable prediction of campaign failure. It can be seen that architectures with more layers performs better. This could be explained by influence of CNN depth, that is number of layers, where deeper architectures represent input image on higher abstraction levels needed to model non-trivial relation between profile image and campaign success or failure. Drawback of deep architectures is higher number of network parameters what implies larger training set to avoid overfitting. This problem is overcome by using pretrained weights and fine-tuning only the last two fully connected layers.

Regarding competing methods from literature, proposed approach could be compared with method presented in [10] where visual features are also used for campaign success prediction as single modality and in combination with textual and meta features. Key difference in comparison with proposed approach is that in [10] all campaign profile images (with size greater than 200 pixels) were used as input of CNN. For each image, its feature map was extracted using pretrained VGGnet16 model. Aggregated feature maps of all images are used as CNN input. In contrast, we used only one (title) image as input to CNN classifier.

Performance comparison is given in Table 3. Our method has significantly higher recall and better F-score, while precision and AUC values are lower compared to results from [10]. Overall, we obtain comparable performance with higher recall, but representing campaign with only one profile image.

Table 3. Results comparison with competing method [10].

Method	**Precision**	**Recall**	**F-score**	**AUC**
Proposed method (DenseNet121)	0,6568	0,8373	0,7361	0,689
Cheng [10] (visual modality only)	0,6809	0,6738	0,6768	0,7340
Zhang [11] (derived image features, projects with goal $ 8 000-$ 40 000)	0,88	0,83	0,81	NA

Regarding other methods from literature, it is hard to make direct comparison because there has not been done much work with success prediction using image content. In [11] authors investigated influence of image modality on campaign success for GoFundMe platform. Project title image is represented with aesthetical and technical scores obtained with pretrained deep learning model. Also, facial features extracted with Face++ recognition platform (number of faces, gender, beauty etc.) are added to investigate the influence of facial attributes. Random Forest is chosen as classifier and evaluation is performed for case when image quality features are used as input to classifier. For each project category authors used different image quality features. Classification with image quality gives higher precision and recall comparable to our method, but only for campaigns with goal between $ 8 000 and $ 40 000.

It should be noted that our analysis is conducted for all campaigns regardless target amount. Also, important difference is that we represent campaign with CNN features of title image without derived visual features. In this way we avoid manual selection of image features for each category moving this task to CNN.

CONCLUSION

In this article we deal with problem of crowdfunding campaign success prediction in pre-posting phase exploring the influence of visual modality on final outcome. Experiments

are performed with image dataset scraped from Kickstarter. Three widely used CNN architectures (VGG16, ResNet50, DenseNet121) are used as feature extractors followed by fully connected neural network as binary classifier. Evaluation shows that DenseNet121 CNN architecture has performance comparable to state-of-the-art methods. Different to other methods, our approach uses only one image per campaign and no derived fetaures leaving the task of feature selection to CNN. Future work would include addition of text and meta features to build stronger multimodal campaign success predictor.

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ANALYSIS OF AIR QUALITY PARAMETERS TO ASSESS THE IMPACT ON LAYERS IN POULTRY FARMS USING DEEP LEARNING

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ABSTRACT

The food security has increased the agriculture production due to satisfying demand of ever-growing population. Due to this growth in population, the demand of protein also increased. A significant amount of population depends upon the chicken and egg to fulfil the demand of protein. The meat and egg production depends on the quality of poultry farming. The presence of air contaminants causes poor air quality within the poultry house which affects health of layers, production of eggs and workers in poultry farm. The proposed work uses data analysis approach and machine learning concept to automatize the process of air quality monitoring in poultry farms. A Convoluted Neural Network Long Short-Term Memory model, along with bidirectional Long Short-Term Memory model is proposed to improve the forecasting performance. This method predicts the Air Quality Index based on air quality parameters. The proposed approach is tested on poultry farm air quality dataset which is collected from different poultry farms. Finally, the obtained performance is compared with existing techniques in terms of RMSE, MAE, MAPE and correlation coefficient.

KEY WORDS

AQI, LSTM, poultry, air quality, agriculture, egg production

CLASSIFICATION

JEL: Q16

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INTRODUCTION

A rise in agricultural productivity is required due to concern about food security because of the world's constantly expanding population, which is expected to reach nearly 9,6 billion people by the year 2050 [1]. However, since the early 1980s, the worldwide per-capita grain output has decreased due to environmental production restrictions. Proteins derived from animals are also becoming more and more popular [2]. As a result, it is predicted that by 2050, worldwide meat consumption would have increased by 70 % [3]. According to a research by Henchion et al. [5] on the trends of meat consumption, consumption of poultry meat and poultry meat products has increased, and this trend is expected to continue over the next ten years due to consumers' preferences for white meat, particularly chicken [6]. Animal health, efficiency and sustainable environmental circumstances have become difficult requirements to meet as chicken production has increased and as knowledge of acceptable conditions for animal welfare has grown [7]. As a result, human surveillance is no longer a practical method for monitoring livestock.These issues have been addressed by Precision Livestock Farming (PLF), which offers effective automated solutions while still upholding animal welfare[8]. PLF supports stockmen by keeping track of several bio-processes and bio-reactions pertaining to animal welfare, health, and production [9].

Due to its high protein, low calorie, and low cholesterol content, chicken meat is becoming more and more popular [10]. Nevertheless, environmental factors, disease outbreaks, the breeding process, and active management activities all affect chicken output levels [10]. To stop contagious illnesses, increase productivity, and assure healthy layers, effective chicken health and welfare management is crucial. However, conventional methods for managing the welfare of layer fowl are prone to high labour costs and ineffective resource management, including excessive feed, water and electricity usage. The combination of Internet of Things (IoT) and Machine Learning (ML) has been viewed in this context as one of the most promising technologies for delivering smart poultry farming, continuous data monitoring, and prescriptive analytics in order to address the aforementioned challenges for efficient resource control and optimal decision-making [11]. The IoT enabled systems play a significant role in chicken farming by offering automated monitoring facilities, according to the study given by Raj et al. [12]. However, a number of characteristics, including water, temperature, air and others, are included in the automated monitoring of chicken farms. In this work, air quality parameters such as CO (Carbon Monoxide), NH_3 (Ammonia), PM2.5 (Fine Particulate Matter having 2,5 µm), PM10 (Fine Particulate Matter having 10 µm) and SO_2 (Sulphur dioxide) are studied. These parameters lead to respiratory diseases in poultry layers which affect the weight, feed-conversion ratio and egg production in poultry farms. Generally, the air quality monitoring is the prime aspect of poultry farms in this endeavour to address problems with egg production, boost output and also economy of farmers.Thus, the main aim of this study is to maintain health and welfare of chickens farmed in poultry houses, the air quality need to be monitored which maximizes the egg production and reduces the risk of respiratory diseases [13].

Compute vision-based technologies serve as the foundation for conventional monitoring-based methodologies. These methods rely on frameworks for picture capture, image processing, and detection. However, the production of eggs and meat is also significantly impacted by the air quality [13]. In order to distinguish between appropriate and unsuitable air quality, this work used deep learning modules to monitor the air quality in chicken farms. Air quality forecasting is crucial for taking the necessary actions to increase poultry farming output.The air quality forecasting/prediction is a time series problem where sensors generates the data which may be contaminated due to uncertainty, redundancy, missing values etc. [13]. Due to these issues, the traditional approaches fail to learn the sequential data patterns that generate inaccurate forecasting. Moreover, the traditional machine learning approaches are not suitable for

complex real-world scenario. Thus, current research community has motivated by these issues and adopted deep learning techniques due to their significant nature of pattern learning. The deep learning based schemes are widely adopted in various domains such as image classification [23], video summarization [24], Natural Language Processing [25], data mining and many more [26]. Thus, the deep learning schemes are adopted by researchers to obtain the improved accuracy in various domains. To predict air quality the deep learning architecture is suitable for sequential, seasonal, nonlinear and cyclical dependency problems between pollutant data. The long-term dependencies from time-series data can be learned using Long Short-Term Memory (LSTM) technique [27].These techniques achieve the better performance but increasing the finer levels of prediction in air quality monitoring leads to inaccurate forecasting which affects the performance of precision poultry farming. Thus, to overcome these issues, a novel hybrid deep learning approach by using Convolutional Neural Network (CNN) and Bi-LSTM model is introduced. The main contributions of this approach are as follows:

- a brief study about existing techniques of precision poultry farming and air quality monitoring is presented,
- in next phase, a data pre-processing scheme which deals with the missing values and performs the data normalization is presented,
- in next stage, a new hybrid approach by combining the CNN and LSTM model is developed,
- the performance of LSTM model is further improved by incorporating bi-directional LSTM model.

Rest of the article is organized in following sections: literature survey describes the brief literature review regarding recent air quality monitoring techniques in poultry farming, proposed model presents proposed solution, results and discussion presents the experimental analysis where the performance of proposed system is analysed and finally, conclusion presents the concluding remarks about this approach.

LITERATURE SURVEY

This segment describes the brief discussion about recent studies in this field of air quality monitoring and forecasting. Okinda et al. [6] reported the importance of early detection of poultry farming related diseases and presented computer vision based monitoring system to identify the zoonotic infections. This model uses a computer vision based approach for data collection and monitoring. In order to obtain the features, the 2D shape features such as circle, variance, convexity and eccentricity etc. parameters are calculated. Along with these parameters, mobility or walking speed is also considered for analysis. Further, the support vector machine classifier is used to perform the classification.

In [11] Fang et al. also used computer vision based pose estimation strategy for poultry behaviour monitoring and identifying the sickness of the chicken. In this work, authors presented a deep learning based framework to analyze the chicken behaviour. The broiler chicken's feature points are utilised to build the posture skeleton, which is subsequently used to track certain body parts. Additionally, the broiler chicken positions were categorised and identified using the Naïve Bayesian model (NBM). Comparing the postures of categorised broiler chickens, preliminary testing showed that we could distinguish between birds in the standing, walking , running, eating, resting, and preening stages.

Yang et al. [14] studied about the impact of fine particulate matters on chicken health in China. In this study, authors considered the analysis of fine particulate to study about the poultry farm pollution. Lahlouh et al. [15] focused on improving the animal production with the help of broiler house systems. Generally, the animal production is affected due to several parameters such as hygro-thermal parameters such as temperature and relative humidity and contaminant gases

such as NH_3, CO_2. In order to perform this operation authors adopted fuzzy logic based approach trained with the help of fuzzy rules. This helps to monitor the chicken health regularly.

Al Assaad et al. [16] reported the issues faced by poultry farmers in the semi-arid climatic region. Therefore, authors presented a comparative analysis of passive cooling systems to meet the indoor air quality. This study presented the impact of NH_3, and CO_2 on poultry farming. Grilli et al. [17] focused on coccidiosis disease detection in poultry farming for precision livestock farming by using combined cheap and specific approaches. This study is based on the Air quality monitoring. Sayour et al. [18] presented wireless sensor network based monitoring system to measure and monitor the air quality. Currently, the WSNs are widely adopted in various real-time systems for data collection, and monitoring such as environment monitoring, weather forecasting etc. In this work, authors mainly focused on temperature, CO_2, NH_3 and humidity monitoring to measure the air quality.

Jayarajan et al. [19] presented IoT based automated approach to monitor the poultry farms because most of the Indian farms use manual and physical methods for this purpose. The IoT based model can help to monitor the temperature, air quality and other parameters which have impact on chickens. This technique monitors these parameters and generates the alert messages to inform to the clients. Similar to this, Lashari et al. [10] also used IoT based system for monitoring the poultry environment. this approach uses humidity, O_2, CO_2, temperature, and NH_3 as the important parameter.

Hofmann et al. [20] reported several conditions of poultry farms which has stressful impact on chickens and their immune system. This review reported the impact of Ammonia, Hydrogen sulphide, Photoperiod, Light Color/Wavelength, and Light Intensity on immune system. High concentration of these gases affects the respiratory and cardiovascular system of the birds. NH_3 is affected due to manure management, temperature and moisture which vary between the houses. Similarly, the H_2S is generated from degradation of liquid manure under anaerobic conditions. Naseem et al. [21] identified Ammonia as an important concern for environmental pollution which is produced from the poultry farming. Production of NH_3 depends on several factors such as bird age, litter type, pH, temperature, ventilation rate and many more. Minimization of NH_3 emission can help to reduce the severe diverse impact of ammonia therefore several types of modern ventilations systems are developed to minimize its emission.

Generally, intensive farming has adopted the antibiotics based solutions for health related complications in farming. This has led to spreading of drugs in environment and contributed to the antibiotic resistance. To mitigate this effect, early detection of disease is highly recommended and several researchers have been working for early disease detection to minimize the use of drugs. Grilli et al. [17] studied about detection of coccidiosis in poultry farms. This method is based on the air quality monitoring system where samples are collected in the presence of coccidiosis. Later, these samples are classified based on the with the help of machine learning approaches. Pereira et al. [22] studied the impact of temperature, ammonia and humidity levels in poultry farming based on the concept of IoT systems. This model mainly concentrates on improving the data transmission method using hardware based system.

PROPOSED MODEL

This section presents the proposed deep learning based solution for air quality prediction and forecasting to improve the poultry farm monitoring. The first phase of this scheme includes data pre-processing where data normalization is employed which helps to minimize the data volatility. In next phase, the CNN and LSTM models are described briefly. Finally, the proposed hybrid CNN-LSTM prediction model is presented.

MISSING VALUE IMPUTATIONS

This stage plays an important role in the field of data analytics. This is used to improve the data representation. During air quality data collection, some sensor may produce faulty values or may lead to missing values in the dataset. Therefore, applying missing value imputation is a primary task. This scheme helps to remove the outlier, imputes the missing values and normalize the input data. In this work, we have collected several data which represent the air quality such as ammonia, particulate matter, CO_2 and SO_2. However, the some of the entries are missing in the dataset which are due to non-working of sensor. First of all, a normalization function is employed to obtain the data in certain range. The normalization function is given as:

$$Y = \frac{(A-M)}{S},\ Y = \frac{A-A_{min}}{A_{max}-A_{min}}, \tag{1}$$

where A denotes the actual input data, M denotes the mean of this data, S is the standard deviation, A_{max} and A_{min} represent the maximum and minimum values of attributes. Furthermore, a missing value imputation method is presented by using a combined KNN and correlation computation model. The missing value dataset is represented as given in Table 1.

Table 1. Missing value data representation.

Id	Col1	Col2	Col3	Col4	Col5
0	2,0	5,0	3,0	6,0	4,0
1	9,0	Nan	9,0	0,0	7,0
2	19,0	17,0	Nan	9,0	Nan

Based on this missing data representation, the correlation between attributes is computed as follows:

$$r_{m_2 j} = \frac{\sum_{i=1}^{q} y_{im_2} y_{ij} - \frac{\left(\sum_{i=1}^{q} y_{im_2}\right)\left(\sum_{i=1}^{q} y_{ij}\right)}{q-1}}{\sqrt{\left[\sum_{i=1}^{q} y_{im_2}^2 - \frac{\left(\sum_{i=1}^{q} y_{im_2}\right)^2}{q-1}\right]\left[\sum_{i=1}^{q} y_{ij}^2 - \frac{\left(\sum_{i=1}^{q} y_{ij}\right)^2}{q-1}\right]}}, \tag{2}$$

where $r_{m_2 j}$denotes the correlation coefficient between missing data and variable j, C_m is the case which has the missing value, V_{m_2} denotes the variable which has the missing value, y_{im_2} denotes the variable in any case which has the missing data and y_{ij} is the complete data.

For missing value imputation, KNN imputation method is applied for a specified numbers of k. The Euclidean distance between data, and missing data is computed as follows:

$$dist\left(C_{m_1}, C_i\right) = \sqrt{\sum_{j=1}^{p}\left(y_{m_1 j} - y_{ij}\right)^2}. \tag{3}$$

Here, $dist\left(C_{m_1}, C_i\right)$ denotes the distance between missing value data and complete data, p represents the total number of variables in the dataset and q denotes the total number of cases. The obtained distance values are sorted based on the k values which are closer to the case which has the missing data. By utilizing the aforementioned distance metrics and other parameters, the missing data attribute values can be estimated as:

$$\hat{y}_{m_1,m_2} = \frac{\sum_{a}^{k} y_{a,m_2}}{k}, \tag{4}$$

where $\hat{y}_{m_1,m_2}$ denotes the estimated missing data and y_{a,m_2}represents the data which is the same variable with missing data and closer to the case which is having missing data. With the help of this process, this model generates a pre-processed data which is later used for learning purpose.

PROPOSED HYBRID MODEL

This section presents the description about CNN-LSTM model for prediction and forecasting approaches. The CNN-LSTM air quality prediction model is constructed by combining the characteristics of CNN and LSTM network. When combined with existing models, the CNN-LSTM air quality index prediction model proposed in this paper combines the efficient feature extraction ability of CNN and the ability of LSTM to deal with long time series. The prediction accuracy of model can be improved by learning, analyzing, and processing the historical data through various structures. The CNN-LSTM model was compared with the other models , and the prediction model with the best performance was selected. CNN-LSTM, which is used to extract the complex characteristics received from the different air quality monitoring equipment, may be described simply as a serial connection of CNN and LSTM modules. The air quality forecast also makes use of these features. The CNN layer of the network's initial section takes into account many inputs, including NH_3, CO_2, SO_2, and others. For the CNN layer, this data is regarded as meta data. The whole CNN module has many hidden layers as well as a single output layer that sends the features that were retrieved to the LSTM for further learning. The hidden layer is comprised of convolution layer which helps to generate the activation map of the data, Rectified Linear Unit (ReLU) layer is used to discard the negative values from activation map and pooling layer which is used to reduce the spatial size resulting in controlling the overfitting.

In this process, the convolution layer performs its operations on the incoming multivariate time series data sequence and passes results to next layers. Let us consider that air quality vector is expressed as $x_i^0 = \{x_1, x_2, \ldots., x_n\}$ where n denotes the time window which is normalized as 60 min unit per window. The use of a 60-minute normalization window refers to a specific design choice related to the temporal aspects of the data being processed. It is used to ensure that the input data within each 60-minute segment is on a consistent scale, aiding the learning process. The outcome of first convolution layer can be expressed as:

$$\begin{aligned} y_{ij}^1 &= \sigma\left(b_j^1 + \sum_{m=1}^{M} w_m^1, jx_{i+m-1}^0, j\right), \\ y_{ij}^l &= \sigma\left(b_j^l + \sum_{m=1}^{M} w_m^l, jx_{i+m-1}^0, j\right), \end{aligned} \tag{5}$$

The y_{ij}^1 denotes the output of first convolution layer and y_{ij}^l denotes the output of l^{th} convolution layers, b_j^1 denotes the bias for the j^{th} feature map, w represents the kernel weight, m is index value of filter and σ is the activation function. Moreover, the convolution layer consist of a pooling layer which is used to combine the neuron outputs from one layer to another layer. This layer helps to minimize the space size of feature representation resulting in minimizing the number of network parameters and reducing the computational cost. Here, this model the max-pooling operation which considers the maximum value of each from previous layer. The max-pooling operation can be expressed as:

$$p_{ij}^l = \max_{r \in R} y_{i \times T + r, j}^{l-1}, \tag{6}$$

where R is the pooling size, y is the input data and T denotes the stride value.

Further, the LSTM unit is considered which the second part of this network is. This layer stores the important information obtained from the CNN module. Mainly, the LSTM unit consolidates the memory units which help to update the memory data of previous hidden states. Thus, LSTM has a characteristic to obtain the temporal relationship of long-term multivariate sequence. Further, the output of previous layers is passed to the gated units available in the LSTM network. The LSTM network becomes the prime choice for forecasting problems because of its capacity to handle the gradient vanishing problems when learning using traditional RNN learning approaches. The LSTM unit cab be defined as a group of vector R^d at time step t. Figure 1 illustrates the basic architecture of LSTM unit.

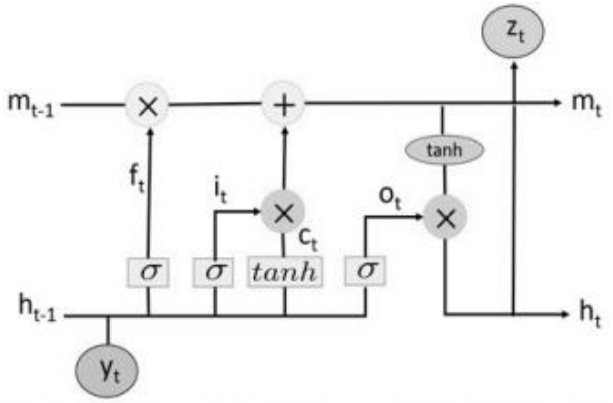

Figure 1. Basic architecture of LSTM Unit.

The other components of LSTM are described further in the text.

Memory cell unit (m_t): it stores the intermediate steps of feature learning process. It can be expressed as:

$$m_t = f_t . m_{t-1} + i_t . c_t. \tag{7}$$

Here, $c_t = \tanh(W_m . [h_{t-1}, y_t] + b_m)$ where t denotes the current time step, $(t-1)$ denotes preceding time step, $h_{(t-1)}$ is the hidden state at time step $(t-1)$, W_m characterise the weight matrix for memory cell, y_t is the input data and b_m is the bias for memory cell unit. The LSTM module contains input gate, forget gate, and output gate. These components are denoted as follows:

- input gate (i_t): it considers the pre-processed air quality data as input from previous layers of CNN. This can be expressed as:
$$i_t = \sigma(W_i . [h_{t-1}, y_t] + b_i), \tag{8}$$
- forget gate (i_t): this is the intermediate gate which resets the old memory data. This can be given as:
$$i_t = \sigma(W_i . [h_{t-1}, y_t] + b_i), \tag{9}$$
- output gate (i_t): this is the final unit of LSTM which generates the final output from learning and prediction steps. This can be given as:
$$o_t = \sigma(W_0 . [h_{t-1} . y_t] + b_0), \tag{10}$$
- finally, the hidden cell state (h_t) used by LSTM as hidden units can be expressed as:
$$h_t = o_t \cdot \tanh(m_t). \tag{11}$$

Generally, these modules process the information from input to output steps in a single direction which suffer from information preserving for accurate forecasting. Thus, to overcome this issue, the proposed model has adopted the bi-directional LSTM architecture which processes the data into two directions as forward and backward. In forward direction, the bi-directional LSTM passes the data from previous index to next point as input whereas in backward direction it passes the data from future inputs to past inputs. This scheme of bi-directional data processing helps to preserve the learned attributes from past inputs and future inputs while processing through different hidden layers. Further, these outputs are processed through the output layer. Figure 2 shows the architecture of bidirectional LSTM.

The forward process is represented as $\vec{h}$ and backward process is denoted as $\overleftarrow{h}$. The outcome of these forward and backward data processing is computed based on the aforementioned conational equations. The final outcome of this bi-directional LSTM is obtained as $Z_T = [Z_{T-k}, Z_{T-k+1}, \dots, Z_{T-1}]$ where each element of this vector is expressed as:

$$z_t = \sigma(\vec{h}, \overleftarrow{h}), \tag{12}$$

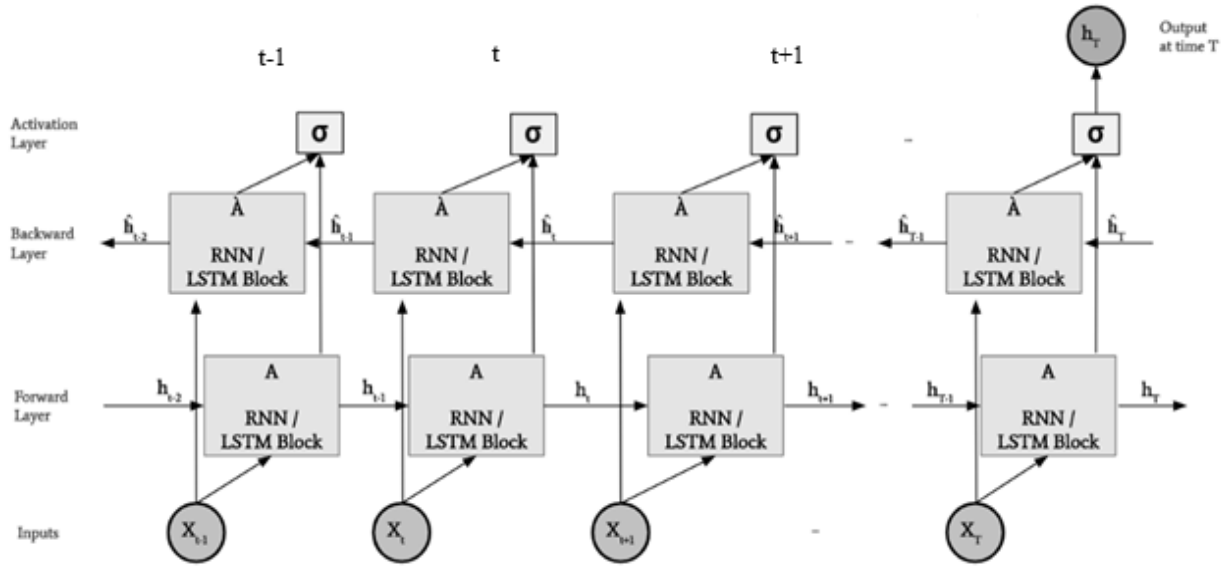

Figure 2. Bi-directional LSTM architecture

where σ is the function which helps to integrate the output of forward and backward passes. Similarly, the output of forward $(\vec{h})$ and backward $(\overleftarrow{h})$ passes can be denoted as:

$$\begin{aligned} \vec{h} &= H\left(W_{y\vec{h}}y_t + W_{\vec{h}\vec{h}}\vec{h}_{t+1} + b_{\vec{h}}\right), \\ \overleftarrow{h} &= H\left(W_{y\overleftarrow{h}}y_t + W_{\overleftarrow{h}\overleftarrow{h}}\overleftarrow{h}_{t+1} + b_{\overleftarrow{h}}\right), \end{aligned} \tag{13}$$

Based on these models of CNN and LSTM, a combined deep learning model is presented to learn the attributes. Below given figure depicts the architecture of proposed model. This model considers the several parameters as input from the data based and processed through the CNN module. These inputs are further transformed into a number of two-dimensional matrices containing time series. The CNN network is then used to extract the features from these matrices. The LSTM receives the output as input. The final prediction result is obtained by decoding the LSTM output using the fully connected layer as shown in Figure 3.

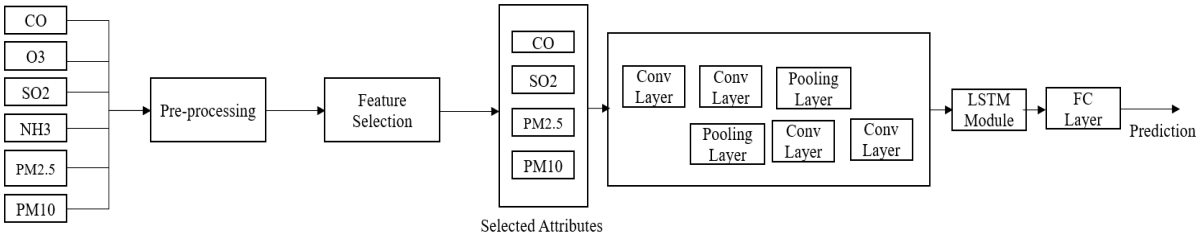

Figure 3. Proposed combined architecture for air quality prediction

It is assumed that the proposed architecture has α layers where β layers are under the training process which is used to train the x_i training data for the y_i labels.

The training process of proposed deep learning model can be expressed as:

$$\begin{aligned} C_i^{\mu} &= g(u^T x_i), \quad \beta = 2, \\ P_i^{\mu} &= g(v^T C_i), \quad w < \beta < \delta - 3, \\ L_i^{\mu} &= g(w^t P_i + d^T L_i), \quad 3 < \beta < \delta - 2, \\ y_i^{\mu} &= f(\zeta^T L_i), \quad \mu = \alpha - 2. \end{aligned} \tag{14}$$

where u denotes the weight matrix of input which corresponds to the convolution layer, v represents the weight matrix from convolution layer to pooling layer, w is the weiht matrix between pooling and LSTM layer, d is the weight of information exchange between LSTM and neurons and finally, ζ characterise the weight of fully connected layer.

RESULTS AND DISCUSSION

This section presents the experimental analysis using proposed approach and compared the performance with various existing techniques. The proposed scheme is applied on air quality data which is collected from poultry farms. This model is trained using NVIDIA RTX 2060 GPU, Intel I core 10th generation processor, 16 GB RAM installed on Linux platform. This implementation includes Keras and Tensorflow libraries for learning along with Adam optimizer.

DATASET ARRANGEMENT

During data collection, several parameters are considered which are collected for a duration of one year from https://kspcb.karnataka.gov.in. Air Quality Index (AQI) is used to measure the quality and how clean the air is and it is a number used by the government agencies to measure the quality of air. Below given Table 2 shows a sample range of these parameters and computed their corresponding threshold to measure the overall AQI.

Table 2. Air Quality Classes and their Corresponding Values.

Air Quality	AQI	PM2.5 (24 hr avg)	PM10 (24 hr avg)	CO	SO2
Good	0-50	0-12	0-54	0-4,4	0-35
Moderate	51-100	12,1-35,4	55-154	4,5-9,4	36-75
Unhealthy	101-150	35,5-55,4	155-254	9,5-12,4	76-185
Very unhealthy	151-200	55,5-150,4	255-354	12,5-15,4	186-304

Let PM2.5 sensor records the 30,1 $\mu g/\mathrm{m}^3$ as average pollution reading for a 24-hour period. The obtained reading is in the range of 12.1-35 which shows moderate air quality index. The AQI for this parameter is computed as follows:

$$I_{PM2.5} = \frac{(I_{High} - I_{Low})}{(C_{High} - C_{low})} \times (C_p - C_{low}) + C_{low} = \frac{(100-51)}{35.4-12.1} \cdot (30{,}1 - 12.1) + 51 = 89. \quad (15)$$

PERFORMANCE MEASUREMENT PARAMETERS

Based on the previous analysis, the dataset is arranged in 5 different classes which is classified with the help of proposed approach. The classification performance of proposed approach is measured by estimating the confusion matrix. Below given Table 3 shows the confusion matrix for 4 class scenario.

Table 3. Confusion matrix representation

		Predicted Class			
		Good	Moderate	Unhealthy	Very Unhealthy
Actual Class	Good	TN	FP	TN	TN
	Moderate	FN	TP	FN	TN
	Unhealthy	TN	FP	TN	TN
	Very unhealthy	TN	FP	TN	TN

True positive (TP): it shows that the classifier correctly predicts the positive class from the given test set.

True Negative: it shows that the classifier model correctly predicts the negative class from the given test set.

The true negative and true positive values show the accuracy of classifier. However, these categories should match the actual values of TP and TN.

False positive: denotes the classifier model incorrectly predicts the positive class.

False negative: denotes that the classifier mistakenly predicted the negative class.

This confusion matrix facilitates in the computation of the proposed approach's overall accuracy, precision, specificity, sensitivity, and F-measure. The symbol for accuracy (acc) stands for the rate of proper classification. It is calculated by dividing the total number of predictions by the percentage of true predictions. It may be computed as follows:

$$Acc = \frac{\text{TruePositive+TrueNegative}}{TP+TN+FP+FN}. \quad (16)$$

Similarly, the Recall performance also can be computed with the help of true negative and false positive values. This can be computed as follows:

$$Recall = \frac{TruePositive}{TruePositive+TN}. \quad (17)$$

Then, Precision of the proposed approach is comptuted. It is computed by taking the ratio of True Positive and (True and False) positives.

$$P = \frac{TruePositive}{TruePositive+FP}. \quad (18)$$

Finally, F-measure is computed which is the mean of precision and sensitivity performance. It is expressed as:

$$F = \frac{2*P*Sensitivity}{P+Sensitivity}. \quad (19)$$

Based on these parameters, the performance of proposed approach is measured and compared with other supervised classifiers. Further, the performance of Air Quality forecasting and compared the performance of proposed approach in terms of Root Mean Square Error (RMSE), MAPE, Mean Absolute Error (MAE), and R2 score/coefficient. These parameters can be computed as follows:

$$RMSE = \frac{1}{n}\sqrt{\frac{1}{n} * \sum_{j=1}^{n}\left(A_j - P_j\right)^2}, \quad MAE = \frac{\sum_{j=1}^{n}|A_j - P_j|}{n}. \quad (20)$$

Here, A_j represents the actual energy consumption data for a given time sequence t, P_j denotes the predicted value of energy consumption at time step j and n denotes the total number of time steps in given dataset.

COMPARATIVE ANALYSIS

This section presents the comparative analysis in terms of aforementioned parameters and obtained performance is compared with traditional machine learning classifiers. The obtained confusion matrix is presented in Table 4.

Based on the aforementioned performance measurement parameters, the performance of proposed approach is measured. Table 5 and Figure 4 show the outcome for this experiment.

Further, the training and testing ratios are varied and the obtained performance is presented in Table 6 and Figure 5.

This experiment shows the average performance is obtained as 97,5, 0,95, 0,95, and 0,955 in terms of Precision, Recall, and F1-Score, respectively. However, the decreased training and testing ratio leads to reduce the performance but overall comparative analysis shows that proposed approach achieved better performance for 70-30 train-test ratio. Similarly, average performance of different classifiers is also presented in Table 7 and Figure 6.

Table 4. Obtained Confusion Matrix by Using Proposed Approach (for 70 % Training and 30 % Testing)

	Good	Moderate	Unhealthy	Very Unhealthy
Good	97	2	2	1
Moderate	1	93	2	2
Unhealthy	1	3	94	1
Very unhealthy	1	2	2	96

Table 5. Performance of Proposed Approach for Each Class(in percentage)

Class	Truth	Predicted	Accuracy	Precision	Recall	F1--Score
Good	100	102	98	95	97	96
Moderate	100	98	97	95	93	96
Unhealthy	100	99	97.25	95	94	94
Very unhealthy	100	101	97.75	95	96	96

Table 6. Performance Analysis of Proposed Approach for Varied Train-Test Ratios (in percentage).

Train-Test Ratio	Accuracy	Precision	Recall	F1-Score
50-50	92,25	92,6	92,5	92,0
60-40	95,94	93,3	94,1	94,6
70-30	97,10	97,1	97,2	97,2
80-20	97,25	98,1	98,1	97,8

Table 7. Performance Measurement and Comparison with Different Classifiers (in percentage).

Classifier	Accuracy	Precision	Recall	F1-Score
SVM	90,93	91,0	90,0	90,0
KNN	89,33	89,3	89,3	89,2
Decision tree	96,64	96,6	96,5	96,4
Random Forest	97,10	97,1	97,2	97,2
Proposed Model	97,50	97,5	97,5	97,65

Further, this experiment is extended for air quality forecasting model and measured the performance in terms of RMSE, MAE and MAPE. In this experiment, first of all we measure the performance for air quality forecasting and obtained performance is presented in Table 7.

Table 7. Comparative Performance for Air Quality Forecasting (in percentage).

Technique	RMSE	MAE	MAPE
Linear regression	137,27	85,54	70,30
Extreme Learning	90,109	53,44	65,87
Neural nets	86,23	48,93	57,93
LSTM	17,55	13,57	7,80
LSTM Encoder Decoder Model	6,332	4,36	2,55
CNN-LSTM	19,74	14,97	11,17
Conv-LSTM	7,47	5,55	2,677
bi-directional LSTM	12,71	10,13	3,17
Proposed Model	8,10	6,15	2,11

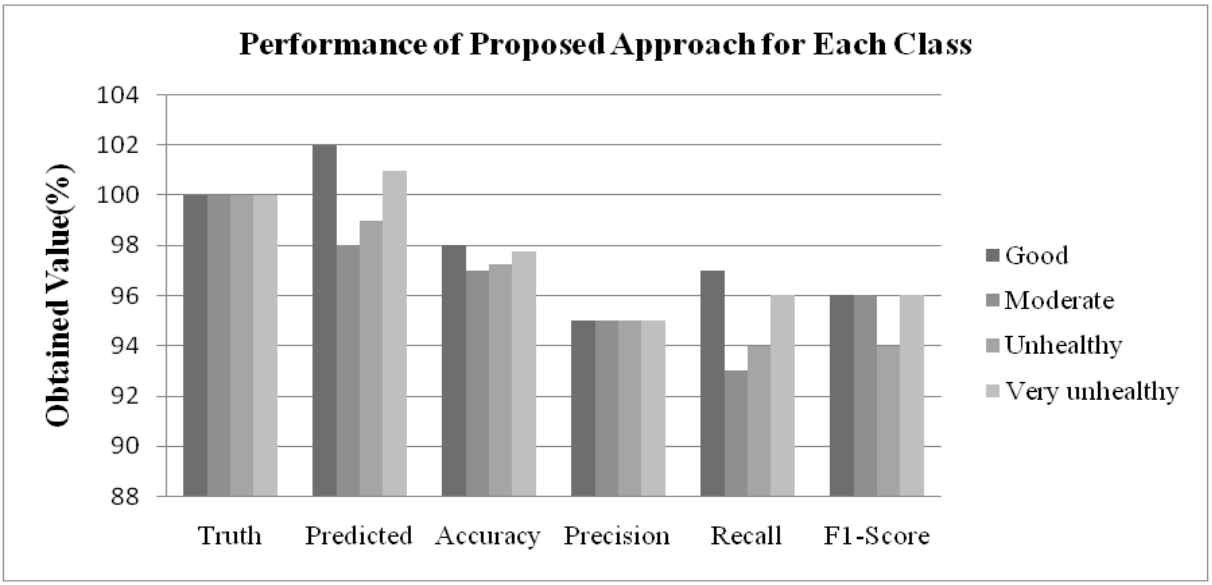

Figure 4. Performance of Proposed Approach for Each Class

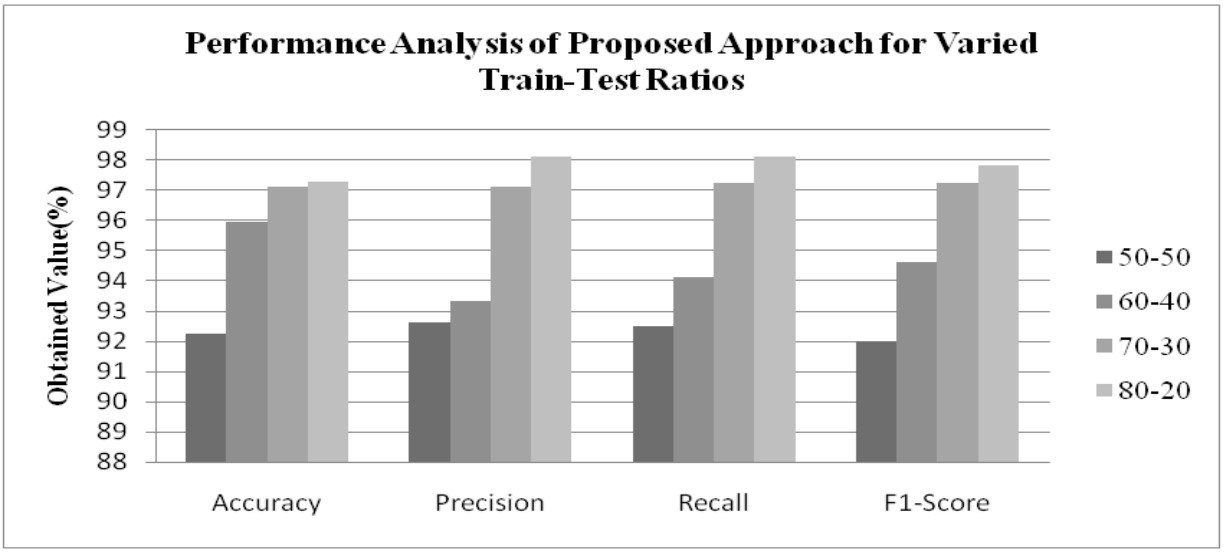

Figure 5. Performance Analysis of Proposed Approach for Varied Train-Test Ratios

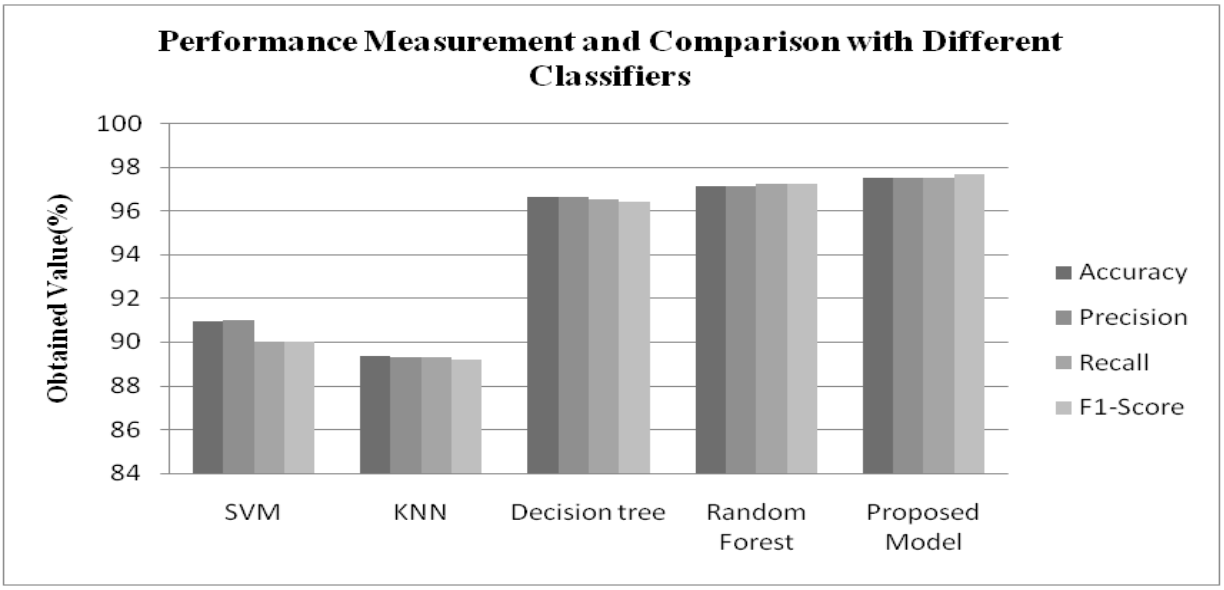

Figure 6. Performance Measurement and Comparison with Different Classifiers.

Finally, a health impact forecasting study on poultry is presented in Table 8 which shows the impact on poultry farms and egg production for different air quality indices. By knowing the air quality index, the poultry farmer can take precautions with respect to health and welfare of chickens farmed in poultry houses. For instance, if air quality is poor or unhealhty, the farmer can provide ventilation and take other actions with respect to welfare of the chickens in poultry farm.

Table 8. Impact of Air Quality on Egg Production.

Air Quality	AQI	Impact on poultry layers in farms
Good	0-50	Quality of air is good for poultry.
Moderate	51-100	Quality of air is moderate. Its an indication for farmers. Moderate effects on poultry layers.
Unhealthy	101-150	Farmers should follow the managemental practices like proper ventilation, litter management etc. This index leads to severe breathing effect on poultry.
Very Unhealthy	151-200	Farmers should take preventive measures to reduce the effect of respiratory diseases which affect the overall health of poultry layers.

CONCLUSION

This article focus on precision poultry farming to cater the health related issues in chickens to increase the meat the egg production. Several methods are present but most of the traditional methods are based on the manual inspection which requires huge amount of time and efforts. Therefore, research community has suggested to incorporate the machine learning based approach for automation of poultry farm monitoring, based on this, computer vision based approaches are introduced however, camera based monitoring systems is a complex task and accuracy also remains a challenging issue. Therefore, a data analysis based approach is presented for poultry farm monitoring by analysing the air quality to improve the health of the chickens. The proposed approach is based on the deep learning based systems where the CNN-LSTM based model is employed to classify the air quality pattern as Good, Moderate, Unhealthy, and Very Unhealthy. The experimental analysis shows that the proposed approach achieves overall accuracy as 97,5 % which can be helpful in appropriate monitoring of poultry chickens.

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KEY WORDS Not more than 5 key words, as accurate and precise as possible.

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