

Age-Related Differences in Fixation Gaze Length While Reading the News with Negative Text Elements

Daryna Ivaskevych ^a, Anton Popov ^b, Volodymyr Rizun ^c,
Yurii Havrylets ^{c,*}, Alla Petrenko-Lysak ^c, Yuliia Yachnik ^c, Sergii Tukaiev ^c

^a National University of Ukraine on Physical Education and Sport, Ukraine

^b National Technical University "Igor Sikorsky Kyiv Politechnic Institute", Ukraine

^c Taras Shevchenko National University of Kyiv, Ukraine

Received August 22, 2022; Revised February 8, 2023; Accepted May 8, 2023

Abstract. The worldwide COVID-19 pandemic has led to the development of stress disorders and increased societal anxiety. The mass media is one of the most decisive factors leading to the development of anxiety and stress in society during a pandemic. However, the mechanisms of mass media's stressogenic effects remain unclear. This study aimed to evaluate age-specific characteristics of gaze behavior related to the perception of anxiety-provoking information. One hundred eighty-nine volunteers took part in the study (164 participants aged between 17 and 22 years old (students, control group), 25 people aged between 59 and 71 (experimental group)). We surveyed participants to determine their level of stress, depression, and anxiety and analyzed eye-tracking data during text perception by using the web eye-tracking technology EyePass. Results showed significant age-related differences in gaze behavior while reading texts with negative elements. Aged adults had shorter median fixation duration. There was no difference between groups in the number of fixations. We can assume that except age factor, other variables might have contributed to our result, namely the occupation of participants, professors at the Scientific and Educational Institute of Journalism, with developed professional skills (reading pattern, method of information perception) but from another side higher vulnerability to adverse COVID-19 outcomes compared to younger adults.

Keywords: mass media, COVID-19 pandemic, gaze behavior, fixation, eye tracking.

Іваскевич Дарина, Попов Антон, Різун Володимир, Гаврилець Юрій, Петренко-Лисак Алла, Ячнік Юлія, Тукаєв Сергій. Вікові відмінності в тривалості фіксації погляду під час читання новин із негативними текстовими елементами.

Всесвітня пандемія COVID-19 призвела до розвитку стресових розладів і зростання суспільної тривожності. Мас-медіа є одним із найвирішальніших факторів, що призводять до розвитку тривоги та стресу в суспільстві під час пандемії. Проте механізми стресогенного впливу ЗМІ залишаються до кінця не з'ясованими. Метою цього дослідження було оцінити вікові особливості поведінки погляду, пов'язані зі сприйняттям інформації, що викликає тривогу. У дослідженні взяли участь 189 добровольців (164 учасники віком від 17 до 22 років (студенти, контрольна група), 25 осіб віком від 59 до 71 року (експериментальна група)). Ми опитали учасників, щоб визначити їхній рівень стресу, депресії та тривоги, та проаналізували дані ай-трекінгу під час сприйняття тексту за допомогою веб-відстеження очей – технології веб-трекінгу EyePass. Результати показали значні вікові відмінності в динаміці зорової уваги під час читання текстів із негативними елементами. Старша доросла група мала меншу середню

* Corresponding author. Yurii Havrylets,  <https://orcid.org/0000-0002-4899-5815>  havrylets@knu.ua

© The Author(s), 2023. This is an Open Access article distributed under the terms and conditions of the Creative Commons Attribution 4.0 International Licence (<http://creativecommons.org/licenses/by/4.0>).

East European Journal of Psycholinguistics, 10(1), 36–47. <https://doi.org/10.29038/eejpl.2023.10.1.iva>

тривалість фіксації. Різниця між групами за кількістю фіксацій не було. Можна припустити, що окрім віку учасників, на наш результат могли вплинути й інші чинники, а саме професія учасників, викладачів Навчально-наукового інституту журналістики з розвиненими професійними навичками (патерн читання та спосіб сприйняття інформації), але, з іншого боку, більша вразливість до несприятливих наслідків COVID-19 порівняно з молодшими людьми.

Ключові слова: масмедіа, пандемія COVID-19, поведінка погляду, фіксація, ай-трекінг.

Introduction

COVID-19 Pandemic Anxiety

The COVID-19 pandemic resulted in an increased prevalence of anxiety. According to Petzold et al. (2020), people experience anxiety and psychological distress despite being diagnosed with COVID-19 or knowing anyone with this diagnosis at the beginning of the quarantine in Germany. Other studies reveal that generalized anxiety disorder and depression are common effects of the COVID-19 pandemic (Hyland et al., 2020). In addition, females are more prone to experiencing higher anxiety levels (Petzold et al., 2020). There are several potential causes of this effect.

The first cause is lifestyle changes associated with the COVID-19 pandemic (Bendau et al., 2021). The lack of surgical masks, potential issues with working from home, and fear of contact with the disease were the leading causes of anxiety during the first three months of the pandemic (Choi et al., 2020). This effect was moderated by the intolerance of uncertainty (Bakioğlu et al., 2021). The increased level of uncertainty in society leads to intense and general distress, the development of mental disorders, and mood deterioration (Pogorilka et al., 2021; Rettie & Daniels, 2021). In the face of uncertainty, most people desire to avoid it and make decisions hastily (Pogorilka et al., 2021). Intolerance of uncertainty contributes to the development of stress and burnout (Kim & Lee, 2018), and the latter negatively contributes to the emotional perception of information (Havrylets et al., 2019).

The second potential cause of heightened anxiety levels is increased mass media consumption. Liu & Liu revealed that all kinds of media resulted in vicarious traumatization, with commercial media having the full mediation effect in mainland China (Liu & Liu, 2020). While new information is beneficial for uncertainty management (Brashers et al., 2000), media consumption did not improve anxiety symptoms at the beginning of the COVID-19 pandemic (Downs & Adrian, 2004). Evidence shows that media consumption increases uncertainty, which correlates with non-compliance with governmental regulations (Mevorach et al., 2021). On the other hand, trust in the agency that produced the media message was associated with a higher level of compliance in Israel in May 2020 (Mevorach et al., 2021). Overall, mass media are associated with increased anxiety related to COVID-19. However, the mechanisms of these processes are not completely clear.

The aim of this study was to evaluate age-specific characteristics of gaze behavior related to the perception of anxiety-provoking information. The significance of this investigation lies in its interdisciplinary nature and the need for further research

involving news messages. At this point, no study has examined psycho-emotional states during news perception based on eye-tracking behavior.

Previous Evidence About the Age-Related Differences in Eye Movements While Reading

There is evidence of age-related differences in information processing while reading. These age-related differences can be caused by the aging process in eyesight (Rayner et al., 2014), attention processes (Gamboz et al., 2010), and cognitive control mechanisms (Borges et al., 2020). It should be noted that text comprehension does not decline in the same way due to the changes in time allocation during the reading (Stine-Morrow et al., 2004). Older adults also differ from younger adults in the semantic processing of the text by allocating fewer resources for detecting coherent anomalous noun phrases and more time for incoherent ones (Daneman et al., 2006). In addition to these changes that might affect text comprehension, there are age-related differences in gaze behavior during reading.

Aging mechanisms alter saccades, fixations, their length, and the occurrence of rereading. Aging is characterized by increased saccades' latency and the weakening ability to suppress reflective saccades (Daneman et al., 2006). According to McGowan et al. (2015), older adults have more fixations and longer duration. In addition, changes in gaze behavior result in a lower chance of fixating on prescription warning labels in older adults (Sundar et al., 2012). While the mechanism for the decrease in fixation time is unclear, these changes, together with changes in attention and cognitive control mechanisms, may change the perception of anxiety-provoking stimuli.

Considering the up-to-date information and changes in society during the COVID-19 pandemic, this study sought answers to the following research question:

RQ1: Are there significant differences in age-related gaze behavior between younger and older groups while reading the news texts about the COVID-19 pandemic?

Method

The study was conducted in April 2021. Participants started answering the questionnaire before the experiment in March 2021. The questionnaire provided informed consent for participants to participate in the experiment. The research team received approval from the Research Ethics Committee of the Scientific and Educational Institute of Journalism to conduct the experiment involving humans (permission dated January 20, 2021).

Participants

Participants of the study were of two age groups. The first group of 164 people included younger adults aged between 17 and 22 years old (mean age 17.53). This group was recruited among students at the Scientific and Educational Institute of Journalism at the Taras Shevchenko National University of Kyiv. The second group of older adults

included 25 people between 59 and 71 years old, with a mean age of 64.5, who were professors at the Scientific and Educational Institute of Journalism at the Taras Shevchenko National University of Kyiv.

A total of 101 people agreed to participate in the second stage of the study. All of them were randomly allocated to three groups. The first group perceived the positive text elements of COVID-19. The second group was exposed to text with neutral text elements about COVID-19. The third group was presented with negative elements within the same text, covering the COVID-19 topic. Only the third group included both younger and older adults. So only results for the third group will be presented in this article.

The examples of the raw trajectories for participants reading different types of texts are presented in Figures 1–3.

Figure 1

Example of Raw Eye Tracking Trajectories for Users Reading Negative Texts

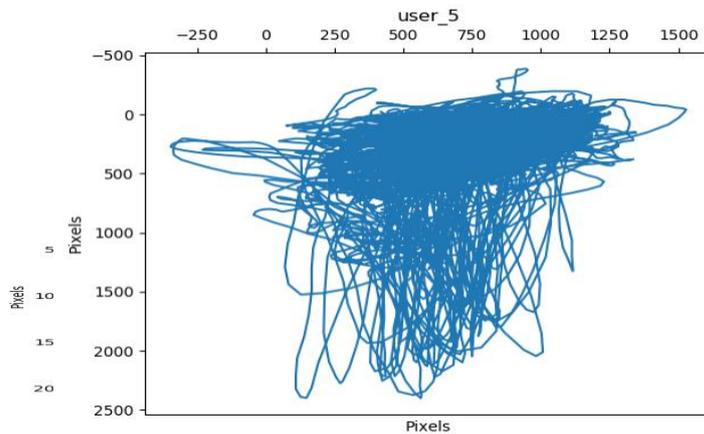


Figure 2

Example of Raw Eye Tracking Trajectories for Users Reading Neutral Texts

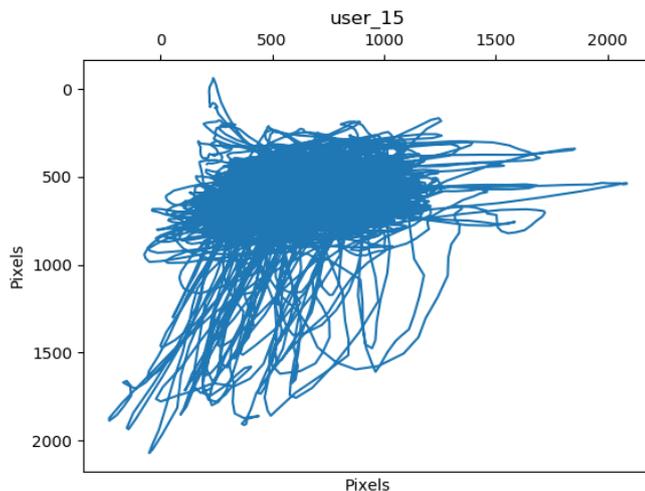
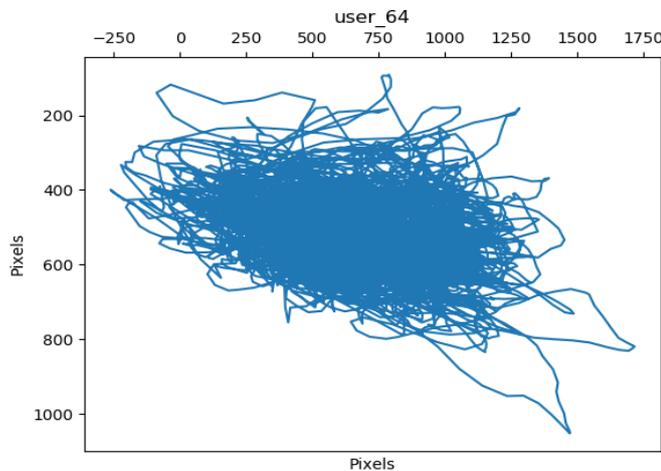


Figure 3

Example of Raw Eye Tracking Trajectories for Users Reading Positive texts



Both horizontal and vertical axes in Figures 1–3 are in pixels. Each user's pixel size differs depending on the computer screen characteristics. Negative values of the coordinates mean that the gaze was directed outside the computer screen area.

Instruments

All participants of the study provided informed consent before being involved in the study. After that, all participants were invited to participate in the first stage of the study, which consisted of filling out the questionnaires. The participants were asked about their sex, age, experience with COVID-19, and/or vaccination. Participants were also asked whether they had a laptop or personal computer with a web camera to evaluate their eligibility for the second research stage, which required these devices to collect eye-tracking data. Along with these questions, they were asked to fill out Psychological Stress Measure (PSM-25), Patient Health Questionnaire (PHQ-9), and Generalised Anxiety Disorder Assessment (GAD-7) questionnaires in order to determine their levels of stress, depression, and anxiety.

The second research stage was an eye-tracking study of text perception. Again, participants with a personal computer or a laptop with a web camera were invited to participate in the study.

Stimuli

To select messages on COVID-19, we used the online monitoring service LOOQME (<https://looqme.io/uk>). The search subject was COVID-19. First, we found 41674 media reports about COVID-19 in Ukrainian media during February – April 2021.

From this selection of media reports, we selected 11 with a negative tone, 11 with a neutral tone, and 11 with a positive tone based on the level of the reports' media visibility.

Fixation of a Gaze

In this work, dispersion-threshold identification algorithm (Salvucci & Goldberg, 2000) utilizes the fact that fixation points are grouped closely together for a certain amount of time. Therefore, if the dispersion of the eye gaze trajectory points is lower than a predefined threshold for a certain time, this region is considered as fixation. The device used for recording the eye tracking trajectories provides the “calibration error” for each recording, which is the noise level of the measured trajectory coordinates, the algorithm was adapted for finding fixation in the presence of measurement errors. Let $X = [x_i, x_{i+1}, \dots, x_{i+N-1}]$, $Y = [y_i, y_{i+1}, \dots, y_{i+N-1}]$ are the horizontal and vertical parts of trajectory, where x_i is the i -th sample of the horizontal coordinate, y_i is the i -th sample of vertical coordinate (in pixels), for $i = 0 \dots N - 1$, N is the duration of the observation window in samples.

Horizontal dispersion D_x and vertical dispersion D_y in the observation window are defined as

$$\begin{aligned} D_x &= \max(X) - \min(X) \\ D_y &= \max(Y) - \min(Y) \end{aligned} \quad (1)$$

If T_x and T_y are the calibration errors in pixels for horizontal and vertical axes, respectively, then the fixation is identified for the current observation window if

$$D_x \leq T_x + D_T \text{ and } D_y \leq T_y + D_T, \quad (2)$$

where D_T is the threshold.

In the current work, fixations were detected in non-overlapping sliding windows of 200 ms duration. If the trajectory deviates less than a calibration error plus a threshold within the observation window, it is considered a fixation. The threshold D_T was empirically selected at 100 pixels, as an estimate of a distance between lines on the screen where text was presented. Afterwards, the total number of fixations was calculated as well as its ratio with respect to the total duration of the recording for every study group.

Eye Tracking Method

Eye-tracking trajectory data were collected using Eyepass (Beehiveor, Ukraine) – a library for gathering webcam eye-tracking data [<https://beehiveor.gitlab.io/gazefilter/recording.html>].

Results and Discussion

Data Preparation

First, data samples where more than 80% of the recording duration (“acceptable” data) was available were selected and used for further analysis. The number of recordings used as samples for each group is presented in Table 1.

Table 1
Data Samples for Each Group Used for the Analysis

Group	Total #	Acceptable #
Negative, older	20	16
Negative, younger	20	17
Positive	26	23
Neutral	35	33
Negative	40	33

After removing recordings with the noise level exceeding the established threshold, 16 older adults and 17 younger adults remained eligible for the analysis. Older and younger groups were compared by the number of total fixations and median duration of the fixation (median data are presented in Table 2, and boxplots for fixations duration and numbers are shown in Figures 2 and 3, respectively). Since the number and duration of fixations were not distributed normally, we used non-parametric statistical tests to determine the difference between the two groups. We used Mann-Whitney U-test in search of statistical significance between the two groups. The results revealed that older adults had a shorter median fixation duration (p-value < .001). However, there was no difference between groups regarding the fixation number (p-value = .1).

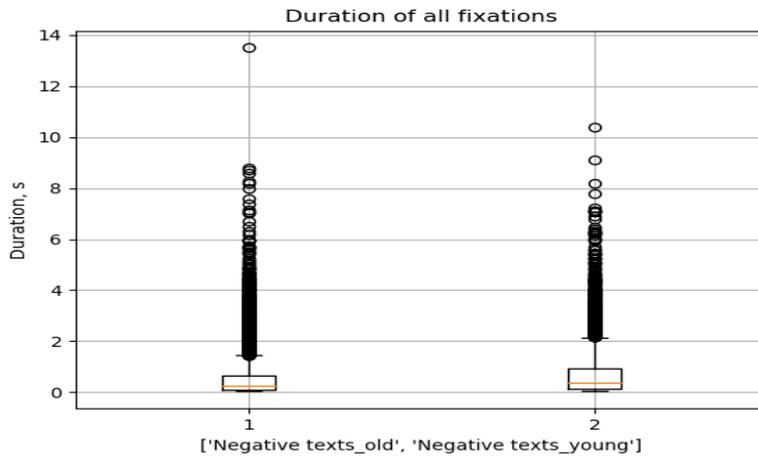
Table 2
Median Fixation Duration and Fixation Number

Group	Fixation duration, lower quartile	Fixation duration, median	Fixation duration, upper quartile	Fixation number, lower quartile	Fixation number, median	Fixation number, upper quartile
Younger adults	.13	.37	.93	70.55	74.23	80.31
Older adults	.1	.23	.63	51.02	64.14	77.82

Boxplots for duration of gaze fixations in older and younger adults are presented in Figure 4.

Figure 4

Duration of Gaze Fixations for Professors / Duration of Fixations for Students
 ($p = 2.3588531632421013e-74$)



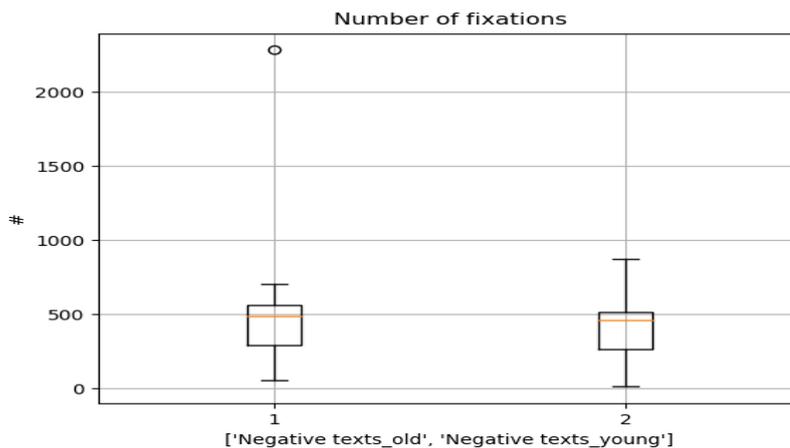
Duration of all fixations, Negative texts_older: [0.1 0.23333333 0.63333333]

Duration of all fixations, Negative texts_Junior: [0.13333333 0.36666667 0.93333333]

Boxplots for the number of gaze fixations in older and younger adults, see Fig. 5.

Figure 5

Number of Gaze Fixations in Professors / Number of Gaze Fixations in Students
 ($p = .3593191418097559$)



A number of all fixations, Negative texts_senior: [296. 486. 560.5]

A number of all fixations, Negative texts_younger: [264. 463. 516.]

The results of this research directly contrast with earlier findings about age differences in gaze fixation duration. For instance, McGowan et al. (2014) showed that older adults have a longer fixation time. However, those authors did not use media content in their research design. Moreover, there are very few, if any, such studies that

use news content. Regarding possible explanations, further research should address this problem using various research designs.

Nevertheless, our findings appear crucial in adapting the eye-tracking method to examine news effects. As Geise admitted, the process of visual perception – is a multidimensional phenomenon to which justice can be done only through a multifaceted theoretical foundation (Geise, 2014).

Many eye-tracking studies in media effects research were performed within Lang's Limited Capacity Model of Motivated Mediated Message Processing, LC4MP (Lang, 2006). In developing this model, Avery and Park (2018) noted that visual attention is measured by dwell time on visual stimuli to identify how they affect message effectiveness. By tracking how people visually move through messages with different motivations, the effects of visual stimuli are isolated in a more sophisticated and valid way than self-reports allow.

Limitations of the Study

Gaze behavior may differ from person to person. According to the media-dependence theory (Ball-Rokeach & DeFleur, 1976), one of the crucial variables that psycho-physiological media effects research should consider is the importance of certain media for an individual. From such attitude derives media trust, an even more important indicator. Therefore, one critical limitation of this paper is paying little attention to media importance and trust. Besides, researchers need to involve many more participants to show systematic trends in media effects using the eye-tracking methodology. However, in our situation, it was primarily challenging to conduct an experiment during the COVID-19 lockdown without harm to the participants' and researchers' health. Thus, we chose the web eye-tracking method when all the participants read the experimental content using their computers.

Conclusions

While these results are statistically significant, other factors besides age might have contributed to these findings. First, the occupation of the study participants should be taken into consideration. As professors at the Scientific and Educational Institute of Journalism, older adults participating in the study may have different reading patterns due to their professional skills. Second, older adults are more vulnerable to adverse COVID-19 outcomes than younger adults (Nidadavolu & Walston, 2021). This may leverage some changes in text processing due to the text's high importance for satisfying basic safety needs. Finally, older adults' higher vulnerability than younger adults may result in differences in attention processes while reading text with negative text elements.

Therefore, there are significant age-related differences in gaze behavior while reading the news with negative text elements. While the origin of these variations between older and younger adults remains unknown, further research should provide more evidence about this effect's origin..

Acknowledgements

The authors of this article express their sincere gratitude to the National Research Foundation of Ukraine, thanks to whose financial and organizational support (grant “Stressogenic Elements of the Latent Impact of Real Media Reports on the COVID-19 Pandemic on Social Groups” No. 2020.01/0050), it became possible to conduct this study and publish the experimental results. Words of gratitude to the management and Scientific Council of the Foundation, curators of the project. Vast appreciation to the experts for their high evaluation of our project, thanks to whom our application won the competition. We want to thank the management and our colleagues from Taras Shevchenko National University of Kyiv, whose care and assistance contributed to the effective work within the project. Words of gratitude are to colleagues and students who agreed to participate and actually contributed to the timely collection and processing of the experimental data.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Data Availability Statement

The data that support the findings of this study are openly available in Mendeley Data <https://doi.org/10.17632/rpytj9dkmx.3>

References

- Avery, E. J. & Park, S. (2018). HPV vaccination campaign fear visuals: An eye-tracking study exploring effects of visual attention and type on message informative value, recall, and behavioral intentions. *Public Relations Review*, 44(3), 321-330. <https://doi.org/10.1016/j.pubrev.2018.02.005>
- Ball-Rokeach, S. J. & DeFleur, M.L. (1976). A dependency model of mass media effects. *Communication Research*, 3, 3-21. <https://doi.org/10.1177/009365027600300101>
- Bakioğlu, F., Korkmaz, O., & Ercan, H. (2021). Fear of COVID-19 and positivity: Mediating role of intolerance of uncertainty, depression, anxiety, and stress. *International Journal of Mental Health and Addiction*, 19(6), 2369–2382. <https://doi.org/10.1007/s11469-020-00331-y>
- Bendau, A., Petzold, M. B., Pyrkosch, L., Mascarell Maricic, L., Betzler, F., Rogoll, J., Große, J., Ströhle, A., & Plag, J. (2021). Associations between COVID-19 related media consumption and symptoms of anxiety, depression and COVID-19 related fear in the general population in Germany. *European Archives of Psychiatry and Clinical Neuroscience*, 271(2), 283–291. <https://doi.org/10.1007/s00406-020-01171-6>
- Borges, M. T., Fernandes, E. G., & Coco, M. I. (2020). Age-related differences during visual search: the role of contextual expectations and cognitive control mechanisms. *Neuropsychology, Development, and Cognition. A Journal on Normal and Dysfunctional Development*, 27(4), 489–516. <https://doi.org/10.1080/13825585.2019.1632256>

- Brashers, D. E., Neidig, J. L., Haas, S. M., Dobbs, L. K., Cardillo, L. W., & Russell, J. A. (2000). Communication in the management of uncertainty: The case of persons living with HIV or AIDS. *Communication Monographs*, 67(1), 63–84. <https://doi.org/10.1080/03637750009376495>
- Choi, E. P. H., Hui, B. P. H., & Wan, E. Y. F. (2020). Depression and anxiety in Hong Kong during COVID-19. *International Journal of Environmental Research and Public Health*, 17(10), 3740. <https://doi.org/10.3390/ijerph17103740>
- Daneman, M., Hannon, B., & Burton, C. (2006). Are there age-related differences in shallow semantic processing of text? Evidence from eye movements. *Discourse Processes*, 42(2), 177–203. https://doi.org/10.1207/s15326950dp4202_5
- Downs, C. W. & Adrian, A. D. (2004). Assessing organizational communication: Strategic communication audits. (1st ed.) The Guilford Press.
- Gamboz, N., Zamarian, S., & Cavallero, C. (2010). Age-related differences in the attention network test (ANT). *Experimental Aging Research*, 36(3), 287–305. <https://doi.org/10.1080/0361073X.2010.484729>
- Geise, S. (2014). Eye tracking in media studies. Theory, method, and its exemplary application in analyzing shock-inducing advertisements. In A. N. Valdivia F. Darling-Wolf (Eds.), *The International Encyclopedia of Media Studies* (pp. 1-26). John Wiley & Sons. <https://doi.org/10.1002/9781444361506.wbiems190>
- Havrylets, Y., Tukaiev, S., Rizun, V., & Shenderovskiy, K. (2019). Impact of TV news on psychophysiological state depending on emotional burnout. *Journal of Content, Community & Communication*, 5(9), 13-25. <http://dx.doi.org/10.31620/JCCC.06.19/04>
- Hyland, P., Shevlin, M., McBride, O., Murphy, J., Karatzias, T., Bentall, R. P., Martinez, A., & Vallières, F. (2020). Anxiety and depression in the Republic of Ireland during the COVID-19 pandemic. *Acta Psychiatrica Scandinavica*, 142(3), 249–256. <https://doi.org/10.1111/acps.13219>
- Kim, K. & Lee, Y. M. (2018). Understanding uncertainty in medicine: concepts and implications in medical education. *Korean Journal of Medical Education*, 30(3), 181–188. <https://doi.org/10.3946/kjme.2018.92>
- Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *Journal of Communication*, 56(1), S57-S80. <https://doi.org/10.1111/j.1460-2466.2006.00283.x>
- Liu, C. & Liu, Y. (2020). Media exposure and anxiety during COVID-19: The mediation effect of media vicarious traumatization. *International Journal of Environmental Research and Public Health*, 17(13), 4720. <https://doi.org/10.3390/ijerph17134720>
- McGowan, V. A., White, S. J., & Paterson, K. B. (2015). The effects of interword spacing on the eye movements of young and older readers. *Journal of Cognitive Psychology*, 27(5), 609-621. <https://doi.org/10.1080/20445911.2014.988157>
- Mevorach, T., Cohen, J., & Apter, A. (2021). Keep calm and stay safe: The relationship between anxiety and other psychological factors, media exposure and compliance with COVID-19 regulations. *International Journal of Environmental Research and Public Health*, 18(6), 2852. <https://doi.org/10.3390/ijerph18062852>
- Nidadavolu, L. S. & Walston, J. D. (2021). Underlying vulnerabilities to the cytokine storm and adverse COVID-19 outcomes in the aging immune system. *The Journals of Gerontology. Series A. Biological Sciences and Medical Sciences*, 76(3), e13-e18. <https://doi.org/10.1093/gerona/glaa209>
- Petzold, M. B., Bendau, A., Plag, J., Pyrkosch, L., Mascarell Maricic, L., Betzler, F., Rogoll, J., Große, J., & Ströhle, A. (2020). Risk, resilience, psychological distress, and anxiety at the beginning of the COVID-19 pandemic in Germany. *Brain and Behavior*, 10(9), e01745. <https://doi.org/10.1002/brb3.1745>

- Pogorilska, N. I., Synelnykov, R. Y., Palamar, B. I., Tukaiev, S. V., & Nezhyva, L. L. (2021). Features of psychological experiences in severe quarantine during the COVID-19 pandemic: The role of tolerance for uncertainty. *Wiadomosci Lekarskie*, 74(6), 1312-1316. <http://dx.doi.org/10.36740/WLek202106104>
- Rayner, K., Yang, J., Schuett, S., & Slattery, T. J. (2014). The effect of foveal and parafoveal masks on the eye movements of older and younger readers. *Psychology and Aging*, 29(2), 205-212. <https://doi.org/10.1037/a0036015>
- Rettie, H. & Daniels, J. (2021). Coping and tolerance of uncertainty: Predictors and mediators of mental health during the COVID-19 pandemic. *The American Psychologist*, 76(3), 427-437. <https://doi.org/10.1037/amp0000710>
- Rizun, V., Havrylets, Y., Ivaskevych, D., Petrenko-Lysak, A., Popov, A., Tukaiev, S., & Yachnik, Y. (2022). Stressogenic elements of the latent impact of real media reports on the COVID-19 pandemic on social groups (experimental study). Mendeley Data, V3, <https://doi.org/10.17632/rpytj9dkmx.3>
- Salvucci, D. D. & Goldberg, J. H. (2000). Identifying fixations and saccades in eye-tracking protocols. Proceedings of the 2000 symposium on eye tracking research & applications. (71-78). <http://dx.doi.org/10.1145/355017.355028>.
- Stine-Morrow, E.A.L., Gagne, D.D., Morrow, D.G., & DeWall, B.H. (2004). Age differences in rereading. *Memory & Cognition*, 32, 696-710. <https://doi.org/10.3758/BF03195860>
- Sundar, R. P., Becker, M. W., Bello, N. M., & Bix, L. (2012). Quantifying age-related differences in information processing behaviors when viewing prescription drug labels. *PloS One*, 7(6), e38819. <https://doi.org/10.1371/journal.pone.0038819>