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# ВИКРИВЛЕННЯ УВАГИ ТА ПОКАЗНИКИ САМОЗВІТУ ЯК ІНДИКАТОРИ КОГНІТИВНИХ І АФЕКТИВНИХ ЗМІН У ПІДЛІТКІВ, ЯКІ БЕРУТЬ УЧАСТЬ У ШКІЛЬНИХ НАВЧАЛЬНИХ ІНТЕНСИВАХ ІЗ СОЦІАЛЬНОГО ПІДПРИЄМНИЦТВА

**Анотація**

Метою цього дослідження було перевірити, чи може легка у застосуванні платформа для моніторингу психічного здоров'я, заснована на технології стеження за поглядом із використанням вебкамери, доповнювати стандартизовані опитувальники. Платформу застосовано для моніторингу психічного здоров'я підлітків у межах шкільних інтенсивів із соціального підприємництва. За допомогою платформи Anima учасники пройшли 691 анонімізовану сесію упродовж п'яти хвиль оцінювання, у кожній з яких поєднувались стандартизовані показники самозвіту тривоги та депресії з показниками викривлення уваги (з англ. Attention Bias, AB), розрахованими за допомогою айтрекінгу з використанням вебкамери. Протягом всіх замірів за даними самозвіту зафіксовано зменшення рівня тривожності та депресивних симптомів. Показники AB залишалися нижчими за пороги високої вираженості та не демонстрували систематичних змін. Розподіли показників AB у першій хвилі подано як попередню референтну точку для підліткової вибірки в цьому контексті. Дослідження підкреслює цінність платформи Anima як економічно ефективного, масштабованого інструменту для моніторингу психічного здоров'я.

*Ключові слова: викривлення уваги, підприємництво, підлітки, тривога, депресія*

# ATTENTION BIAS AND SELF-REPORT MEASURES AS INDICATORS OF COGNITIVE AND AFFECTIVE CHANGE IN ADOLESCENTS PARTICIPATING IN SCHOOL-BASED SOCIAL ENTREPRENEURSHIP BOOTCAMPS

**Abstract**

This study evaluated whether a low-burden, webcam-based eye-tracking platform can complement standard questionnaires when monitoring mental health of adolescents participating in school-based social entrepreneurship bootcamps. Using the Anima platform, high school students completed 691 anonymized sessions across five assessment waves, which combined standardized self-report measures of anxiety and depression with webcam-based eye-tracking indices of attention bias (AB). Across waves, self-report data indicated reductions in anxiety and depressive symptoms. AB indices stayed below the severe cutoffs and showed no systematic change. First-wave AB distributions are reported as a provisional reference point for adolescent performance in this context. The study highlights Anima's value as a low-burden, scalable tool for mental health monitoring.

*Keywords: Attention Bias, entrepreneurship, adolescents, anxiety, depression*

## Introduction

Contemporary psychodiagnostics increasingly integrates traditional self-report measures with novel, more objective approaches to assessing mental states. One such direction involves the use of biomarkers, particularly eye-tracking–derived indices of visual attention. Prior research has demonstrated that such indicators as hypervigilance toward threatening stimuli (Abado et al., 2020; Kimble et al., 2014) or avoidance of them may reflect automatic response patterns associated with anxiety states (Godara et al., 2021).

In clinical practice, standardized self-report scales such as the GAD-7 and PHQ-9 remain the most common tools for psychological screening (Arndt et al., 2024). Their primary purpose is to quantify subjective experiences or assess the severity of symptoms related to anxiety, depression, and other conditions for which self-reporting is applicable. This approach is also widely adopted in empirical research due to its convenience, efficiency, and standardization. Strong associations between self-reported and behavioral markers are often interpreted as evidence of the validity of either the instruments or the research outcomes. However, such correlations are typically examined at a single time point, while the dynamics of this relationship throughout the course of a psychological intervention remain largely unexplored, as discussed in our previous work (Solonskyi, 2024).

In our current research, this relationship was examined in the context of school-based social entrepreneurship bootcamps. These bootcamps represent structured educational programs that combine teamwork, creativity, and problem-solving aimed at developing socially oriented projects. Such an environment is emotionally and cognitively engaging for adolescents, providing a valuable opportunity to observe how participation in complex social learning activities may influence attention patterns and self-assessed emotional states.

Using the Anima platform, we employed a webcam-based eye-tracking method to detect anxiety-related (hypervigilance, avoidance) and depression-related (dysphoric and anhedonic biases) AB markers. We have employed them during the assessment of adolescents participating in psychological training programs. The participants completed testing across five assessment periods, spaced by 3-4 weeks each. Following each AB test, respondents completed standardized self-report questionnaires. Due to data confidentiality, repeated measures could not be linked across sessions; thus, each assessment period was analyzed as an independent group.

The present study focuses on identifying attention bias and self-assessment metrics as potential indicators of cognitive and affective change in adolescents following participation in social entrepreneurship bootcamps in schools. This approach extends the use of webcam-based eye-tracking beyond clinical diagnostics toward understanding adaptive psychological changes in educational and developmental contexts.

## Literature review

### Common types of school-based interventions and their goals

Schools have increasingly become venues for preventive and therapeutic psychological programs targeting adolescent mental health. Common types of school-based interventions include Cognitive-Behavioral Therapy (CBT) Programs (Gee et al., 2020), Social and Emotional Learning (SEL) Curricula (Cai et al., 2025), Resilience and Positive Psychology Interventions (Tareke et al., 2023) or others.

Beyond traditional interventions, participation in school-based social entrepreneurship bootcamps represents a distinctive educational format that can indirectly influence adolescents' mental health and psychological well-being. These programs combine experiential learning, social problem-solving, and teamwork within a goal-oriented framework that requires sustained cognitive engagement and emotional regulation. Unlike therapeutic interventions, social entrepreneurship bootcamps are not designed primarily to reduce symptoms but to foster agency, self-efficacy, and social connectedness – factors known to buffer against anxiety and depressive states. Social entrepreneurship education in schools provides not only economic or civic knowledge but also an arena for developing the cognitive and affective components of empathy, which are essential for prosocial motivation and sustainable leadership. Recent findings indicate that adolescents with stronger cognitive empathy demonstrate a greater intention to initiate social ventures, whereas affective empathy, or emotional resonance with others' distress, appears to play a lesser predictive role (Dickel & Johnson, 2024).

In our context these mechanisms are particularly salient. Participation requires adolescents to analyze real social problems, coordinate collective goals, and anticipate the consequences of their actions for others, processes that activate both cognitive control and emotional regulation systems.

Empirical evidence supports that structured entrepreneurial education during adolescence can enhance both cognitive competencies and self-efficacy, which are strongly associated with adaptive psychological development. A quasi-experimental study by Ho et al. demonstrated that secondary school students who participated in entrepreneurship training exhibited significantly higher levels of entrepreneurial alertness and entrepreneurial self-efficacy (Ho et al., 2018). These findings suggest that experiential social entrepreneurship initiatives not only cultivate economic or leadership skills but may also engage deeper cognitive-affective mechanisms related to attention control, motivation, and self-assessment.

From this, we expect to see the increase in hypervigilance of participants throughout the program; a decrease in avoidance of emotionally salient stimuli, indicating improved tolerance of social or cognitive stressors encountered during teamwork and public presentation tasks. We expect higher self-ratings of self-efficacy and perceived problem-solving ability across sessions, consistent with the development of mastery and agency through project-based learning (although, this process may not be linear). Over time, self-reported anxiety and emotional exhaustion are expected to decline, reflecting improved affective regulation in response to complex collaborative challenges.

**Attention Bias**

Attention bias refers to a cognitive distortion manifesting as alterations in automatic attentional patterns resulting from exposure to stress, emotionally adverse experiences, or the presence of mental disorders. While attentional distortions can also arise from personal interests or professional habituation, such variations are non-pathological and do not interfere with daily functioning and therefore fall outside the scope of the present study. In clinical contexts, AB is among the key neurobehavioral indicators of anxiety and affective disorders (Mobini & Grant, 2007). In adults, a robust finding is that anxious individuals exhibit an attention bias toward threatening stimuli. They tend to more quickly orient toward or have difficulty disengaging from threat cues (like angry faces) compared to non-anxious individuals (Telzer et al., 2008). This bias is thought to play a role in the maintenance of anxiety by preferentially attuning the person to danger and classic meta-analysis further confirm this (Clauss et al., 2022). However, little is known about attention bias characteristics in children and adults.

An early comprehensive meta-analysis (Dudeney et al., 2015) focused on anxious youth found that, overall, children and adolescents with anxiety do exhibit a significant bias toward threat, though smaller than that observed in adults. Across 38 studies with over 4,000 children, anxious youth were more attentive to threat stimuli than neutral stimuli, and they showed a slight but significant overall bias compared to non-anxious peers. Notably, age moderated the effects: the difference in bias between anxious and non-anxious individuals increased with age, meaning that older adolescents showed a more pronounced threat bias than younger children did. The other study examined 1,291 children and adolescents (ages ~8–18) using a standardized dot-probe task with threat faces. They found that attention bias toward threat correlated positively with overall anxiety symptom severity across the sample (Abend et al., 2018). Importantly, this association held for certain anxiety subtypes: the bias was specifically linked to greater social anxiety and school phobia symptoms. The relationship did not hold for some other anxiety types (panic, generalized anxiety) and was not moderated by age in that study.

Attention biases are also observed in depression, but they manifest somewhat differently from anxiety-related threat bias. Depressed adults consistently show negative attention biases – a tendency to focus on sad or negative information and have difficulty disengaging from it (Li et al., 2023). According to a Beck's cognitive theory of depression, depressed individuals preferentially attend to negative cues (e.g., sad faces, negative words) and interpret ambiguous information pessimistically (Beck & Dozois, 2011).

**Unsolved parts of the general problem**

Despite the extensive literature on attention bias in clinical and non-clinical populations, developmental differences in attentional patterns remain insufficiently understood. Research suggests that the direction and magnitude of AB may vary with age due to the ongoing maturation of cognitive control and affective regulation systems during adolescence. Adolescents, in particular, display heightened emotional reactivity and less stable executive control (Mueller et al., 2017), which may amplify selective attention toward emotionally salient or threatening stimuli. In contrast, adults typically demonstrate greater top-down modulation, allowing for more efficient disengagement from negative cues.

This developmental asymmetry implies that AB may serve as a sensitive indicator of ongoing cognitive and affective changes during adolescence – a period marked by neural reorganization and increased vulnerability to emotional dysregulation. Understanding these differences is essential for evaluating the efficacy of psychological interventions aimed at improving emotional resilience and adaptive attention regulation in youth populations.

**Aims of the study**

The aim was to evaluate psychological well-being and attentional processes among Ukrainian high school students participating in school-based social entrepreneurship bootcamps, combining self-reported measures of anxiety and depression with objective Attention Bias (AB) metrics, and to assess change across measurement waves and schools.

**Objectives of the study**:

1. To assess baseline levels of anxiety, depression, and cognitive-emotional functioning using standardized questionnaires (STAI, BDI-II, GAD-7, PHQ-9, ASMQ).

2. To monitor changes in self-reported symptoms of anxiety and depression across repeated measurement waves, including school-specific comparisons.

3. To evaluate school-level heterogeneity in both questionnaire and Attention Bias outcomes.

4. To identify potential risk indicators and advantages of using Anima during the bootcamp program.

**Methods and Measures**

The study was conducted within the framework of collaboration between Anima and the "Platform for Social Change", during which psychologists from the platform implemented training programs in 6 schools and lyceums under "Bootcamp" project. Students completed testing sessions between training modules in rooms designated for psychological assessment. Participation in the study was based on convenience sampling: students who took part in the Bootcamp program were invited to complete the assessments, and only those who provided informed consent were included in the dataset. Each participant provided informed consent for data processing and agreed to the terms of participation prior to the assessment.

During each session, participants selected the psychological domain that interested them most: anxiety, depression, or stress and burnout (based on their preferences). Each domain included an in-house Attention Bias (AB) test and standardized self-report questionnaires. Each AB test consisted of a slideshow presenting paired images according to the selected theme:

- The anxiety test paired neutral stimuli with anxiety-inducing or arousal-related images, such as depictions of injured individuals, animals, spiders, and snakes.
- The depression test presented pairs of faces with contrasting emotional expressions (sadness vs. joy), contrasting contexts (wedding vs. funeral), and hedonic-relevant stimuli (e.g., food).
- The stress and burnout test were a combined version incorporating all the aforementioned categories of stimuli.

All image pairs were matched for composition, color balance, contrast, tone, and background, ensuring that observed attentional effects reflected semantic context rather than visual discrepancies. Participants were informed that they could discontinue the test at any point by pressing the Esc key. Yet there were no recorded cases of participants discontinuing the test.

Following the anxiety test, participants completed the General Anxiety Disorder-7 questionnaire (GAD-7, (Aleksina et al., 2024) and the State–Trait Anxiety Inventory (STAI, translated). The GAD-7 is a brief screening tool for generalized anxiety disorder and general anxiety severity, consisting of seven items rated on a four-point Likert scale from 0 ("not at all") to 3 ("nearly every day"), yielding a total score from 0 to 21. The STAI-Y1 measures situational anxiety ("state anxiety") using 20 statements rated on a four-point scale from 1 ("not at all") to 4 ("very much so"), with several reverse-coded items. Higher total scores indicate higher situational anxiety. Participants also responded to additional custom-developed diagnostic questions for differential anxiety screening. If certain criteria were met, they were offered supplementary questionnaires.

After completing the depression test, participants filled out two widely validated self-report instruments: the Patient Health Questionnaire-9 (PHQ-9, (Kohut & Chaban, 2025) and the Beck Depression Inventory-II (BDI-II, translated). The PHQ-9, based on DSM criteria, assesses the presence and severity of depressive symptoms over the past two weeks through nine items rated from 0 to 3, with total scores ranging from 0 to 27. The BDI-II, developed by Aaron Beck, measures emotional, cognitive, and somatic components of depression through 21 items rated from 0 to 3, yielding a total score between 0 and 63.

Finally, following the combined test, participants completed the Anima Self-Metrics Questionnaire (ASMQ), an original 10-item instrument. Five items assessed anxiety-related symptoms, and five assessed mood-related symptoms. Responses were provided on a 0–10 scale, with verbal anchors marking the endpoints and midpoint, and intermediate values represented by clickable graphical elements.

All questionnaires were presented in Ukrainian language. Formal cultural-linguistic adaptation procedures were not available for all instruments; these efforts are beyond the scope of the present study and will be reported elsewhere. The measures were selected due to their relevance to the study aims and their widespread use in Ukrainian clinical and research practice. To support their adequacy in the current sample, internal consistency estimates are reported below.

Across the five measurement waves, the STAI showed excellent internal consistency. Cronbach's α ranged from .904 to .937, and McDonald's ω ranged from .907 to .938. The GAD-7 internal consistency increased (α = .789–.948; ω = .799–.951): Wave 1 (α = .789, ω = .799), Wave 2 (α = .833, ω = .836), Wave 3 (α = .909, ω = .913), Wave 4 (α = .923, ω = .925), Wave 5 (α = .948, ω = .951). This upward trend is consistent with a potential training-program effect (i.e., more coherent responding over time), but it is not, by itself, causal evidence. The PHQ-9 showed high internal consistency: Cronbach's α ranged from .825 to .925, and McDonald's ω ranged from .875 to .934. The BDI-II showed excellent internal consistency: Cronbach's α ranged from .908 to .961, and McDonald's ω ranged from .914 to .970. Finally, across the four measurement waves, ASMQ–Anxiety showed acceptable-to-good internal consistency: Cronbach's α ranged from .778 to .888, and McDonald's ω ranged from .783 to .890. ASMQ–Mood showed lower-to-good internal consistency: Cronbach's α ranged from .661 to .888, and McDonald's ω ranged from .695 to .890. For some instruments, only four waves were reported because the final wave had insufficient sample size for that specific measure.

**Study sample**

The participants were senior high school students from cities located in the western regions of Ukraine. Participation in the study was voluntary, and the testing procedure required strict anonymity and confidentiality at all stages. It was impossible to record sociodemographic characteristics or the exact number of participants. However, throughout the program, a total of 691 completed testing sessions were recorded, and the aggregated results of these sessions are presented in the following sections. Across all participating institutions, the number of completed testing sessions varied substantially, reflecting differences in program duration and school participation intensity (see Figure 1). The largest number of sessions was recorded in school #5 (N = 213), followed by school #1 (N = 269). Moderate participation was observed in school #3 (N = 135) and school #6 (N = 57). In contrast, school #4 (N = 7) and school #2 (N = 8) showed limited engagement.

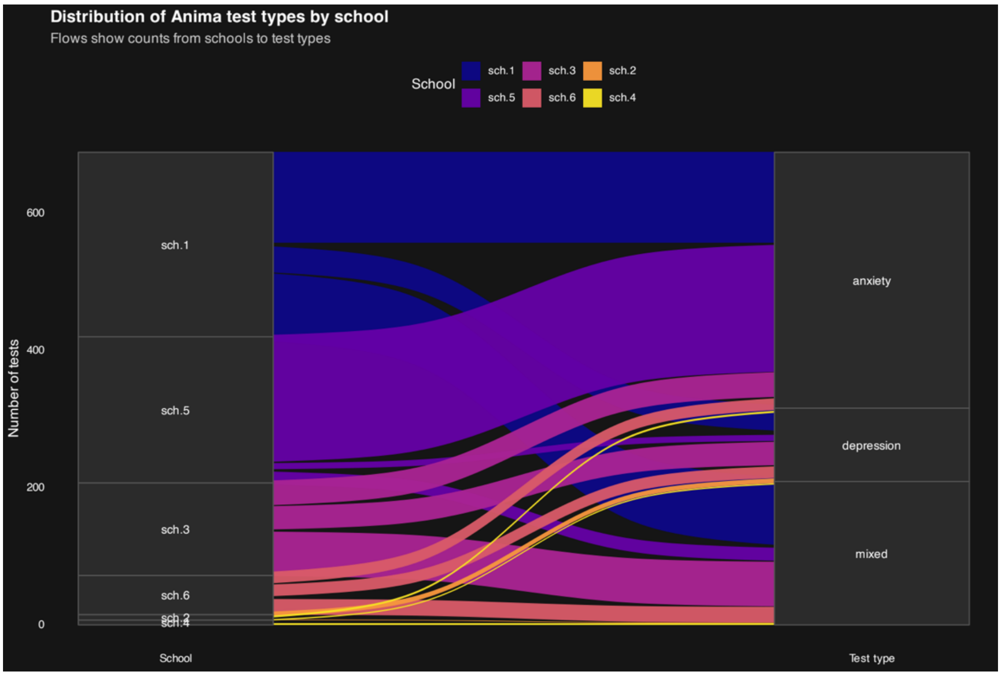


*Figure 1. Alluvial chart of Anima test distribution across schools*

**Statistical analysis**

All statistical analysis was done on Mac Os 26.0.1 (25A362) using Microsoft Excel software for data management, R programming language (ver. 4.4.2) and RStudio for data cleaning, data analysis and visualization (Posit team, 2025). Along with it, the following packages were used: readxl, writexl, dplyr, tidyr, e1071, stringr, forcats, ggplot2, ggalluvial, viridis, broom, sandwich, lmtest, purr, multiwayvcov, emmeans, tibble.

Because strict anonymity precluded linking individuals across waves, analyses were conducted as repeated cross-sections rather than within-person longitudinal models. Consequently, tests comparing waves were treated as independent-sample comparisons (i.e., no paired procedures), and time trends were modeled at the aggregate level with school indicators. For each questionnaire and AB metric in the first wave, we reported the mean, SD, median, skewness, kurtosis, and the Shapiro–Wilk test of normality. Because Wave 5 had incomplete coverage, primary pre/post contrasts used Wave 1 vs. Wave 4. Group means were compared with Welch's t tests, which are robust to unequal variances and unbalanced sample sizes. We used Welch's t tests despite non-normality in dysphoric and anhedonic bias scores because our estimand was the mean difference; Welch's test targets this estimand and is reasonably robust to moderate departures from normality at the present sample sizes. These comparisons were applied to PHQ-9, BDI-II, GAD-7, STAI, and to AB metrics (hypervigilance, avoidance, dysphoric and anhedonic biases). To assess whether average levels changed over time and whether trends varied by school, we fit linear regressions of the form outcome ~ centered time × school. Given potential dependence within waves and within schools in repeated cross-sections, we used cluster-robust inference. Two-way clustered variances (wave and school) were numerically unstable; therefore, we adopted a conservative fallback: the element-wise maximum of one-way cluster-robust variances (by wave, by school) and HC1. This approach preserves Type I error control under modest misspecification at the cost of power, so positive findings are conservative and null results should be interpreted with this reduced sensitivity in mind. Model adequacy regarding heterogeneous slopes was evaluated with omnibus Wald tests comparing interaction (time × school) to additive specifications.

AB thresholds reflected a priori criteria: hypervigilance, avoidance, dysphoric > 0.25 and anhedonic > 0.18 flagged as "severe." For anxiety-related AB (hypervigilance, avoidance) and depression-related AB (dysphoria, anhedonia), we primarily used indices from the dedicated anxiety and depression tests because they provide the fullest measurement. For depression-related AB specifically, we additionally drew metrics from the mixed test when needed, as substantially more students completed this version, increasing precision and stability of estimates. AB distributions were visualized with density plots to summarize between-school dispersion and changes across waves.

## Results

### Descriptive statistics

In the first wave STAI scores were on average 25.11 (SD = 10.19), with a median of 23. The distribution was approximately symmetric (skewness = 0.28) and slightly platykurtic (kurtosis = –0.79). The Shapiro–Wilk test suggested no significant departure from normality, p = .052. BDI scores averaged 12.40 (SD = 9.60), with a median of 10. The distribution showed a moderate positive skew (0.94) and near-normal kurtosis (0.20). However, the Shapiro–Wilk test indicated a significant deviation from normality, p = .004. GAD-7 scores had a mean of 6.72 (SD = 4.28) and a median of 6. The distribution was close to symmetric (skewness = 0.38, kurtosis = –0.27), and normality was not violated according to the Shapiro–Wilk test, p = .077. PHQ-9 scores were on average 9.67 (SD = 6.05), with a median of 10. The distribution was approximately symmetric (skewness = 0.23) and somewhat platykurtic (–1.14). The Shapiro–Wilk test indicated significant non-normality, p = .027. ASMQ scores had a mean of 40.90 (SD = 15.05) and a median of 42.5. The distribution was slightly negatively skewed (–0.28) and mildly platykurtic (–0.41). The Shapiro–Wilk test indicated no significant deviation from normality, p = .668. Means, standard deviations, medians, and distributional characteristics are reported in Table 1.

***Table 1.***
***Descriptive statistics and normality tests for the questionnaires***

| Variable | M | SD | Median | Skewness | Kurtosis | Shapiro p | n* |
|---|---|---|---|---|---|---|---|
| STAI | 25.10 | 10.19 | 23 | 0.28 | -0.78 | 0.05 | 65 |
| BDI-II | 12.40 | 9.60 | 10 | 0.93 | 0.20 | 0.003 | 42 |
| GAD-7 | 6.72 | 4.28 | 6 | 0.38 | -0.26 | 0.07 | 65 |
| ASMQ | 40.9 | 15.04 | 42.5 | -0.28 | -0.41 | 0.66 | 40 |
| PHQ-9 | 9.66 | 6.04 | 10 | 0.23 | -1.13 | 0.02 | 42 |

*Note: * – n of respondents without missing data*

At the beginning of the program, some students showed noticeable depressive symptoms (by PHQ-9 and BDI-II) – loss of interest, depressed mood, sleep and energy problems; in isolated cases, thoughts of self-harm were reported. By the end of the program, responses of "never" or "only a few days" predominated across all PHQ-9 items. Occasional difficulties remained only in relation to loss of interest and self-esteem – issues that most easily "cling" to adolescence. Thoughts of self-harm had completely disappeared by the end of the cycle. Targeted risk monitoring is also important. At the final measurement in one school, a few responses indicated frequent suicidal thoughts. It is important that the team has a clear protocol for such cases: an individual conversation, involvement of the school psychologist, and communication with parents if necessary.

For the analysis of AB metrics, we selected hypervigilance and avoidance (accompanied the anxiety test) and dysphoric and anhedonic biases (accompanied the depression test). Although these indices were also included in the mixed test, the dedicated anxiety and depression tests provided them in a more complete form. Group-level averages for the Attention Bias metrics for the first wave remained below the severity thresholds. The distribution is illustrated in Figure 2.

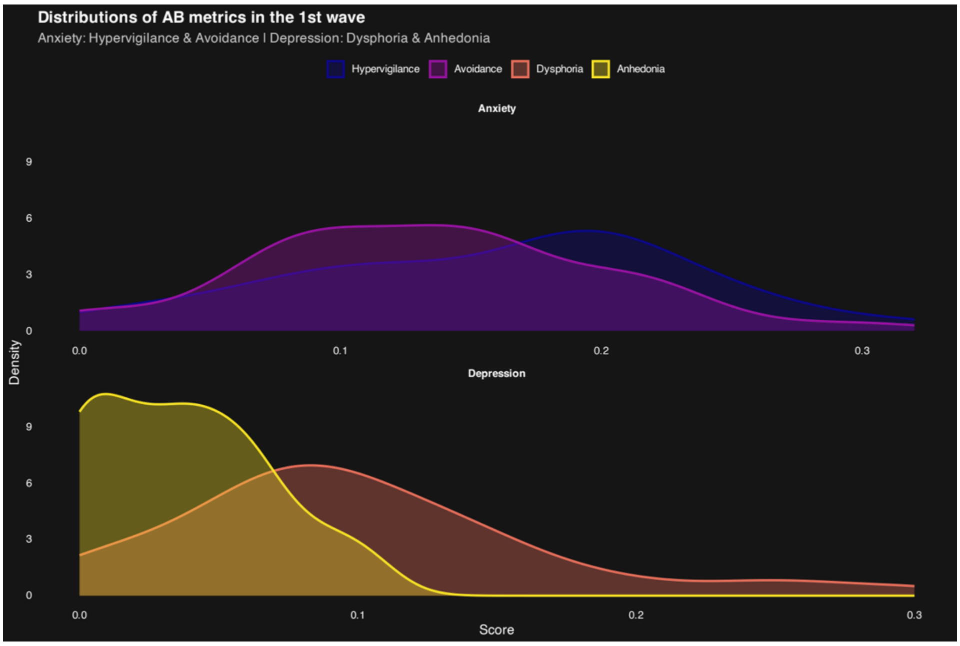


*Figure 2. Density plot of attention bias metrics*

Hypervigilance showed a mean of 0.16 (SD = 0.08, Median = 0.18), which is below the severity threshold of 0.25. The distribution was approximately symmetric (skewness = −0.18, kurtosis = −0.43), and the Shapiro–Wilk test did not indicate deviation from normality, p = .193. Avoidance demonstrated a mean of 0.13 (SD = 0.07, Median = 0.14). This value was also below the severity threshold of 0.25. The distribution was symmetric (skewness = 0.20, kurtosis = 0.02) with no evidence of non-normal distribution, p = .386. Dysphoric bias had a mean of 0.10 (SD = 0.07, Median = 0.09), which is below the severity threshold of 0.25. However, the distribution was positively skewed (skewness = 1.01) with leptokurtosis (1.36). The Shapiro–Wilk test suggested significant non-normality, p = .012. Anhedonic bias was the lowest-scoring index, with a mean of 0.04 (SD = 0.03, Median = 0.04), far below the severity threshold of 0.18. The distribution was moderately skewed (0.46) and platykurtic (–0.70). A significant deviation from normality was detected, p = .002.

***Table 2.***
***Descriptive statistics and normality tests for the Attention Bias metrics***

| Variable | M | SD | Median | Skewness | Kurtosis | Shapiro p |
|---|---|---|---|---|---|---|
| Hypervigilance | 0.15 | 0.07 | 0.18 | -0.18 | -0.43 | 0.19 |
| Avoidance | 0.13 | 0.06 | 0.14 | 0.20 | 0.01 | 0.38 |
| Dysphoric | 0.10 | 0.06 | 0.09 | 1.00 | 1.36 | 0.01 |
| Anhedonic | 0.03 | 0.03 | 0.04 | 0.46 | -0.69 | 0.001 |

**Between-wave differences**

A Welch's t test was conducted to compare depression severity between Wave 1 and Wave 4 (as not everyone passed tests on Wave 5). For the PHQ-9, the mean score decreased slightly from 9.67 (SD = 6.05) at Wave 1 to 8.50 (SD = 6.01) at Wave 4, but this difference was not statistically significant, t(22.45) = –0.79, p = .41. For the BDI, scores showed a clearer decrease, from 12.40 (SD = 9.60) at Wave 1 to 8.21 (SD = 9.22) at Wave 4. This reduction approached significance, t (23.15) = –1.75, p = .16, suggesting a downward trend in self-reported depressive symptoms across measurement waves.

For the GAD-7, mean scores decreased from 6.72 (SD = 4.28) at Wave 1 to 4.20 (SD = 4.93) at Wave 4, a statistically significant reduction, t(141.58) = 3.28, p = .001. The mean difference was –2.52 (95% CI [1.00, 4.04]), with a medium effect size, g = –0.54. For the STAI, scores decreased from 25.11 (SD = 10.19) at Wave 1 to 22.66 (SD = 11.10) at Wave 4, but this difference was not statistically significant, t(140.27) = 1.38, p = .170. The mean difference was –2.45 (95% CI [–1.06, 5.96]), effect size small, g = –0.23.

A Welch's t test was used to examine changes in attention bias metrics between Wave 1 and Wave 4. For hypervigilance, mean scores were nearly identical across waves (Wave 1: M = 0.16, SD = 0.08; Wave 4: M = 0.15, SD = 0.09). The difference was not statistically significant, t(141.81) = 0.58, p = .564, 95% CI [–0.02, 0.03], g = –0.09. For avoidance, scores were also highly stable (Wave 1: M = 0.13, SD = 0.07; Wave 4: M = 0.13, SD = 0.09). No significant difference was found, t (140.66) = 0.13, p = .893, 95% CI [–0.02, 0.03], g = –0.02. For anhedonia, mean scores were very similar across waves (Wave 1: M = 0.03, SD = 0.03; Wave 4: M = 0.03, SD = 0.03). The difference was not statistically significant, t(80.92) = –0.61, p = .541, 95% CI [–0.02, 0.01], g = 0.13. For dysphoria, scores were slightly higher at Wave 4 (Wave 1: M = 0.05, SD = 0.05; Wave 4: M = 0.07, SD = 0.06), but the increase did not reach statistical significance, t(78.71) = –1.31, p = .195, 95% CI [–0.04, 0.01], g = 0.28.

**Modeling across measurement waves**

We modeled GAD-7 scores as a function of measurement wave and school, allowing school-specific linear trends. Specifically, we fit a linear regression with centered wave (time) and school as a factor, including their interaction: *GAD-7 ~ time × school*. To account for dependence within waves and within schools in repeated cross-sections, cluster-robust inference was used. Two-way clustered variances (wave and school) were numerically unstable; therefore, we used a conservative fallback that takes the element-wise maximum of one-way cluster-robust (by wave, by school) and HC1 variances. Because we used a deliberately conservative variance estimator due to two-way clustering instability, any positive findings are robust to modest misspecification, whereas null results should be interpreted with the corresponding loss of power in mind.

For the reference school (school#1), the linear time trend was not statistically significant, b = −0.184, SE = 0.355, t = −0.517, p = .605, indicating no evidence of average change in GAD-7 across waves. Relative to school#1, school#5 showed a lower mean level, b = −3.474, SE = 0.575, t = −6.041, p < .001, and school#3 was also lower, b = −2.351, SE = 0.708, t = −3.322, p = .001. The mean for school#6 did not differ significantly from school#1, b = 1.234, SE = 1.587, t = 0.778, p = .437. School-specific time slopes did not differ from the school#1 slope at α = .05: time×school#5 b = −0.586, SE = 0.413, t = −1.419, p = .157; time×school#3 b = −0.814, SE = 0.497, t = −1.639, p = .102; time×school#6 b = 2.204, SE = 1.288, t = 1.711, p = .088. An omnibus Wald test comparing the interaction model to the additive model was marginal, F(3, 362) = 2.543, p = .056, providing at most weak evidence that time trends vary by school.

The two-way cluster variance–covariance matrix (wave and school) for PHQ-9 was numerically unstable; we therefore used a conservative fallback equal to the element-wise maximum of one-way (by wave, by school) and HC1 variances. For the reference school (school#1), the intercept indicated a mean PHQ-9 score of 10.24 at the average wave (SE = 0.24, t = 41.92, p < .001). The linear time trend for school#1 was statistically significant and negative, b = −0.630, SE = 0.100, t = −6.308, p < .001, indicating a decrease in PHQ-9 across waves. Relative to school#1, school#3 showed a lower mean level at the average wave, b = −1.792, SE = 0.956, t = −1.874, p = .064 (marginal), and school#6 was substantially lower, b = −2.330, SE = 0.233, t = −9.979, p < .001. School-specific time slopes differed as follows: the time × school#3 interaction was not significant, b = 0.314, SE = 0.640, t = 0.490, p = .625, whereas the time × school#6 interaction was positive and large, b = 2.120, SE = 0.235, t = 9.040, p < .001, indicating a markedly steeper upward trend for school#6 compared with school#1. Corresponding per-school slope estimates (with robust CIs) were school#1 = −0.630 [−0.829, −0.431], p < .001; school#3 = −0.316 [−1.120, 0.487], p = .436; school#6 = +1.490 [1.397, 1.583], $p \approx 2.75 \times 10^{-48}$.

For AB metrics, we filtered through the same schools that were used for anxiety and depression measurements mentioned earlier. The overall time effect for hypervigilance was nonsignificant, b = –0.004, SE = 0.006, t(362) = –0.71, p = .477. None of the schools showed significant differences in intercepts relative to School 1, although School 6 trended lower, b = –0.037, SE = 0.021, t(362) = –1.77, p = .077.

Interaction terms between time and school were nonsignificant, all ps > .43. Per-school slopes indicated no meaningful change across waves: School 1 slope = −0.004 (95% CI [−0.015, 0.007], p = .477), School 5 slope = 0.004 (95% CI [−0.019, 0.026], p = .749), School 3 slope ≈ 0.000 (95% CI [−0.027, 0.025], p = .943), and School 6 slope = −0.006 (95% CI [−0.055, 0.043], p = .805). The Wald test confirmed that adding interactions did not improve model fit, $F(3, 362) = 0.23$, $p = .874$. The linear model tested change in avoidance bias over time across the same four schools. The main time effect was nonsignificant, b = 0.001, SE = 0.004, $t(362) = 0.20$, $p = .845$. School intercepts did not differ significantly from School 1, although School 6 trended lower, b = −0.023, SE = 0.017, $t(362) = -1.33$, $p = .186$. Time × school interactions were nonsignificant, all ps > .31. Per-school slopes indicated no systematic changes: School 1 slope = 0.001 (95% CI [−0.007, 0.009], p = .845), School 5 slope = 0.002 (95% CI [−0.013, 0.016], p = .827), School 3 slope = 0.001 (95% CI [−0.024, 0.026], p = .934), and School 6 slope = −0.023 (95% CI [−0.071, 0.024], p = .339). A Wald test comparing interaction and additive models showed no evidence of school-specific slope differences, $F(3, 362) = 0.34$, $p = .796$.

Graphically, hypervigilance distributions were comparatively stable, with modest between-school differences across waves. Avoidance distributions were more variable, showing marked differences by school, particularly in School 6, which displayed extreme clustering in Waves 2 and 4 (most likely due to the low sample size in these waves). Though, across both metrics, Wave 3 and Wave 4 appear as periods of higher divergence between schools, while Wave 1 and Wave 5 were more uniform. The trend of anxiety-related AB metrics across measurement times depicted on Figure 3.

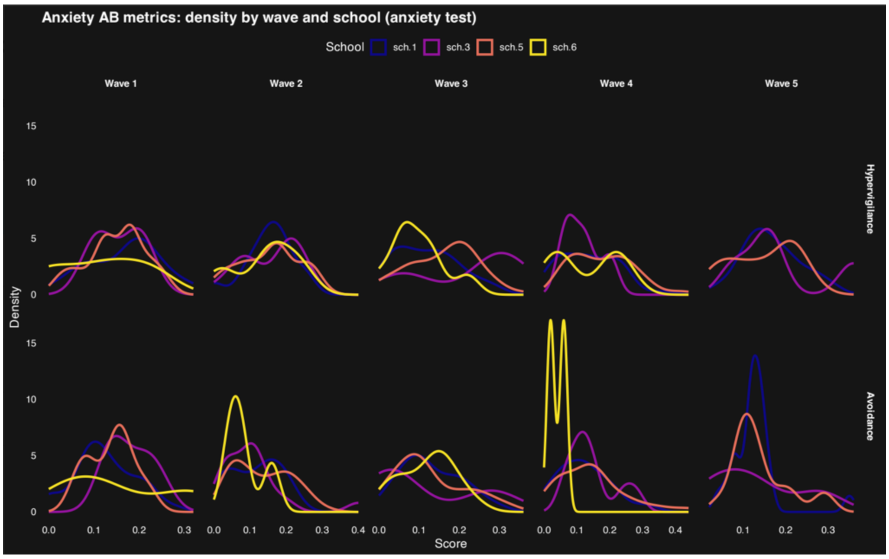


*Figure 3. Density distributions of anxiety-related Attention Bias metrics (hypervigilance and avoidance) across five measurement waves by school*

An increase in avoidance and cognitive fatigue at the final stages, particularly in schools with higher anxiety levels, indicates resource depletion. This highlights the need to slow down the pace toward the end of the cycle and to include body-oriented or restorative practices. The dynamics of the indicators also confirm the importance of the program's concluding stage – precisely at the end, most participants demonstrate psychological stabilization, a reduction in suicidal thoughts (as seen from questionnaires), anxiety, and emotional distortions.

For the analysis of Attention Bias metrics related to depression, we drew dysphoric and anhedonic bias values from the mixed test. Although these measures were also available in the dedicated depression test, a substantially larger number of students completed the mixed version, which provided greater statistical power for the analyses.

The linear model tested change in anhedonic bias over time across three schools (school#1, school#3, school#6). The overall time effect was nonsignificant, $b = 0.003$, $SE = 0.003$, $t(181) = 0.97$, $p = .334$. School 3 showed a higher intercept compared to School 1, $b = 0.015$, $SE = 0.006$, $t(181) = 2.38$, $p = .018$, while School 6 did not differ from School 1, $p = .891$. Interaction terms between time and school were nonsignificant, all $ps > .55$. Per-school slopes indicated no meaningful change in anhedonic bias over waves: School 1 showed a small positive slope (0.003, 95% CI [−0.003, 0.010], $p = .334$), School 3 a near-zero slope (0.000, 95% CI [−0.012, 0.012], $p = .949$), and School 6 a slightly negative slope (−0.004, 95% CI [−0.029, 0.021], $p = .748$). The Wald test confirmed that including interactions did not improve model fit, $F(2, 181) = 0.32$, $p = .728$.

The model for dysphoric bias showed a significant positive main effect of time, $b = 0.0018$, $SE = 0.0008$, $t(181) = 2.11$, $p = .036$, indicating a small overall increase across measurement waves. Both School 3 ($b = -0.018$, $SE = 0.005$, $t(181) = -3.76$, $p < .001$) and School 6 ($b = -0.028$, $SE = 0.004$, $t(181) = -6.90$, $p < .001$) had lower baseline dysphoria levels than School 1. Interaction terms were not significant, all $ps > .30$. Per-school slopes revealed that dysphoria increased slightly in School 1 (0.0018 per wave, 95% CI [0.0001, 0.0034], $p = .036$). For School 3, the slope was positive but nonsignificant (0.0029, 95% CI [−0.0011, 0.0068], $p = .151$). School 6 showed a small negative but nonsignificant slope (−0.0014, 95% CI [−0.0091, 0.0063], $p = .727$). The Wald test indicated that the additive model was sufficient, with no evidence of meaningful interactions, $F(2, 181) \approx 0$, $p = 1.00$.

Visually, dysphoric bias distributions showed noticeable fluctuations across waves, with schools diverging more strongly in Waves 1 and 4. In Wave 4, both Schools 3 and 6 showed pronounced peaks, whereas School 1 remained more evenly distributed. By Wave 5, distributions converged, with all schools showing relatively flat and uniform curves. Anhedonic bias distributions were highly skewed toward very low values, particularly in Wave 1, where Schools 3 and 6 displayed extreme clustering near 0.03–0.05. The sharp peaks observed in early waves (especially Wave 1 for anhedonic bias) likely reflect the influence of small sample sizes in some schools. Overall, depression-related AB metrics were more heterogeneous across schools in the earlier measurement waves. The trend of depression-related AB metrics across measurement times depicted on Figure 4.

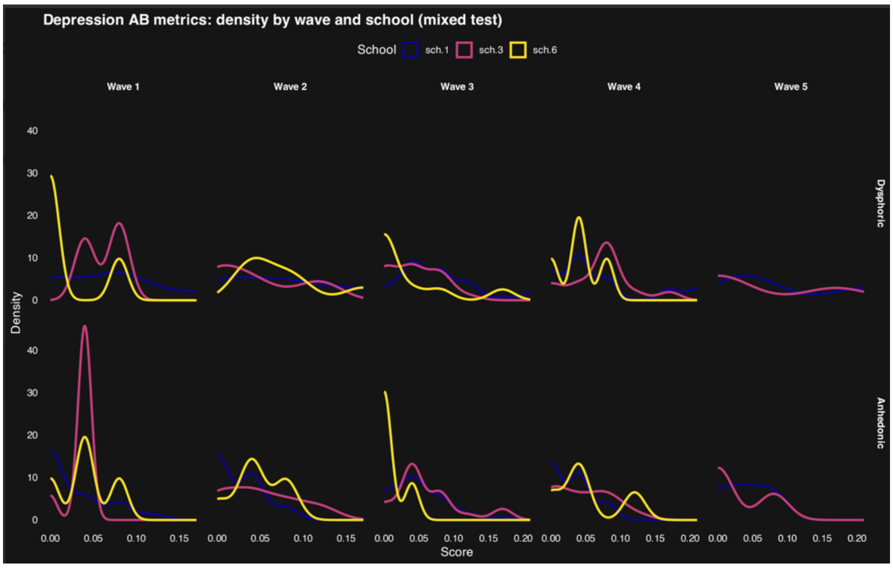


*Figure 4. Density distributions of depression-related Attention Bias metrics (dysphoric and anhedonic bias) across five measurement waves by school*

## Discussion

### Baseline descriptives as a provisional reference for adolescent attention bias

Because first-wave testing preceded substantial program exposure and included broad participation, it offers a practical baseline for adolescent AB in this context. The group profile was hypervigilance M = 0.16 (SD = 0.08, Median = 0.18), avoidance M = 0.13 (SD = 0.07, Median = 0.14), dysphoric bias M = 0.10 (SD = 0.07, Median = 0.09), and anhedonic bias M = 0.04 (SD = 0.03, Median = 0.04). All means were well below severity thresholds established for adults. The adolescent baseline can be carried forward as a comparative anchor to detect abnormal scores and establish population norm in further studies. While self-report measures showed meaningful change across the program, Attention Bias indices remained largely stable at the group level. Group-aggregated AB results can obscure clinically relevant individual differences. For risk monitoring, it is the individual profile of AB – such as a persistent hypervigilant or dysphoric bias exceeding normative thresholds – that signals potential vulnerability. Thus, while mean-level stability across schools suggests no systematic shift in attentional processes, attention to individual AB trajectories remains essential for identifying students who may require targeted support.

## Conclusions

Deploying Anima alongside the entrepreneurship bootcamp provided a low-burden, school-ready way to monitor both subjective symptoms and objective attentional patterns across waves without breaking anonymity. Across 691 completed sessions, the platform captured meaningful change in self-reported anxiety while showing relative stability in eye-tracking–based Attention Bias (AB) indices. Specifically, GAD-7 decreased significantly from Wave 1 to Wave 4 (medium effect), whereas STAI showed a nonsignificant decline; depressive questionnaires (PHQ-9, BDI-II) trended downward but did not reach significance in the two-wave comparison.

Regression models with conservative, cluster-robust inference supported this picture and revealed school-level heterogeneity: for example, PHQ-9 declined in school#1 but increased across waves in school#6, while GAD-7 levels were lower on average in school#3 and school#5 than in school#1. These differences likely reflect real variation in implementation context (mentor intensity, pacing, engagement with project work) within the bootcamp format, rather than measurement noise, because inference remained conservative throughout.

The AB metrics were consistently below a priori severity thresholds in the first wave and showed no systematic mean-level change in most models, with visualizations indicating only episodic between-school divergence in mid-program (Waves 3-4). It suggests that Anima's AB indices provide an objective anchor that is less susceptible to short-term fluctuations in self-report and can help distinguish perceived symptom relief (e.g., GAD-7) from deeper attentional reweighting.

**Data availability statement.** All data generated and analyzed in this study, including the Excel dataset and R script, are openly available and can be freely accessed at https://osf.io/3cq24. Use of these data requires proper citation of the present article.

**Declaration of Conflicting Interests.** One of the authors is a co-developer of the Anima platform, which may represent a potential conflict of interest regarding the interpretation of the study results. However, no conflicts of interest related to the authorship and/or publication of this article are declared.

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