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AFFECTIVE DYNAMICS IN AI-ASSISTED AND TRADITIONAL SECOND LANGUAGE WRITING: AN IDIODYNAMIC STUDY INFORMED BY COMPLEXITY DYNAMIC SYSTEMS THEORY

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Abstract
Second language (L2) writing often involves rapid, idiosyncratic shifts in anxiety, motivation, and perceived control, yet these dynamics remain underexplored in generative AI-mediated writing. Guided by Complex Dynamic Systems Theory (CDST), this study examined second-by-second affective trajectories as two Turkish EFL learners with contrasting profiles (one typically anxious, one confident) completed comparable timed academic essays with and without a GPT-based writing assistant. Methodologically, this qualitative two-case study employed a CDST-informed idiodynamic approach, combining second-by-second self-ratings of anxiety, motivation, and perceived control during video-replay sessions with stimulated recall interviews. The anxious writer showed pronounced volatility in the traditional condition, with anxiety spikes and concurrent drops in motivation and control; AI support attenuated these fluctuations by restoring perceived control and stabilizing affect. The confident writer maintained consistently high control and motivation and low anxiety in both conditions, using AI mainly for reassurance. Overall, perceived control emerged as a key attractor shaping affective self-regulation, and AI operated as a context-sensitive co-regulator rather than a uniform aid. Pedagogically and technologically, the findings suggest that AI-enhanced writing environments should provide adaptive, profile-sensitive scaffolding, while teachers should monitor learners' momentary sense of control and integrate metacognitive support to foster sustainable self-regulation.

Keywords: affective dynamics, artificial intelligence (AI), complexity dynamic systems theory (CDST), L2 learners, second language (L2) writing

Introduction

Second-language (L2) writing is a cognitively and affectively complex task, often triggering shifts in anxiety, motivation, and perceived control as learners compose text (Huang et al., 2025; Waked et al., 2023). With the emergence of generative artificial intelligence (AI) tools, educators have gained new means of supporting L2 writers by facilitating idea generation, offering linguistic and organizational feedback, and providing immediate assistance that may also strengthen learners' sense of control during the writing process (Aladini et al., 2025; Lu et al., 2026; Mekheimer, 2025). However, how AI assistance interacts with learners' moment-by-moment affective experiences during writing remains underexplored. Such rapid, real-time fluctuations in emotion and cognition align with Complex Dynamic Systems Theory (CDST), which views affective-cognitive processes as dynamic and non-linear (Alraythi et al., 2026). According to CDST, language learning and performance emerge from the continuous interaction of a learner's emotional and cognitive subsystems, leading each individual to follow a unique, temporally constructed trajectory (Chang & Zhang, 2021; Li & Jin, 2025). Two key properties of complex systems under CDST are self-organization and feedback sensitivity, meaning that a learner's internal system can reorganize into different stable states over time (Saqr et al., 2026; Yang, 2021). Being sensitive to various situational factors or attractors, it may settle into particular attractor states under certain conditions. In other words, an L2 writer's anxiety or motivation may periodically stabilize at certain levels (attractors) or fluctuate rapidly, reflecting the interplay of personal, task, and contextual influences.

The majority of traditional research concerning L2 writing has focused on either static questionnaires or global affective scales, which can only reflect general emotional tendencies and struggles, ignoring the rapid contextually sensitive changes that occur in the moment (Bailey & Almusharraf, 2022; Hijriyah et al., 2025; Li, 2024; Zhou et al., 2022). This has meant that much of the prior research on writing anxiety or motivation was measured at trait-levels (Gao, 2026; Ren et al., 2025), giving only scarce information about the simultaneous moment-to-moment emotional changes that happen during the writing experience. Researchers have pointed out this reality in calls for a more dynamic and process-oriented approach to emotional variables in SLA (Ali & Abdulrazzaq, 2024; Hang, 2025; Shahini, 2025; Wang et al., 2024; Wu & Kabilan, 2025). The idiodynamic method directly addresses this methodological issue by providing a fine-tune lens to longitudinally examine second-by-second changes in learners' affective states (He et al., 2022). Although this method has been successfully employed in speaking contexts to trace dynamic emotional patterns (Esmaeilee et al., 2025; Kohnke & Moorhouse, 2025; Winkler & Appel, 2024), its use within L2 writing contexts remains almost absent in L2 research, in addition to limited research on affective dynamics in AI-supported writing contexts. The research aims to fill this gap by integrating CDST and idiodynamic analysis to examine how learners' emotions change and self-organize during L2 writing tasks completed with and without AI support. Mapping the emerging attractor states in addition to the variabilities between the emerging and other attractor states, we provide empirical evidence to support the dynamic nature of emotion in L2 writing.

Literature review

AI-Assisted L2 writing and affective dynamics

AI, particularly generative AI based on large language models, refers to computational systems capable of producing human-like text through probabilistic language prediction and adaptive interaction with users. In L2 writing contexts, such systems function as intelligent writing assistants that can generate ideas, suggest linguistic alternatives, reorganize discourse structures, and provide immediate feedback during the composing process (Marzuki et al., 2023; Shan et al., 2025; Wang & Wang, 2025). As a result, generative AI is increasingly positioned not only as a technical support tool but also as a mediational resource shaping learners' cognitive and affective engagement with writing tasks.

In pedagogical practice, AI has been implemented in L2 writing through multiple instructional configurations, including grammar-checking tools, automated writing evaluation systems, and conversational large language model interfaces that support brainstorming, revision, and text expansion. These tools enable learners to interact with feedback iteratively and on demand, thereby facilitating vocabulary development, syntactic accuracy, and discourse organization (Ekizer, 2025; Hijriyah et al., 2025). Importantly, such interactional affordances allow AI to function as both a cognitive scaffold and an affective regulator during writing, particularly by supporting learners' perceived control over task completion.

A growing body of research suggests that AI-supported writing environments may positively influence affective variables such as motivation, confidence, and anxiety. For example, Xia and Guo (2025) reported that AI-mediated writing environments encouraged learners to take greater linguistic risks by lowering perceived evaluative pressure during task completion. In a different line of inquiry, Heydarnejad (2025) found that students participating in AI-supported writing activities reported lower levels of foreign language anxiety compared with those engaged in conventional writing tasks. Together, these findings indicate that AI may facilitate affective engagement by providing immediate, neutral, and non-judgmental feedback during writing.

Despite these documented benefits, several scholars have cautioned against the uncritical integration of AI into L2 writing instruction. While AI can enhance drafting efficiency and linguistic accuracy, excessive reliance on automated assistance may weaken learners' sense of authorship, agency, and emotional investment in writing (Cui et al., 2025). Moreover, reduced engagement in core composing processes such as planning, revising, and reflective monitoring may limit learners' metacognitive awareness and undermine the development of autonomous writing strategies (Revesai, 2025; Shi et al., 2025; Teng et al., 2022). Over time, such dependency may contribute to affective stagnation or increased anxiety when learners are required to perform writing tasks without technological support (Biju et al., 2024; Oruç et al., 2026; Tian & Zhang, 2025). These concerns highlight the need for pedagogical frameworks that integrate AI as a context-sensitive scaffold while simultaneously fostering emotional resilience, sustained engagement, and learner autonomy.

Affective factors in L2 writing tasks

Not only is L2 writing cognitively demanding, but it is also highly affective (Gao, 2026; Ren et al., 2025). Emotional variables such as motivation, anxiety, and perceived control have a significant effect on learners' investment in writing tasks, as well the products of their writing (Guo et al., 2025; Kaplan et al., 2025; Zahari et al., 2025). In particular, foreign language writing anxiety (FLWA) has been established as a key affective barrier. FLWA is typically defined as apprehension or tension that is situation specific and occurs during L2 writing activities (Bay et al., 2025; Gao, 2022; Sun et al., 2025). High levels of writing anxiety are negatively correlated with writing self-efficacy which can contribute to decreased quality in written texts (An & Li, 2024; Busse et al., 2023; Li, 2022). Conversely, positive emotions such as enjoyment, curiosity, and interest have consistently been associated with improvements in learners' attention, persistence, and resilience through the writing process (Miao et al., 2025; Zhao & Ma, 2025).

Emotions surrounding L2 writing are dynamic and often shift throughout a writing event (Chenekew Goshu et al., 2025; Li, 2024; Wang et al., 2024). Previous studies using retrospective questionnaires have demonstrated that confidence and a positive disposition towards writing typically enhance motivation, while anxiety surrounding negative evaluation and perceptions of difficulty increase anxiety (Huang & Wu, 2025; Ryder et al., 2025; Zhai, 2025). More recent examinations of emotion have moved past the 'static snapshots' of emotion to an examination of its dynamism. For example, experience-sampling methods and designs with repeated measures have highlighted that learners often experience dramatic variations in motivation and anxiety in the midst of a writing event (Rodd, 2024; Xu et al., 2025; Zhang et al., 2025). A learner can start a task with a good deal of motivation, but moments after will find him or herself disappointed because of linguistic challenges; this reflects the fluctuating and transient nature emotions contribute to in language learning contexts (Huo et al., 2025; Liu & Xin, 2025).

In light of such intra-individual variability, L2 writing researchers have drawn upon affective theories such as Pekrun (2024) Control-Value Theory of Achievement Emotions more explicitly. The Control-Value Theory posits that learners' momentary emotions (such as enjoyment, boredom, and anxiety) depend upon their perceptions of control and value that they assign to the task; however, when perceptions of control and/or value are low, learners may instead become anxious or disengaged. These views run parallel to applied linguistics more broadly, where L2 affect is increasingly understood to be context-sensitive and dependent on time (Kimchi et al., 2025; Kutlu et al., 2024; Yu et al., 2026). Therefore, research techniques like idiodynamic analysis and dynamic tracking are necessary to allow researchers to study the ups and downs of emotions that occur during writing process.

Idiodynamic method for intra-individual affective variability

The idiodynamic method, initiated by Vo et al. (2025), was developed to track moment to moment affective dynamics in L2 communication. The method involves recording a learner's performance (e.g. their videoed speaking or writing session), and then after the recording is made, the learner watches the video and provides continuous self-ratings of a target affective state (e.g., anxiety, enjoyment, motivation) on a second-by-second basis. This gives a very fine-grained time series of the learner's emotional trajectory, which can be analyzed alongside qualitative recall data. The strength of the method is that it shows how emotions spike, dip, and co-vary with actual task events for each individual learner, as opposed to averaging those things out (Dammas et al., 2025). For example, in Darasawang and Reinders (2021), they were able to show that an L2 speaker's willingness to communicate could go from very low to very high during a single conversation, something that would not have been possible or countenanced with traditional one-off surveys. Since then, there have been more studies using the idiodynamic paradigm in relation to a number of emotions and a variety of contexts, highlighting its potential (Aubrey, 2025; Li et al., 2025; Yetkin & Özer-Altınkaya, 2025).

Fu et al. (2025) demonstrated the use of idiodynamic self-ratings to examine anxiety during foreign-language, oral presentations; they found, as expected, that learners high in trait anxiety exhibited higher initial and mean anxiety during their oral presentations, but, unexpectedly, some learners low in anxiety exhibited an actual spike in anxiety during points of pressure. These idiosyncratic differences underscore the point that we need to examine intra-individual data where one learners' emotion graph has several peaks of anxiety while another learner's graph is relatively calm, even though they may maintain a similar average anxiety level. Furthermore, more recently, researchers have also examined the idiodynamic method within L2 writing and other skills. For example, examined dynamics of enjoyment and anxiety represented during monologue tasks, and found that the two emotions can exhibit a see-saw relationship within the individual, where when anxiety spiked enjoyment tended to drop and vice versa, while also acknowledging that the strength of such a relationship varied greatly for different moments of the monologue task (Aubrey, 2022). Overall, the idiodynamic approach, typically affiliated with stimulated recall interviews, provides a good person-specific overview of how and why a learner's emotional state varies during a language task. This method aligns well with Endrejat and Burnes (2022) foundational focus on the "individual as a whole" as a focus of psychological research. The idiodynamic data, which are measured moment to moment, allow researchers to investigate the individual's emotional dynamics instead of relying on a group average (Guedat-Bittighoffer et al., 2025; Lu, 2022; Springstein et al., 2024).

Complex Dynamic Systems Theory (CDST) in language and emotion research

CDST has been increasingly utilized in the last 15 years in applied linguistics to understand L2 development and affect as emergent, time-evolving processes (Gui et al., 2021; Huang et al., 2025; van Dijk et al., 2025; Yang, 2021). CDST differs from static trait models in its stance that the language learner is a complex system interacting with, and comprised of, multiple components (cognitive, affective, social, etc.) in time that are vulnerable to both internal and external influences. A central notion in CDST is that of attractor states: patterns or preferred states of relatively stable behavior that a dynamic system tends to settle into under certain conditions. In terms of language learning emotions, attractor states could be construed as representations of repeated emotional orientations or moods learners may experience. For example, R. Wang and Xu (2026) established a number of four prevalent attractor states in the classroom, namely, interest, boredom, neutral attention, and anxiety, each sustained by a complex basin consisting of factors such as the learner's goals or expectations, the difficulty of the task, and the classroom environment.

Importantly for CDST, learners' emotional states are not static; they are dynamic and can alter (on occasion, suddenly) when the system moves to a different region. Small events like a particularly confusing sentence or a moment of success can induce non-linear change, or phase shift, and move a learner from one attractor to another (Gernigon et al., 2024; Larsen-Freeman, 2019; Petropoulos et al., 2026). Empirical work supports this perspective and suggests that emotional trajectories are often marked by abrupt transitions. For example, in a longitudinal study of L2 motivation and emotion, Tian and McCafferty (2022) observed times of relative stability punctuated by sudden jumps corresponding to significant experience (e.g., a discouraging result on a test eliciting a rapid decline in motivation). In conclusion, research that is inspired by CDST treats L2 affect as a process rather than product: a dynamic system that is always evolving, marked by instability, feedback loops, and emergent order.

Recent research in second language acquisition has increasingly modeled affective processes as complex, dynamic systems by integrating CDST with fine-grained methodological approaches capable of capturing moment-to-moment variability. For example, Wang et al. (2024) used the idiodynamic method to trace fluctuations in foreign language anxiety during speaking tasks, demonstrating that learners' affective states evolve dynamically rather than remaining stable across task performance. Similarly, Li et al. (2024) employed CDST-informed analyses to examine variability in learners' motivation and emotional engagement, highlighting the nonlinear and context-sensitive nature of affective development. More recently, Wang and Xu (2026) further illustrated how learner emotions emerge through interactions among cognitive, contextual, and interpersonal subsystems during communicative language tasks. Collectively, these studies demonstrate the growing recognition that L2 affect is best understood as a dynamic, self-organizing process shaped by multiple interacting subsystems over time.

However, only a limited number of studies have explicitly combined CDST with the idiodynamic method within AI-mediated learning environments. One notable example is Zhang et al. (2026), who investigated learners' motivation during AI-assisted speaking practice and identified nonlinear interactions among linguistic performance, affective experience, and feedback from a verbal AI tutor. Their findings revealed that multiple subsystems including linguistic, cognitive, metacognitive, affective, and contextual dimensions became dynamically coupled during task completion, resulting in individualized motivational trajectories across learners. Such work supports the view that L2 learning emotions are not fixed attributes but emergent states constructed through moment-to-moment interaction within complex adaptive systems.

Nevertheless, despite these advances, applications of CDST-informed idiodynamic analysis to L2 writing remain scarce, particularly in AI-mediated environments. Most existing research has focused primarily on speaking or classroom interaction rather than writing processes (e.g.,Danilevičienė & Vaznonienė, 2018; Herder et al., 2020; Maine, 2024; Siengsanoh, 2021), leaving unresolved questions about how affective dynamics unfold during the recursive and self-regulated activity of composing texts. Furthermore, very few studies have examined how AI-generated feedback interacts with learners' emotions and perceived control during writing (e.g.,Urzúa et al., 2025; Vistorte et al., 2024; Yang et al., 2025). Consequently, the current literature provides only limited insight into how CDST-informed frameworks combined with idiodynamic analysis can illuminate emotional variability across both AI-supported and traditional writing conditions. To address this gap, the present study investigates the following research questions:

1. How do learners' moment-to-moment affective states (anxiety, motivation, and perceived control) fluctuate during AI-assisted versus traditional L2 writing tasks?
2. What distinct emotional trajectories can be identified for learners with different affective profiles?
3. How does AI assistance influence learners' self-perceived control and affective regulation during writing?
4. To what extent can these affective dynamics be interpreted through the lens of Complexity Dynamic Systems Theory (CDST)?

In this study, CDST is adopted as the theoretical framework, and the idiodynamic method is used to capture fine-grained temporal variation in learners' affective experiences across traditional and AI-supported writing tasks. This approach enables the interpretation of moment-to-moment affective change as part of a broader system of self-organization, feedback sensitivity, and contextual adaptation during L2 writing.

Method

Participants

This study adopted a qualitative contrasting-case design within a CDST-informed idiodynamic framework, which prioritizes intensive within-participant analysis of moment-to-moment affective variability rather than large-sample generalization. Accordingly, two adult Turkish EFL learners, referred to by the pseudonyms (Ali and Buse), were recruited from a larger pool of volunteer participants at a public university in Türkiye through purposive sampling based on contrasting affective writing profiles. Participants were recruited during the initial phase of a broader study investigating affective experiences in L2 writing. All volunteers first completed a short screening questionnaire measuring writing anxiety and writing confidence, followed by brief semi-structured interviews about their emotional experiences during academic writing tasks. Based on these screening results, two contrasting cases were selected for in-depth analysis. Ali consistently reported relatively low levels of writing anxiety and stable writing confidence, whereas Buse reported higher anxiety levels and more fluctuating confidence across writing situations. Selecting these contrasting affective profiles enabled closer examination of how emotional trajectories unfolded differently across traditional and AI-assisted writing conditions.

Both participants were undergraduate students enrolled in English-medium coursework at the same institution and had comparable formal educational backgrounds in English as a foreign language. At the time of the study, both learners were classified at approximately intermediate proficiency level (CEFR B1–B2) according to institutional placement procedures. Each participant had received at least six to eight years of prior formal English instruction and reported only limited prior experience using generative AI tools for academic writing purposes. Participants were recruited on a voluntary basis and provided informed consent prior to participation. They were informed about the aims of the study, the procedures involved, their right to withdraw at any time without penalty, and the anonymization of identifying information in all research reporting. No financial or academic incentives were provided. The study followed standard institutional ethical guidelines for research involving human participants.

Tasks

Each participant undertook two comparable timed writing tasks under different conditions on separate days. In the AI-assisted condition, the learner composed a 300-word academic essay on a familiar topic with the help of a generative AI assistant. The AI was a GPT-based writing tool (similar to ChatGPT) capable of interacting via text: it could answer questions, suggest wording or ideas, and provide feedback on grammar or content. Participants were introduced to the AI tool in a brief orientation session before writing. They learned how to ask the AI questions like "How can I organize my ideas?" or "Please check this paragraph for mistakes." They were also told that the assistant could help with everything from coming up with ideas to final editing. The AI did not write the essay for them; instead, it acted as a consultant and only answered questions when asked. At any time during their writing, participants could ask for feedback or suggestions. In the traditional (no-AI) condition, the learner wrote a similar essay on a similar topic without any AI help, using only what they already knew, their notes, and their skills. Both essay prompts were made to be the same level of difficulty and type, so that they could be compared fairly. The two conditions were switched between the two participants (one did the AI-assisted task first and the other did the non-AI task first) to avoid order effects. Each writing task had a time limit of 15 minutes. This task design enabled us to discern fluctuations in emotional trajectories with and without AI assistance for each individual.

Instruments and measures

During the writing tasks, multiple instruments were used to collect behavioral data and continuous self-ratings of participants' affective experiences. The idiodynamic method was employed to capture moment-to-moment fluctuations in anxiety, motivation, and perceived control, as this approach allows participants to evaluate their emotional experiences dynamically while viewing recordings of their own task performance (MacIntyre & Ducker, 2022). Grounded in CDST, the idiodynamic method is designed to reveal intra-individual variability over time that cannot be captured through conventional pre- and post-task questionnaires (MacIntyre & Ducker, 2022).

For each writing session, synchronized video recordings were produced that captured participants' on-screen writing activity as well as their facial expressions during task performance. These recordings provided temporally aligned evidence of participants' typing behavior, their interaction with the AI assistant (in the AI-supported condition), and their observable affective reactions. The recordings served as the primary stimulus material for subsequent continuous self-rating procedures.

Following each writing session, participants completed an idiodynamic self-rating protocol adapted from MacIntyre and Ducker (2022). During this procedure, participants watched the playback of their writing sessions and continuously evaluated three target affective variables anxiety, motivation, and perceived control using a real-time rating interface on a 0–5 scale (0 = none; 5 = very high). The video recordings were replayed at normal speed, approximately one second per interval, while participants adjusted the rating scale dynamically to reflect their moment-to-moment emotional experiences. This process generated time-series datasets for each affective variable, yielding approximately sixty data points per minute of writing and enabling fine-grained visualization of affective trajectories across task performance.

The adaptation of the idiodynamic protocol involved selecting focal affective constructs relevant to AI-assisted L2 writing contexts and implementing a continuous rating interface synchronized with video playback. Procedural validity was ensured by following established idiodynamic research practices, including immediate post-task replay, participant-controlled rating adjustments, and temporal alignment between behavioral recordings and affective judgments. Interpretive reliability of the ratings was further strengthened through the integration of stimulated recall interviews, which enabled participants to confirm and elaborate the reasons underlying observed fluctuations in their affective trajectories. Such triangulated procedures are widely recognized as appropriate strategies for enhancing validity and reliability in CDST-informed idiodynamic research (MacIntyre & Ducker, 2022).

Following the continuous rating procedure, stimulated recall interviews were conducted to obtain qualitative explanations of affective changes observed in the time-series graphs. During these interviews, the researcher and participants jointly examined graphical representations of the self-rating trajectories and identified salient peaks, declines, or moments of transition. At each identified point, participants were invited to explain the thoughts, reactions, or contextual factors that contributed to the observed emotional change. For example, participants reported increased anxiety when encountering grammatical uncertainty and increased motivation when receiving useful suggestions from the AI assistant. All retrospective verbalizations were audio-recorded and transcribed for analysis. This procedure followed established stimulated recall methodology and enabled the integration of quantitative trajectory data with participants' interpretive accounts (MacIntyre & Ducker, 2022). By combining continuous self-rating trajectories with stimulated recall explanations within a single analytic framework, the study achieved methodological triangulation that supported a more comprehensive understanding of affective dynamics during L2 writing. This integrated dataset allowed affective fluctuations to be interpreted not only as numerical trends over time but also as context-sensitive responses embedded within learners' ongoing cognitive and emotional activity.

Procedure

Each participant completed two writing tasks followed by an idiodynamic self-rating and stimulated recall procedure in a quiet laboratory setting. The full session lasted approximately 90-120 minutes. After providing informed consent and receiving a brief orientation, participants completed the two writing tasks in a counterbalanced order, with one participant beginning in the AI-assisted condition and the other in the traditional condition. To minimize potential researcher influence on participants' affective experiences, the research team monitored the sessions from an adjacent observation room. During each task, both the participant's screen activity and webcam footage were recorded to capture the full writing process, including on-screen composing behavior, interaction with the AI tool in the AI-assisted condition, and visible facial reactions. Each writing task took approximately 15-20 minutes to complete. In the AI-assisted condition, participants were allowed to consult the AI tool freely as needed, and all interactions with the system were captured in the recordings. In the traditional condition, no external assistance was permitted. After each writing task, participants took a short break before beginning the idiodynamic self-rating procedure.

Using dedicated idiodynamic software, participants then watched a synchronized replay of their own writing session, consisting of the screen recording and webcam footage displayed together, and rated their anxiety, motivation, and perceived control on a 100-point continuous scale. The replay was shown three separate times, once for each affective variable, so that each emotion could be rated independently. As participants watched the replay, they moved a slider in real time to indicate the intensity of the target emotion at each moment. Each rating session took approximately 10-15 minutes. The researcher remained available for technical assistance but did not intervene in the rating process. Once the three ratings were completed, the software automatically generated graphical representations of each affective trajectory over time.

These graphs were then used to support a stimulated recall interview. The researcher and participant jointly reviewed salient peaks, declines, or turning points in the trajectories, and the participant was asked to explain what had been happening at those moments. For example, the researcher might ask, "Here your anxiety dropped sharply. Do you recall what was occurring at that moment?" Participants used the replayed recording as a memory aid to verbalize the thoughts, reactions, and contextual triggers underlying their emotional changes.

The same procedure was repeated for the second writing task. By the end of the session, each participant had completed two essays, produced six affective trajectory graphs, and participated in two stimulated recall interviews. At the end of data collection, all participants were fully debriefed.

Data analysis

A mixed-methods analytic strategy was employed to integrate quantitative time-series data with qualitative stimulated recall accounts. For each participant, the trajectories of anxiety, motivation, and perceived control were examined both visually and descriptively across the two task conditions. Three-line graphs were generated for each task to display second-by-second changes in the three affective variables. To identify salient affective events for further qualitative interpretation, we used two operational criteria: (1) marked movement, defined as an increase or decrease of approximately 20 points within a 5- to 10-second interval, and (2) local extrema, defined as visually salient peaks, troughs, or turning points relative to the surrounding trajectory. These points were not treated as statistically fixed thresholds, but as analytically meaningful fluctuations to guide the interpretation of moment-to-moment emotional change.

We then compared the trajectories within and across participants and conditions by examining their overall patterns, mean levels, ranges, and moments of instability. Particular attention was given to short-term affective shifts rather than only overall averages. These visually identified fluctuations were subsequently used to guide the stimulated recall interviews, during which participants were asked to explain what they had been thinking, feeling, or experiencing at the moments corresponding to the observed changes in the graphs. To improve analytic consistency, both researchers independently reviewed the graphs and identified salient fluctuations before discussing their interpretations and agreeing on which moments would be treated as affectively significant for follow-up analysis. All stimulated recall interviews were conducted in Turkish to minimize language-related constraints and allow participants to express their experiences with greater precision. The interviews, which lasted approximately 20 to 30 minutes, were audio-recorded with participants' consent and transcribed verbatim for analysis.

The interview transcripts were analyzed using Naeem et al. (2023) six-phase thematic analysis. In Phase 1, both researchers familiarized themselves with the data by reading and rereading the transcripts alongside the corresponding affective graphs and replay segments. In Phase 2, initial inductive codes were generated to capture recurrent emotional triggers, self-regulatory responses, perceptions of AI support, moments of uncertainty, and reflections on writing performance. In Phase 3, these initial codes were grouped into broader candidate themes by identifying conceptual similarities across coded segments. At this stage, several provisional categories were created, including AI-mediated reassurance, linguistic difficulty, time pressure, self-monitoring, and control restoration. In Phase 4, the candidate themes were reviewed against the full dataset and the time-series evidence to determine whether they were sufficiently coherent internally and distinct from one another. During this stage, some preliminary themes were merged because they overlapped conceptually, while others were collapsed into subthemes or discarded when they lacked enough supporting data. For example, codes related to hesitation, fear of making mistakes, and uncertainty about wording were integrated into a broader theme of linguistic insecurity, while isolated references that did not recur meaningfully across the dataset were not retained as final themes.

In Phase 5, the refined themes were defined and named by specifying their central organizing concepts and clarifying how each theme contributed to the explanation of learners' affective trajectories. The final themes captured recurring sources of emotional fluctuation and regulation across the writing tasks, such as time pressure, AI as immediate reassurance, language-related uncertainty, and self-evaluative monitoring. In Phase 6, these themes were woven into the final analytic narrative by linking participants' interview accounts to specific peaks, drops, and turning points in the idiodynamic graphs. This integration allowed the qualitative themes to explain not only what participants reported, but also when and why those affective shifts occurred during task performance.

To support coding rigor, the transcripts were initially coded independently by two researchers using MAXQDA 2022, after which coding decisions and theme boundaries were discussed collaboratively until consensus was reached. Agreement during the coding stage was high (Cohen's kappa = .87), indicating substantial consistency in the identification of meaningful coded segments. Finally, the qualitative themes were triangulated with the time-series data, contextual video evidence, and participants' own explanations to construct a rich account of affective dynamics in AI-assisted and traditional L2 writing.

Findings and Discussion

Findings

Case 1: Buse (fluctuating affective trajectory)

Buse's expertise with idiodynamic graphs has provided evidence that emotions are dynamic in nature during both writing tasks. In the traditional writing session (Figure 1), she initially felt good about the task during the first 20 seconds, with high motivation (about 80-85/100), low anxiety (about 20/100), and high feelings of perceived control (about 80/100). As noted by Buse, "I knew the topic really well, so I was really pumped to start writing." After the first 20 seconds, the balance changed quickly. About 30 seconds, she was feeling a lot more anxious, less motivated, and less in control.

For 50 to 60 seconds, she struggled to get her message across, which contributed to an increase in her anxiety (about 80/100), a decrease in her motivation (about 40-45/100), and a dramatic drop in her perceived control (about 35/100). "I did not know how to describe what I wanted to say clearly, and I started getting really nervous," she said. The same moment of mental blockage impacted all three emotion areas and suggested how deeply interwoven anxiety, motivation, and perceived control are when participating in a task. "I felt like I was beginning to lose control over the task because, for the moment, I couldn't articulate what I wanted to say," she explained.

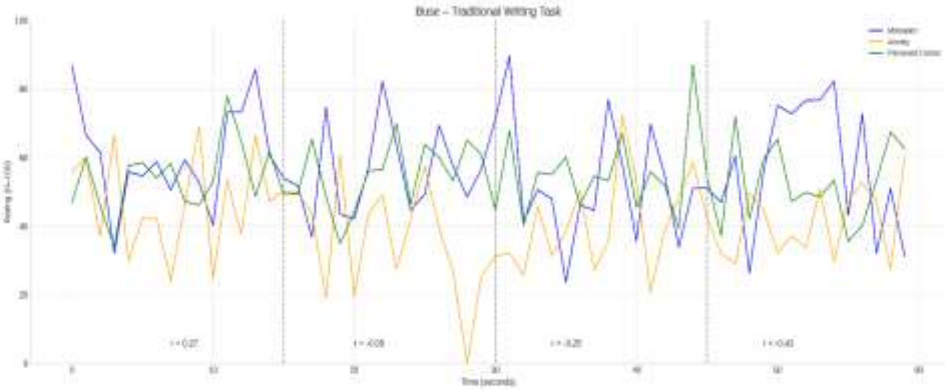

Figure 1. Buse's motivation, anxiety& perceived control over time (traditional writing task)

During the AI-assisted session (Figure 2), the intervention of the AI appeared to slow this decline in well-being. The AI assistant suggested a relevant phrase after her peak in anxiety, and it enabled her to improve quickly. After about 50 to 60 seconds, her anxiety rating had dropped to moderate (about 55/100), her motivation was replenished (about 55), and her perceived control had improved (about 60). She stated, "Once the AI gave me a hint, I felt like I was in charge again and wanted to keep going."

Once the AI task was completely finished (50-60 seconds), her emotion levels went flat: her motivation stayed in the mid-60s, her anxiety stayed in the low-50s, and her control stayed in the 65/100 range. In summary, Buse started in a high-motivation, low-anxiety, and high-control attractor state, transitioned to a low-motivation, high-anxiety, and low-control state, and then improved with the help from AI as well as her self-regulation (like taking breaks and talking to herself). Her trajectory indicates that she has transitioned between many different affective attractor states and, furthermore, that these three dimensions are quite differently related to each other.

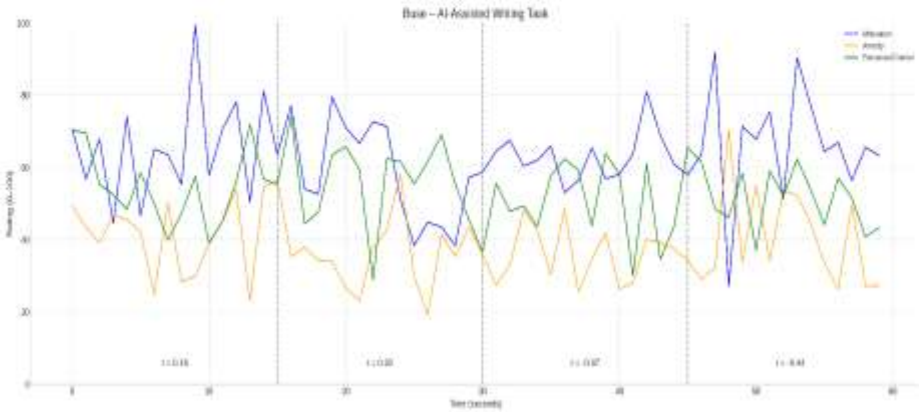

Figure 2. Buse's motivation and anxiety over time (AI-Assisted writing task)

It is evident from the lens of Complex Dynamic System Theory (CDST) that Buse's system stabilized not in a single emotional state, but also reorganized dynamically, in response to both internal challenges and external support. Her graphs suggest that she is sensitive to the challenges of each moment, particularly if she has difficulty with a word or some uncertainty needs to be reestablished with the assistance of the AI. The changes in her graphs demonstrate that, under stress, an affective system is always in the midst of reorganization; in response to stress, an affective system may react in both reactive ways or in more resilient patterns of twisting organization.

Case 2: Ali (stable affective trajectory)

In contrast to Buse, Ali's emotional state remained consistent during both writing tasks. In the traditional session (Figure 3), his motivation remained high (around 80-85 /100), his anxiety was low (ranging from 15-25 /100), and his perceived control was high (ranging from 85-90/100). He referred to the task as being "smooth," and "under control," due to his planning, saying "I had written down my points beforehand and writing was just following the plan." His proactive efforts helped him remain emotionally stable.

Any emotional disruption was negligible, even with slight pause in thinking about the word choice around the 50 second mark. Motivation was slightly decreased (from 85 to 75), the anxiety was slightly increased (from 20 to 30), and perceived control dropped a few points (from 88 to 80); however, each returned back to baseline quickly. "I just looked at the word and moved on, so it really didn't bother me," he said. Overall, these small fluctuations were quick and manageable.

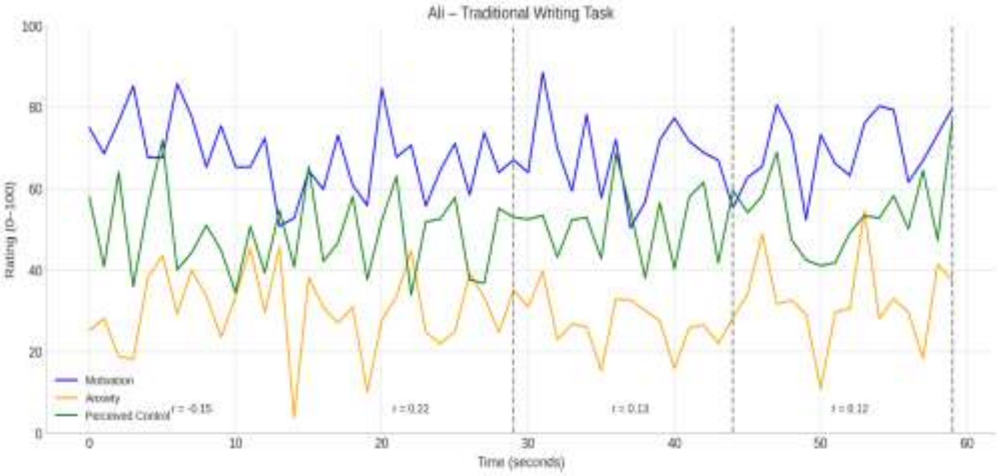

Figure 3. Ali’s motivation, anxiety and perceived control over time (traditional writing task)

Throughout the AI-aided writing journey, Ali’s emotional variables tracked fairly stable (Figure 4). He was mainly motivated and felt in control, but he was slightly anxious. His idiodynamic graph indicated merely small and temporary changes in those emotional variables indicating that his emotional state regained stability quickly and without intervention. During the initial section of the task, there was an inverse relationship: when motivation and control peaked, anxiety was at its lowest. As the writing task progressed, the tri-dimensional emotional variables behaved in a more positive correlation of movement, during which time small increases or decreases in motivation and perceived control would happen in concert, then anxiety was flat. Ali reported he had not interacted much with the AI platform, or the AI’s interface beyond the introductory tutorial, instead, the AI was described as a background, comforting mechanism rather than a mechanism of regulation. As Ali indicated just knowing the AI device was present was comforting which helped him feel confident and capable of retaining a competent yet pronounced sense of control. Ultimately, Ali’s trajectory path reflected an attractor that was indicative of a relative emotional resiliency, demonstrating that he had a strong sense of self-control in an environment where he was feeling highly competent and exerting significant amounts of control.

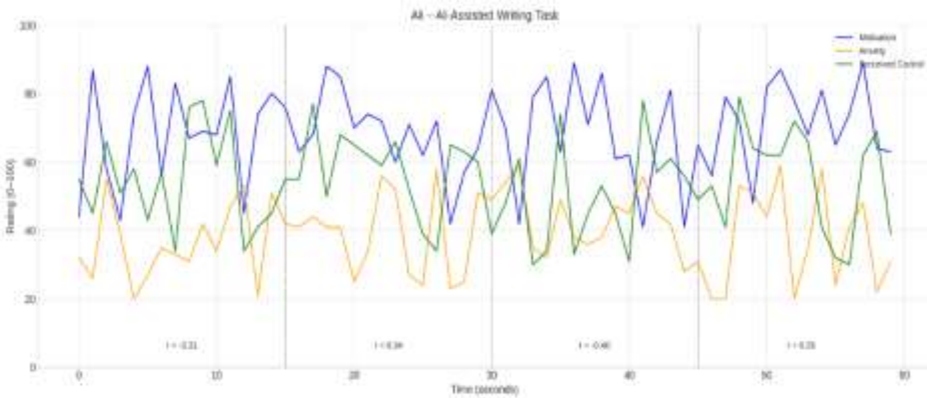

Figure 4. Ali’s motivation, anxiety and perceived control over time (AI-assisted writing task)

Conversely, Ali had virtually nothing to share during the stimulated recall, which illustrated how flat his affective curves were. From the perspective of a CDST, his system was located in an attractor of calm and volatility. Small perturbations (e.g., uncertainty about language), were quickly accommodated which demonstrated a strong resistance to change and self-regulation. Ali's affective trajectory can generally be categorized as low variability and high stability.

In summary, the results present two distinct kinds of affective trajectories. Buse's emotional experience traversed multiple attractor states, beginning with a 'confident writer', transitioning into a 'frustrated writer', and then finishing as a 'recovered writer' after receiving assistance. In contrast, Ali's trajectory remained securely within one attractor (the 'assured writer') defined by limited change and overall stability.

Most notably, perceived control is a key affective point in the two trajectories. When Buse was struggling with the thinking process, her perceived control dropped significantly, but as soon as the AI interacted with her, her perceived control significantly increased. Ali's perceived control was consistently high throughout both tasks, indicating that he was stable on the inside and had planned in advance for the tasks. The results align with CDST's perspective that affective systems organize and re-organize autonomously, depending, at least in part, on the requirements of the task, as well as a learner's characteristics and any external support.

AI had disparate effects on each participant. For Buse, AI was an adaptive tool that allowed her to move on from her anxiety; contrastingly, Ali utilized AI as a preventative scaffold that kept him stable. Overall, these illustrative findings suggest that individual affective profiles can influence unique dynamic responses to the same tasks, and that AI tools can serve as both emotional and cognitive transitional tools.

Discussion

The findings of this study demonstrate that learners' anxiety, motivation, and perceived control evolved as dynamically interacting subsystems rather than as independent affective variables during L2 writing. From a CDST perspective, these constructs formed recursive feedback loops in which fluctuations in one subsystem triggered adjustments in the others over time (Chang & Zhang, 2021; Tian et al., 2025; Xie, 2025). What is particularly important is not only that affective variability occurred, but why it emerged differently across the two learners. The contrasting trajectories observed in Ali and Buse suggest that affective responses to writing tasks were shaped by differences in perceived coping capacity, task appraisal, and access to internal regulatory resources.

This interpretation aligns with Pekrun (2024) control-value theory, which identifies perceived control as a key antecedent of academic anxiety. However, the present findings extend this framework by demonstrating that perceived control operated differently depending on learners' affective profiles and regulatory readiness. For Buse, anxiety increased when linguistic uncertainty and time pressure exceeded her momentary coping capacity, leading to reductions in perceived control and subsequent instability in motivation. In contrast, Ali maintained relatively stable levels of perceived control even when encountering difficulty, suggesting that his prior writing confidence and familiarity with academic tasks functioned as protective regulatory resources. In this sense, the difference between the two learners was not simply one of anxiety level, but of how task demands were interpreted and managed within their evolving affective systems. AI support therefore became particularly consequential for Buse because it functioned as an external scaffold during moments when her internal control weakened, whereas for Ali it primarily reinforced an already stable regulatory structure.

The findings further indicate that self-regulation in AI-assisted writing environments emerges from the interaction between learner-internal resources and situational scaffolding rather than from technological support alone. Learners' prior proficiency, familiarity with timed writing, and affective resilience interacted differently with AI-mediated assistance. Ali appeared able to rely primarily on internal regulatory resources when AI was absent, suggesting that his emotional stability was anchored in an already coherent self-regulatory system. By contrast, Buse relied more visibly on AI as a temporary stabilizing mechanism that helped restore perceived control during moments of uncertainty. This interpretation is consistent with previous research showing that AI-mediated feedback can reduce evaluative pressure and support emotional engagement by providing immediate and non-judgmental assistance during writing (Khasawneh & Belton, 2025; Mohammed & Khalid, 2025; Sun et al., 2025). At the same time, the present findings also resonate with cautionary claims that AI does not independently generate learner agency, but instead amplifies existing regulatory capacities depending on how learners mobilize available support resources (Achuthan, 2025; M. Li & Wilson, 2025; Nguyen & Doan, 2025). For this reason, AI is better understood not as the source of control, but as a context-sensitive amplifier of perceived control operating within a broader system of learner agency.

From a CDST perspective, the trajectories observed in this study illustrate how affective variables co-evolve through recursive feedback processes during writing. In Buse's case, fluctuations were frequently triggered when linguistic uncertainty, time pressure, or self-monitoring demands exceeded her available coping resources. Under these conditions, perceived control declined first, anxiety increased rapidly, and motivation became unstable. This sequence suggests that her affective system was particularly sensitive to disruption and therefore more dependent on contextual scaffolding for stabilization. By contrast, Ali's trajectory remained comparatively stable because momentary writing difficulties did not appear to threaten his underlying sense of competence. His prior confidence and tolerance for difficulty likely buffered the destabilizing effects of task-related challenges, allowing him to maintain relatively consistent levels of control and motivation. These findings extend previous CDST-informed research by demonstrating that emotional variability in writing depends not only on task conditions but also on learners' evolving interpretations of those conditions in real time (Foley & Melese, 2025; Siegel & Seedhouse, 2025; Tan et al., 2021).

The role of feedback as a stabilizing or destabilizing force within affective systems provides additional insight into these trajectories. MacIntyre and Ducker (2022) argue that feedback may interrupt or reinforce emotional loops depending on how it enters the learner's dynamic regulatory system. The present findings support this claim by showing that AI-mediated feedback functioned differently across learners. For Buse, AI support acted as a restorative intervention at moments of instability, helping interrupt anxiety escalation and re-establish a workable sense of control. For Ali, however, AI did not substantially alter the trajectory of his emotional system, but instead confirmed and slightly reinforced an already stable pattern of self-regulation. In this respect, AI functioned less as a corrective mechanism and more as a confirmatory resource.

The concept of attractor states further clarifies these differences. Buse's movement across states such as "optimistic writer," "overwhelmed writer," and "recovered writer" reflects a system characterized by repeated transitions between destabilization and reorganization. These transitions were not random but structured around recurring interactions between internal appraisal processes and external scaffolding. Ali's trajectory, by contrast, remained close to a relatively stable "assured writer" attractor with minimal deviation across conditions. This pattern is consistent with Wirtz and Pfenninger (2025) description of high-stability developmental trajectories in L2 affective systems. At the same time, the present findings refine earlier claims by demonstrating that stability itself may emerge from alignment among proficiency, confidence, and regulatory resilience rather than from fixed personality traits alone. AI did not eliminate these differences between learners; instead, it interacted with them, amplifying stability for one learner while facilitating recovery for the other.

Taken together, these findings provide further theoretical support for the application of CDST to the study of affective dynamics in L2 writing. Group-level or cross-sectional approaches are unlikely to capture the micro-level feedback processes through which emotions evolve during task performance. By integrating CDST with the idiodynamic method, the present study was able to trace not only whether anxiety, motivation, and perceived control changed, but also how and why these changes emerged over time and across conditions. The findings therefore support a view of affective self-regulation in L2 writing as a system-level phenomenon emerging from the interaction of cognitive, emotional, and technological subsystems. Within this system, AI may function as a co-regulator of affective experience, but its regulatory value depends on learners' readiness, vulnerability, and access to complementary internal resources.

Finally, these results contribute to a growing body of research suggesting that generative AI should not be conceptualized solely as a linguistic support tool in L2 writing, but as part of a broader affective–cognitive ecology of learning. Rather than uniformly improving writing experiences, AI appears to interact selectively with learners' existing regulatory systems, strengthening stability for some learners while supporting recovery for others. Understanding this variability is essential for designing pedagogical environments in which AI functions not merely as a corrective instrument, but as an adaptive scaffold aligned with learners' moment-to-moment affective needs.

Implications for pedagogy

The findings of this study offer useful implications regarding teaching practices; design of tutoring systems; and theoretical investigations in teaching a second language. One key finding suggests the necessity of maintaining perceived control of emotions while engaging in cognitive overload. Learners' ability to self-regulate worry and motivation were closely tied to their immediate perceptions of control, which was rarely stable and shifted in significant ways throughout the writing process (Hwang, 2025; Pibooltaew & Chantarakamol, 2025).

These insights suggest that adaptive systems will ultimately need to be capable of detecting and responding to affective change in real-time in AI-supported learning contexts. Instead of employing a one-size-fits-all scaffolding approach, intelligent tutors should vary the support they provide for the emotional profile and state of the learner. For example, learners with reactive emotional profiles, like Buse, benefit from supportive scaffolding that immediately targeted affective perturbations as they were occurring. Learners with more stable trajectories, like Ali, would benefit from support expressed in the form of useful (proactive) reassurance techniques prior to, or leading up to, challenges (Modak et al., 2023; Schweighart et al., 2024; Tsekouropoulos et al., 2025).

Investigating students' perceived control with regards to writing or any other language production tasks could benefit human teachers as well. Teaching practices that are mindful of cues for emotional difficulties and can attend to those needs may be more effective than strict, uniform practice. For instance, teachers can identify indications of declines in perceived ownership by utilizing things such as teacher check-ins and in-the-moment self-assessments. In this regard, individualised approaches such as cognitive re-framing, encouragement, and even explicit instruction on strategies may support the restoration of an emotional equilibrium and aid in preventing even further reductions in both motivation and performance (Brockbank & Feldon, 2024; Monazam-Tabrizi et al., 2026). Additionally, encouraging sustainable self-regulation is dependent on more than just technology. Pedagogical strategies that embed AI feedback and metacognitive reflection, for example in mindfulness or emotional awareness, might enhance learners' long-term self-regulatory capability. Teachers may formatively use AI, not only as a source of feedback, but as a mirror for discussing emotional strategies that help students navigate how they then regain control after moments of disorganization. In this way, this holistic approach embeds AI into a wider emotional ecology of learning.

The results also shed light on the ways that educational technology should be designed to be responsive to emotions. More resilient learning experiences can be created with AI systems that can perceive emotional cues and modify their behavior according to emotional input. Together with acting as language scaffolding, these systems may also work as co-regulators of emotion, improving perceived control and lowering anxiety levels by providing proactive reassurance or adaptive support. Deeper engagement and better learning results can be achieved when these technologies are matched with the needs of the students (Balalle, 2024; Cabalbag, 2025; Heilporn et al., 2025).

Conclusion

This study advances research on L2 writing by demonstrating that learners' emotions during writing are best understood as dynamic, self-organizing systems in which perceived control plays a central regulatory role. Using a CDST-informed, idiodynamic approach, we showed that affective trajectories differed markedly across learner profiles and task conditions: the anxious writer exhibited pronounced volatility in motivation and anxiety when perceived control weakened, whereas AI mediation helped stabilize these fluctuations by providing timely linguistic and strategic support; in contrast, the confident writer maintained a comparatively stable affective pattern and used AI primarily as reassurance. These findings position generative AI not merely as a feedback tool but as a potential affective co-regulator whose impact is contingent on learners' momentary needs and baseline profiles. Pedagogically, AI-enhanced writing environments should prioritize adaptive scaffolding that supports learners' perceived control and fosters sustainable self-regulation rather than dependence. Given the idiographic scope and small sample, future research should extend these analyses across larger and more diverse cohorts, writing genres, and AI interfaces, ideally through longitudinal designs and multimodal measures to triangulate affective change during extended drafting and revision processes.

This study has several limitations that should be considered when interpreting the findings. First, the analysis was based on two contrasting Turkish EFL learners from the same institution, which provides rich idiographic insight into within-person affective dynamics but necessarily limits statistical generalizability to broader L2 populations and instructional contexts. Second, the idiodynamic ratings relied on self-report and may reflect subjective interpretation of the scales, while the stimulated recall procedure although anchored to specific time points remains retrospective and thus vulnerable to memory and rationalization biases. Third, the writing tasks were brief, timed, and focused on first-draft production in a controlled setting; therefore, the observed affective trajectories may differ in authentic classroom writing where drafting, revision, peer interaction, assessment pressure, and extended time-on-task are salient. Finally, the AI-assisted condition used a single GPT-based interface and did not experimentally manipulate the type, timing, or intensity of feedback, so the affective effects reported here may not transfer to other tools or alternative feedback designs. Future research should replicate these procedures with larger and more diverse samples, longitudinal and classroom-based writing cycles, and triangulated measures (e.g., keystroke logging, eye-tracking, physiological indices) to strengthen validity and identify which AI features most consistently support perceived control and adaptive affect regulation.

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