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Teaching practices mediating the effect of teachers' psychological stress, and not physiological on their visual focus of attention

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The aim of the present study was to investigate the association between teachers' ($N = 53$) physiological and psychological stress and their visual focus of attention as well as the mediating effect of teaching practices on this association in authentic classroom settings. Data were collected using multimodal methods of measurement: salivary cortisol levels for physiological stress, a self-reported questionnaire for psychological stress, observed teaching practices during one school day, and eye-tracking video recordings of classroom teachers during one lesson for teachers' visual focus of attention. The results showed that neither teachers' physiological nor psychological stress was directly related to their visual focus of attention. However, using more child-centered teaching practices compared with teacher-directed ones was related to a higher number of fixations on students, longer total fixation duration, and more individualized distribution of visual focus of attention on students. Teacher's teaching practices mediated the effect of teachers' psychological stress on their fixation counts on students and distribution of visual focus of attention. The results suggest that teaching practices are related to the visual attention teachers' give to students and that teachers' stress affects their visual focus of attention through teaching practices. The practical implications of this study suggest that teachers should receive training and support to recognize their stress level and its association with their teaching.

KEYWORDS

teacher stress, teaching practices, teacher visual focus of attention, cortisol, eye-tracking, Grade 1

1 Introduction

Teachers need to manage several unpredictable classroom situations and the demands arising from them during the school day. Accordingly, teachers need to give immediate visual focus of attention and interact with students involved in these situations to assess their learning-related needs and behaviors. It has been reported that teachers' perceptions of their work-related stress are linked to the way they interact with students. For instance, when teachers are highly stressed, they tend to offer less emotional support to students and show lower quality of classroom organization (Penttinen et al., 2020). They also give less individualized visual focus of attention to the students (Chaudhuri et al., 2022a). Furthermore, teachers who report

experiencing less stress tend to give more attention to students' individual learning experiences, respond more to students' needs, and use less reactive classroom management strategies (Clunies-Ross et al., 2008; Turner and Thielking, 2019).

Unpredictable situations often occur during teaching in authentic classroom settings and it might be demanding for teachers to give immediate visual focus of attention to students in order to notice relevant information and monitor moment-to-moment changes in students' learning-related behaviors (Van den Bogert et al., 2014). Accordingly, teachers need to adjust their teaching practices and provide adaptive pedagogical support based on the needs of their students (Seidel et al., 2021). However, we are far from understanding how teachers' stress is related to their teaching practices and classroom behavior toward students. Previously, laboratory-based studies have shown that relationships exist between stress and cognition, and visual gaze behavior and stress. For instance, Buchanan et al. (2006), argued that physiological stress can negatively influence cognition in terms of memory responses in a word recall test. In addition, Vatheuer et al. (2021) argued that an individual typically shows visual gaze avoidance during a strong cortisol response in socially stressful situations. The researchers of the mentioned study have warranted the use of eye-tracking to detect the effects of stress on social interaction situations.

Similarly, teaching involves social interactions between teachers and students whereby the teacher must encourage student's participation, manage challenging student behaviors, and monitor academic developments among other social activities in authentic classroom settings. Previous research has shown that teachers' high work-related stress is associated with less individualized visual focus of attention on students in authentic classroom settings (Chaudhuri et al., 2022a). In addition, Jõgi et al. (2023a) showed that there were no relationships between physiological stress and positive affect in authentic classroom settings. However, teachers' self-efficacy beliefs were related to lower stress and higher positive affect in the middle of the school day. Furthermore, Jõgi et al. (2023b) showed that teachers' physiological stress did not have an effect on teachers' teaching practices or student's learning outcomes. However, Jõgi et al. (2023b) argued that teachers with lower self-reported stress used relatively more child-centered teaching practices than teacher-directed ones. The present study is different from the previously conducted studies as we are investigating how teachers' psychological (self-reported) and physiological (cortisol levels) stress in the classroom are related to teachers' visual focus of attention in authentic classroom settings and whether teacher's teaching practices mediate this association.

1.1 Teachers' stress

Teaching is a stressful occupation due to high pressure and many demands, novel tasks, and recurring problems which need to be solved in the classroom (Johnson et al., 2005; Broughton, 2010). Many teachers experience the feeling that they do not have enough time and resources to do their work the way they want to (Aulén et al., 2021). In addition, disruptive student behaviors (Clunies-Ross et al., 2008) or less supportive leadership cause strain in the teaching environment (Skaalvik and Skaalvik, 2009). Therefore, teachers typically report higher levels of stress than many other professionals (Aloe et al., 2014; Herman et al., 2020). Stress is harmful, as higher stress is linked to greater burnout (e.g., Pogere et al., 2019) and higher turnover intentions among teachers (Skaalvik and Skaalvik, 2011; Madigan and Kim, 2021). Furthermore, stressed teachers also use fewer child-centered teaching practices in the classroom (Jõgi et al., 2023b) and have poorer relationships with their students (Aldrup et al., 2018). However, less is known about how teacher stress and teaching practices are associated with their visual focus of attention while teaching.

Teacher stress can be categorized as a subjective experience (psychological stress) or a physiological stress. The latter can be objectively assessed while the former, which is often based on self-ratings, is a subjective evaluation of challenges in the teaching environment and an individual's abilities to cope with these (Schlotz, 2019; Becker et al., 2022). In the present study, teachers' physiological stress was measured by salivary cortisol, the most suitable way to collect cortisol samples non-invasively in ambulatory settings. Cortisol is released in the body through the hypothalamic–pituitary–adrenal axis when a person gets into a stressful situation and the sympathetic nervous system is activated (Kudielka et al., 2012). Higher daytime cortisol levels are characteristic of people under chronic stress (Miller et al., 2007) and can be a risk factor for several psychological and physiological malfunctions, for example, increased anxiety or suppression of the immune system (Chrousus, 2009). Recent research results suggest that self-reported stress and physiological stress are two different facets of stress that might not be correlated (Katz et al., 2016; Becker et al., 2022). Therefore, in the current study, both indicators of stress were investigated to obtain a more complete picture of teachers' stress-related experiences at work—including both the physiological and psychological measures of stress.

1.2 Teaching practices

The development of primary school students' academic skills and motivation depend on practices their teachers choose to use (Lerkkanen et al., 2012, 2016; Kikas et al., 2018; Pakarinen and Kikas, 2019; Tang et al., 2022). Teachers differ in terms of the teaching practices they deploy in the classroom (Lerkkanen et al., 2016; Tang et al., 2017; Kikas et al., 2018). A common theoretical framework for studying teaching practices is treating them as child-centered and teacher-directed ones, which have roots in constructivism and behaviorism, respectively (Daniels and Shumow, 2003; Stipek and Byler, 2004). Child-centered teaching practices emphasize children's active participation, addressing children's needs, interests, and initiatives, and teacher's active scaffolding of children's learning. Teachers using teacher-directed practices typically give the same instruction and tasks to all students and emphasize correct answers rather than the learning process (Stipek and Byler, 2004). In practice, most teachers employ both child-centered and teacher-directed practices depending on the goal of learning task, but teachers differ in the ratio of using one or another (Daniels and Shumow, 2003). Subsequently, during teaching, teachers' visual focus of attention toward students in the classroom can vary based on student- related factors such students' basic academic skills, individual support for students in basic academic skills, and students' behavior toward the teacher (Goldberg et al., 2021; Chaudhuri et al., 2022b). Although several studies have examined the role of teaching practices in student outcomes, less is known how teaching practices are associated with

teachers' visual focus of attention while teaching. It is noteworthy that although both teaching practices and teachers' visual focus of attention are measured from authentic classroom settings, yet, they are two different constructs. Teaching practices measure the ratio of child-centered versus teacher-directed practices based on the learning task whereas teachers' visual focus of attention measures teachers' classroom behavior in terms of duration of visual gaze toward students during teaching.

1.3 Teacher visual focus of attention

Teacher visual focus of attention has been defined as the teacher's gaze on relevant targets in the classroom, such as students, to process information related to their learning and behavior during teaching in authentic classroom settings (van den Bogert et al., 2014). The classroom is an information-dense environment in which multiple unforeseen situations arise that require the teacher's immediate visual attention. Despite the unforeseen demands in the classroom environment, teachers need to notice students in order to assess their learning-related behaviors and adjust their instruction accordingly (Jarodzka et al., 2021).

Previous research has shown that all students in a classroom receive the teacher's visual attention; however, the amount of it varies (Dessus et al., 2016). There are many student-related factors, such as academic skill levels and classroom behavior, that can determine the amount of teacher visual focus of attention toward students. For instance, teachers direct a longer visual focus of attention to students with poor basic academic skill levels in order to provide more individual and adaptive pedagogical support to the students (Seidel et al., 2021; Chaudhuri et al., 2022b). Furthermore, teachers direct longer visual focus of attention to students showing more interactive, disruptive, and off-task behavior during a lesson (Yamamoto and Imai-Matsumura, 2013; Goldberg et al., 2021; Shinoda et al., 2021). In addition, teacher-related factors, such as perceived stress at work, can affect their visual focus of attention in the classroom. For example, higher teachers' stress in terms of their perceived inadequacy is associated with less individualized visual focus of attention on students in the classroom (Chaudhuri et al., 2022a). In summary, there is evidence that teachers' perception of stress can be related to their classroom behavior in terms of visual focus of attention on students. However, little is known about the way teachers' physiological and psychological stress are related to teachers' visual focus of attention through their teaching practices.

1.4 Aim of the study

We expand on the previous findings by addressing three important issues. First, we are far from understanding how teachers' physiological and psychological stresses are related to the way they allocate their visual focus of attention in the classroom. Second, the role that teaching practices play in teachers' visual focus of attention has been less investigated. Third, it is unclear whether teaching practices mediate the association between teachers' stress and visual focus of attention. We used multimodal data collection methods to increase the ecological validity strongly recommended in teachers' well-being research (Francis et al., 2017; Hascher and Waber, 2021). Our theoretical model is presented in Figure 1, and our specific research questions (RQ) and hypotheses (H) are the following:

RQ1: To what extent are teachers' physiological and psychological stresses related to their visual focus of attention in the classroom?

H1: We expected that higher physiological and psychological stress would be related to less individualized distribution of visual focus of attention and fewer attention fixations on students (Chaudhuri et al., 2022a).

RQ2: To what extent are teachers' teaching practices related to their visual focus of attention in the classroom?

H2: We expected that using more child-centered practices compared with teacher-directed ones is related to more individualized distribution of visual focus of attention and more fixations on students (Goldberg et al., 2021; Seidel et al., 2021).

RQ3: Do teaching practices mediate the effect of teachers' stress on their visual focus of attention?

H3: We expected that teachers' higher physiological and psychological stress would be related to their visual focus of attention in the classroom through employing less child-centered teaching practices compared with teacher-directed ones (Chaudhuri et al., 2022a; Jõgi et al., 2023b).

2 Methods

2.1 Participants

In the present study, 53 teachers (3 males) teaching Grade 1 from 31 schools and seven municipalities of Central Finland located in both rural and urban areas participated. The teachers reported their work experience in years ($M_{exp} = 16.07$, $SD = 9.43$, $Min_{exp} = 0.5$, $Max_{exp} = 39$) and their class size ($M_{cs} = 19.3$, $SD = 4.34$, $Min_{cs} = 7$, $Max_{cs} = 25$). The data used in the study were part of a larger project that focused on the role of teacher and student stress on teacher–student interactions in

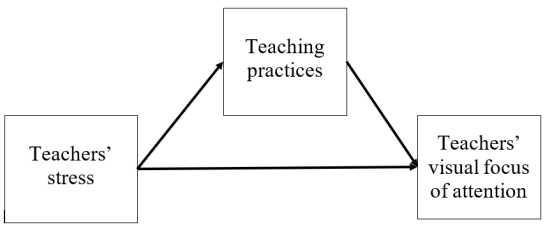

FIGURE 1
Theoretical model hypothesized in the study.

the classroom (Lerkkanen and Pakarinen, 2021). The study was approved by the university ethics committee before the data collection began, and it was determined to be in line with the Finnish National Board on Research Integrity (TENK, 2012). Teachers were informed that participation in the study was voluntary. Teachers, as well as their students' parents, gave written consent for their participation prior to data collection.

2.2 Measures

2.2.1 Teachers' physiological stress

We used saliva cortisol as teachers' physiological stress indicator. Teachers were asked to give six saliva samples during two working days: at awakening, 30 and 45 min after awakening, at 10:00 a.m., at the end of the school day at approximately 12:00–1:00 p.m., and before bedtime. Salivette® Cortisol swabs (Sarstedt, Nümbrecht, Germany) were used for collecting saliva samples. Samples were assayed by Cortisol Luminescence Immunoassay (CLIA RE62011; IBL International Corp.) in Dresden LabService GmbH, Germany. According to our protocol, a cortisol sample was excluded if the teacher had eaten within 30 min before sampling or had been ill on the sampling day. We also excluded cortisol samples with concentrations larger than 73 nmoL/L as physiologically implausible (Miller et al., 2013).

In the current study, we used samples from two time points during or after the lessons, at 10:00 a.m. and at approximately 12:00–1:00 p.m. For both samples, cortisol levels from two sampling days were averaged (Wolf et al., 2008; Massey et al., 2016). Higher cortisol levels have been interpreted as indicating higher physiological stress (Miller et al., 2007; Berry et al., 2014).

2.2.2 Teachers' psychological stress

An adapted version of Gerris's Parental Stress Inventory (Gerris et al., 1993; Pakarinen et al., 2010) was used to measure teachers' teaching-related psychological stress. The self-reported questionnaire consisted of three items about teaching-related stress (e.g., "I have a lot more problems in guiding the children than I expected."; "I often feel guilty or inadequate when thinking about what kind of teacher I am." and "I sometimes feel that guiding children is an overwhelming task for me."; Cronbach's alpha = 0.76.) which were rated on a 5-point Likert scale (1 = "Does not apply to me at all" and 5 = "Applies to me very well"). The average score of the three items was calculated and used as a psychological stress indicator.

2.2.3 Teachers' teaching practices

Teaching practices were measured using the Early Childhood Classroom Observation Measure (ECCOM; Stipek and Byler, 2004; Tang et al., 2017). Teachers employing child-centered and teacher-directed practices in their classrooms were rated by trained research assistants from three video-recorded lessons of 45 min from one school day. The dimensions of teaching practices were assessed based on three subscales: classroom management (4 items), classroom climate (4 items), and instruction (7 items), rated on a 5-point scale (see Appendix 1 for table showing description of subscales). The scale points on each of these items show the percentage of instructional time teacher used child-centered or teacher-directed teaching practices (1 = '0–20%' of time, 5 = '81–100%' of time). The mean of all items from all the three sub-scales were used to estimate child-centered and teacher-directed practices (see also Tang et al., 2017). Previous research has shown that teachers employ child-centered and teacher-directed practices during teaching, however, one of these practices are typically dominating (Daniels and Shumow, 2003; Stipek and Byler, 2004). Since child-centered and teacher-directed practices often show strong negative correlation such as $r = -0.89$ in the present study sample, these dimensions cannot be added as individual observed variables in the same statistical model due to multicollinearity. Accordingly, in the present study, the ratio of child-centered to teacher-directed practices was used in the analysis (see also Lerkkanen et al., 2012; Roubinov et al., 2020). A ratio score more than 1 indicated that the teacher implemented more child-centered practices whereas a ratio score of less than one meant that the teacher implemented more teacher-directed practices during teaching (Roubinov et al., 2020; Jõgi et al., 2023b). The inter-rater reliability was assessed based on 11 observations that were observed by two observers. There was good agreement between observers (intraclass correlation coefficient ICC[1] = 0.88 for child-centered practices and ICC[1] = 0.79 for teacher-directed practices). For further analyses, one out of the two observations was randomly chosen for each teacher. The mean of all items from all the three sub-scales were used to estimate child-centered and teacher-directed practices (Tang et al., 2017).

2.2.4 Teachers' visual focus of attention

Teachers' visual focus of attention was measured using mobile eye-tracking technology. Teachers wore Tobii Pro Glasses 2 (Tobii AB, Danderyd, Sweden) for 20–25 min from the beginning of the second lesson of a normal school day. The authentic classroom setting during the eye-tracking video recording was ensured by giving the teachers freedom to conduct the lesson the way they wanted. The teachers' eye-tracking videos were recorded during 20 literacy lessons, 26 math lessons, and four activity-based lessons. Furthermore, two trained research assistants calibrated the eye-tracking glasses using a one-point calibration before recording the eye-tracking videos. Thereafter, to ensure good data quality, the calibration was rechecked and validated by asking the teacher to look at three points on the wall. Only after successful calibration did the research assistants start the eye-tracking recording. After the eye-tracking videos were recorded, the fixations were filtered from the video recordings using the I-VT Attention filter setting of the Tobii Pro Lab v.1.128 analysis software. The I-VT Attention filter was best suited for identifying fixation metrics, as the participant's physical movements were not restricted while recording the eye-tracking videos. Each teacher's visual focus of attention was determined based on their areas of interest (AOIs) in the classroom. The AOIs were defined as the targets that the teacher looked at in the eye-tracking videos, such as students, instructional materials (such as those related to teaching and learning), and non-instructional materials (such as walls, curtains, tables, chairs, etc.). AOI codes have been previously determined and used in prior research (see Chaudhuri et al., 2022a,b). Furthermore, trained research assistants mapped fixations on the AOIs identified from eye-tracking video recordings using the Tobii Pro Lab v.1.128 software, based on where the teacher focused their visual attention. For example, teachers' gaze on an individual student was shown by a red circle on the video; then, the research assistant manually

mapped the gaze on the respective student's picture and identified it as the teacher's AOI.

To ensure intercoder reliability, double coding was done with 20% of the videos from the whole dataset, which provided a double coding agreement average of 90.09%. Once the eye-tracking video recordings were coded, further analysis was conducted using the teachers' visual focus of attention in terms of the teachers' total fixation duration on students and fixation counts on students. Furthermore, to ensure good quality data, eye-tracking video recordings with a gaze sample percentage of 70% and above were selected. The gaze sample percentage is defined as the total percentage of the recording duration when one or both eyes are detected by mobile eye-tracking glasses. Accordingly, three videos from the present dataset had to be excluded due to a gaze sample percentage lower than 70%. The values of total fixation duration greater than 3 *SD* were excluded from the further analyses as outliers ($n = 2$).

2.3 Procedure

These questionnaires were given to the teachers on the same day they were instructed about the salivary cortisol sampling. The teachers filled out the questionnaires in their preferred time. Teaching practices were video-recorded on the first salivary cortisol sampling day by trained research assistants. Typically, on the same day as the video recording, the eye-tracking videos were recorded during the second lesson of the school day.

2.4 Analysis strategy

In the present study, fixation was defined as the time when the eye was relatively still and took input from the environment for information processing (Holmqvist et al., 2015). Accordingly, teachers' fixation metrics, such as total fixation durations and fixation counts, were considered as indicators of teachers' visual focus of attention and used for further analysis. Teachers' total fixation duration can be defined as the duration of time during eye tracking when the eye is relatively still and provides the ability to process information from the targets in the classroom environment (van den Bogert et al., 2014; McIntyre et al., 2017; Goldberg et al., 2021; Seidel et al., 2021). Additionally, fixation counts can be defined as the total number of times fixations occur in an AOI (such as students) in a given time period during an eye-tracking recording (Holmqvist et al., 2015). Next, in order to estimate teachers' distribution of visual attention among students, teachers' total fixation duration on students was used to calculate the Gini coefficient using the Gini package in R (Zhicheng et al., 2021). The Gini coefficient ranged from 0 to 1, wherein 0 referred to an equally distributed visual focus of attention on all students and 1 referred to an unequal distribution, wherein only one student received all the visual focus of attention (Cortina et al., 2015). In the classroom context, high teachers' total fixation duration and fixation counts on a student typically indicate that the teacher is processing information related to student characteristics (Seidel et al., 2021). According to Cortina et al. (2015), the high number of fixation counts on a student can typically occur when a teacher engages in providing feedback to an individual student.

Descriptive statistics and bivariate correlations were estimated using IBM SPSS 28.0 (IBM, Armonk, NY, USA). Path analyses with mediation were modeled using MPlus 8.8 (Muthén and Muthén, 1998–2022). Missing data was managed through a full information maximum likelihood (FIML) procedure that allows the inclusion of all available data into the model estimation.

In total, we conducted nine path analyses with regression. For each of three dependent variables of visual focus of attention (Gini coefficient, total fixation duration, fixation counts), we tested three path models with each of three stress indicators (psychological stress, cortisol at 10:00 a.m., cortisol at 12:00–1:00 p.m.) and teaching practices as independent variables. In all nine models, the direct paths from stress and teaching practices to the visual focus of attention indicator were estimated, and the indirect path from stress through teaching practices to attention was modeled. All nine models were identified with zero degrees of freedom and a perfect fit (Raykov et al., 2013).

3 Results

3.1 Bivariate associations between teachers' psychological and physiological stress, teaching practices, and visual focus of attention

The descriptive statistics of the study variables are indicated in Table 1. The bivariate correlations are shown in Table 2. The higher salivary cortisol levels of teachers at 10:00 a.m. were related to their higher cortisol levels at 12:00–1:00 p.m. All three visual focus of attention indicators also correlated in the expected directions. A higher Gini coefficient was related to shorter total fixation duration

TABLE 1 Descriptive statistics of stress, teaching practices, and visual focus of attention.

Indicator	*N*	*M*	*SD*	Min	Max
Psychological stress	52	2.16	0.74	1.00	4.00
Physiological stress					
Cortisol at 10:00 a.m. (nmol/l)[a]	53	2.29	0.55	1.20	4.24
Cortisol at 12:00–1:00 p.m. (nmol/l)[a]	53	2.15	0.45	1.10	3.48
Teaching practices[b]	53	1.33	0.76	0.30	3.70
Visual focus of attention					
Gini coefficient[c]	49	0.51	0.11	0.29	0.76
Total fixation duration (ms)	48	24,935.09	8,117.45	10,629.19	45,437.40
Fixation counts	50	61.65	23.57	27.64	134.00

[a]Cortisol concentrations are natural logarithm transformed and aggregated over two sampling days. [b]Ratio of child-centered practices to teacher-directed ones. [c]Distribution of teachers' visual focus of attention.

TABLE 2 Bivariate correlations between used indicators.

Indicator	1	2	3	4	5	6
1. *Psychological stress*	–					
Physiological stress 2. Cortisol at 10:00 a.m. (nmol/l)[a]	−0.01	–				
3. Cortisol at 12:00–1:00 p.m. (nmol/l) [a]	0.13	0.52***	–			
4. Teaching practices[b]	−0.43**	−0.05	−0.02	–		
Visual focus of attention 5. Gini coefficient[c]	0.12	0.15	−0.06	0.12	–	
6. Total fixation duration	−0.11	−0.20	0.03	−0.11	−0.57***	–
7. Fixation counts	−0.13	−0.13	−0.06	−0.13	−0.48***	0.60***

[a]Cortisol concentrations are natural logarithm transformed and aggregated over two sampling days. [b]Ratio of child-centered practices to teacher-directed ones. [c]Distribution of teachers' visual focus of attention. **$p < 0.01$, ***$p < 0.001$.

TABLE 3 Regression model showing direct and indirect effects with variables such as cortisol at 10:00 am, visual focus of attention, and teaching practices.

	Visual focus of attention indicator					
	Gini coefficient[c] $R^2 = 0.12$		Total fixation duration $R^2 = 0.06$		Fixation counts $R^2 = 0.16$	
	β	*p*	*β*	*p*	*β*	*p*
Direct effects on visual focus of attention						
Cortisol at 10:00 a.m.[a]	0.10	0.282	**−0.16**	**0.029**	−0.09	0.329
Teaching practices[b]	**−0.33**	**0.001**	0.18	0.212	**0.39**	**<0.001**
Direct effect of cortisol on Teaching practices[b]	−0.04	0.713	−0.04	0.713	−0.04	0.710
Indirect effect of cortisol at 10:00 a.m. through Teaching practices	0.01	0.724	−0.01	0.735	−0.02	0.719

β, standardized regression coefficient. *p*, value of *p*. [a]Cortisol concentrations are natural logarithm transformed and aggregated over two sampling days. [b]Teaching practices-ratio child-centered teaching practices (CC) compared with teacher-directed practices (TD). [c]Distribution of teachers' visual focus of attention. Values in bold are significant.

and lesser fixation counts. A longer fixation duration was related to more fixation counts. However, no associations were found between teachers' psychological and physiological stress and teachers' visual focus of attention indicators.

Teachers' practices were related to their psychological stress, as teachers reporting lower stress used more child-centered practices in the classroom compared with teacher-directed ones. Teaching practices were not correlated with visual focus of attention indicators (Table 2).

3.2 Teaching practices mediating the association between teachers' psychological stress and visual focus of attention

Next, we tested nine separate regression models, in each of which one of three stress indicators explained one of three visual focus of attention indicators through teachers' teaching practices (see Tables 3–5). We found that neither teachers' psychological nor physiological stress was directly related to the teachers' visual focus of attention, except in one case. The higher the teachers' cortisol level in the middle of the school day, the less attention they paid to students in the classroom (β = −0.16, $p = 0.029$; see Table 3). There was a direct effect of teaching practices on the Gini coefficient (distribution of teacher visual focus of attention) and fixation counts. Teachers' use of more child-centered teaching practices compared with teacher-directed ones was related to the more individualized distribution of visual focus of attention (β-s = −0.33 … −0.36, $p = 0.001$ … 0.007) and a greater number of fixations or fixation counts on individual students (β-s = 0.39 … 0.46, $p < 0.001$; see Tables 3–5).

We also tested the indirect effect of teachers' stress on visual focus of attention through their teaching practices. We found an indirect effect of teacher's psychological stress on teachers' visual focus of attention through their practices (see Table 5). Teaching practices mediate the association between teachers' psychological stress and their distribution of visual attention ($\beta = 0.16$, $p = 0.034$) and number of fixations ($\beta = -0.21$, $p = 0.009$). However, there were no indirect effects of teachers' physiological stress on teachers' visual focus of attention (see Tables 3, 4).

TABLE 4 Regression model showing direct and indirect effects with variables such as cortisol at 12:00–1:00 p.m., visual focus of attention, and teaching practices.

	Visual focus of attention indicator					
	Gini coefficient[c] $R^2 = 0.12$		Total fixation duration $R^2 = 0.04$		Fixation counts $R^2 = 0.15$	
	β	*p*	*β*	*p*	*β*	*p*
Direct effects on focus of attention						
Cortisol at 12:00–1:00 p.m.[a]	−0.08	0.555	0.03	0.793	0.00	0.997
Teaching practices[b]	**−0.34**	**0.001**	0.19	0.197	**0.39**	**<0.001**
Direct effect of cortisol on Teaching practices[b]	−0.05	0.727	−0.05	0.727	−0.05	0.727
Indirect effect of cortisol at 12:00–1:00 p.m. through Teaching practices	−0.02	0.730	−0.01	0.716	−0.02	0.722

β, standardized regression coefficient. *p*, value of *p*. [a]Cortisol concentrations are natural logarithm transformed and aggregated over two sampling days. Teaching practices- ratio of child-centered teaching practices compared with teacher-directed practices. [c]Distribution of teachers' visual focus of attention. Values in bold are significant.

TABLE 5 Regression model showing direct and indirect effects with variables such as psychological stress, visual focus of attention, and teaching practices.

	Visual focus of attention indicator					
	Gini coefficient[b] $R^2 = 0.12$		Total fixation duration $R^2 = 0.04$		Fixation counts $R^2 = 0.17$	
	β	*p*	β	*p*	*β*	*p*
Direct effects on focus of attention						
Psychological stress	−0.05	0.745	−0.01	0.988	0.13	0.320
Teaching practices[a]	−0.36	0.007	0.20	0.193	**0.46**	**<0.001**
Direct effect of stress on Teaching practices[a]	**−0.45**	**<0.001**	**−0.45**	**<0.001**	**−0.45**	**<0.001**
Indirect effect of psychological stress through Teaching practices	0.16	0.034	−0.09	0.236	−0.21	0.009

β, standardized regression coefficient. *p*, value of *p*. [a]Ratio of child-centered teaching practices compared with teacher-directed practices. [b]Distribution of teachers' visual focus of attention. Values in bold are significant.

4 Discussion

The aim of the present study was to investigate whether teachers' physiological stress, psychological stress, and teaching practices are associated with teachers' visual focus of attention and whether teachers' teaching practices mediate the effect of teachers' stress on their visual focus of attention. The results indicated that teachers' use of more child-centered teaching practices compared with teacher-directed ones was related to more individualized distribution of visual focus of attention and a greater number of fixations on students while teaching. In addition, the teacher's cortisol levels at 10:00 a.m. had a small, direct negative effect on the amount of total fixation duration on students. Furthermore, there was an indirect effect of teachers' psychological stress on teachers' visual focus of attention through their teaching practices.

First, the association between teachers' physiological and psychological stress and its relationship with teachers' visual focus of attention were investigated. The results showed that most of the measures of teachers' stress were not associated with the teachers' visual focus of attention. In this regard, our results do not support the hypothesis expecting that higher physiological and psychological stress is related to less individualized distribution of visual focus of attention and fewer fixations on students. This issue needs further investigation.

Second, the association between teachers' teaching practices and their visual focus of attention was investigated. The results showed that the more teachers used child-centered teaching practices compared with teacher-directed ones, the more they individualized the distribution of visual focus of attention among students and the greater the number of fixations on students. Teachers using child-centered teaching practices emphasize children's active participation, address their needs, interests, and initiatives, and actively scaffold their learning. In this regard, student-related factors in the classroom play an important role in guiding teachers' visual focus of attention during child-centered teaching practices. For instance, teachers give longer durations of visual focus of attention to students showing disruptive or interactive behavior (Goldberg et al., 2021), increased hand-raising behavior to participate in discussions (Kosel et al., 2023), and poor performance in basic academic skills (Chaudhuri et al., 2022b). Therefore, our results supported the hypothesis expecting that teachers using more child-centered practices compared with teacher-directed ones is related to more individualized distribution of visual focus of attention and more fixations on students.

Third, the mediating effect of teachers' teaching practices on the association between teachers' stress and their visual focus of attention was investigated. The results showed that teachers' physiological stress, in terms of their higher cortisol levels at 10:00 a.m., had a small effect on their shorter total fixation duration on students. However, there was an indirect effect of teachers' psychological stress on their visual focus of attention (distribution of visual attention and fixation counts) through their teaching practices. In other words, on a positive note, less psychological stress was related to more child-centered teaching practices, which in turn was related to more individualized distribution of visual attention and more fixations on students. It is plausible that employing more child-centered teaching practices would involve increased teachers' visual attention on students to provide individual support in order to encourage their academic and social skills development (Chaudhuri et al., 2022b). However, on a negative note, high psychological stress could be related to more teacher-centered teaching practices, which in turn could be related to less visual focus of attention on students. This result is supported by previous research stating that teachers experiencing high levels of psychological stress tend to show low quality of classroom organization, offer less emotional support (Penttinen et al., 2020), and use less instructional dialogue to support students' higher-order thinking skills (Bottiani et al., 2019). Therefore, our results are in line with the hypothesis that teachers' higher physiological and psychological stress is related to their visual focus of attention in the classroom and resulting in employing less child-centered teaching practices compared with teacher-directed practices.

4.1 Practical implications of the study

Teachers need to be aware of their stress levels as they are linked to the teaching practices they use in the classroom which in turn link to their visual focus of attention to the students. For example, mobile eye-tracking technology can be used during in-service trainings to generate teacher's awareness of their visual focus of attention toward students. Previous research has shown that while watching their own teaching videos, teachers reflected more critically on their own teaching practices and suggested alternative teaching strategies (Keller et al., 2021; Muhonen et al., 2023).

4.2 Limitations and future research directions

The present study has some limitations. First, this study was cross-sectional in design. In the future, a longitudinal approach throughout the academic year could provide in-depth insights into issues that affect teacher's work-related stress, teaching practices, and visual focus of attention. Second, teachers' visual focus of attention was measured for the first 20–25 min of a lesson, whereas teaching practices were assessed based on three full lessons. In the future, it could be beneficial to record entire lessons in order to study the variation in teachers' visual focus of attention during the beginning, middle, and end of a lesson. Previous research has shown that teachers' visual focus of attention varies based on their pedagogical intentions. For example, teachers focus their attention more on task-related targets when giving instruction than while reflecting on tasks (Maatta et al., 2021). Third, student-related factors and classroom composition were not considered in the present study. It is possible that there are more contextual factors, such as students' academic skill levels (Chaudhuri et al., 2022b), that influence the relationships between teachers' stress, teaching practices, and teachers' visual focus of attention. Also, we ran separate regression models for each of three outcomes and each of three stress measures due to the small sample size and the risk of multicollinearity. However, this increases the chance of Type I errors. In the future, multilevel modeling approaches need to be used to investigate other physiological measures related to teachers such as anxiety, and emotional arousal in association with teacher's visual focus of attention thereby allowing the examination of teachers' intraindividual differences. Furthermore, it would be beneficial to investigate whether teachers' physiological and psychological stress, teaching practices, and teachers' visual focus of attention vary based on teachers' work experience, particularly, between novice and expert teachers. Lastly, majority of the sample in this study consisted of females and there was little representation of the male gender ($N = 3$). This could be considered as a limitation in understanding how teaching related stress, teaching practices, and teacher visual focus of attention could vary across teachers' genders.

5 Conclusion

The current study makes a unique contribution to the existing literature by examining both physiological and psychological stress and their role in teachers' visual focus of attention in authentic classroom situations. The results indicate that teachers' psychological stress is related to their visual focus of attention through their teaching practices. Accordingly, teachers need to be encouraged to develop coping strategies in relation to their work-related stress since it effects their teaching practices and classroom behavior toward students.

Data availability statement

The datasets presented in this article are not readily available because cortisol and eye-tracking data cannot be shared publicly. Requests to access the datasets should be directed to the principal investigator of the project, M-KL (marja-kristiina.lerkkanen@jyu.fi).

Ethics statement

The studies involving humans were approved by University of Jyväskylä's ethical committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SC: Conceptualization, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. A-LJ: Conceptualization, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. EP: Conceptualization, Funding acquisition, Methodology, Resources,

Writing – original draft, Writing – review & editing. M-KL: Conceptualization, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Appendix 1

TABLE A1 Description of ECCOM child-centered and teacher-directed dimensions – subscales and scale items (based on Stipek and Byler, 2004; Lerkkanen et al., 2012).

Subscales and scale items	Dimensions	
	Child-Centered	*Teacher-Directed*
Management 1. Child responsibility	Children are allowed to take responsibility to the degree that they are able.	Children do not have opportunities to take responsibility (teacher control).
2. Management	Teacher has clear but somewhat flexible classroom rules and routines.	Teacher has clearly communicated expectations and classroom rules that are rigidly adhered to.
3. Choice of activities	Mixture of teacher and child choice.	Teacher makes most choices.
4. Discipline strategies	Conflict resolution is smooth; consequences are appropriate and apply equally.	Discipline is imposed without explanation or discussion; consequences are inconsistent.
Climate 5. Support for communication skills	Teacher encourages children to engage in conversation and elaborate on their thoughts.	Teacher does not encourage children to engage in conversation (teacher controlled conversation).
6. Support for interpersonal skills	Teacher provides opportunities for cooperative, small-group activities that promote peer interactions.	Teacher does not provide opportunities for children to develop interpersonal skills.
7. Student engagement	Teacher attempts to engage all children in ways that will improve their skills and understanding.	Teacher engages children in rote activities (e.g., rigid expectations about being engaged in work).
8. Individualization of learning activities	Teacher is attentive to children's individual skill level and adapts tasks accordingly.	Tasks are not flexible or adapted to children's individual needs (e.g., all do the same tasks).
Instruction 9. Learning standards	Teacher holds children accountable for attaining some individualized standard (assists and challenges children at their respective level).	Teacher rigidly holds children accountable for completing work and for attaining a universal standard (e.g., standards are rigid and invariable).
10. Coherence of instructional activities	There are connections between and within academic lessons (concepts/skills are embedded into a broader set of goals).	Academic lessons are distinct and disconnected (concepts/skills are presented as an isolated set of facts or skills to be learned).
11. Teaching concepts	Tasks and lessons are designed to teach identifiable concepts and develop understanding.	Tasks are designed to help children learn facts or procedures. Problem solving is constrained.
12. Instructional conversation	Teacher solicits children's questions, ideas, solutions, or interpretations around a clearly defined topic.	Teacher dominates instructional conversation; children's participation is limited.
13. Literacy instruction	The teacher provides a broad array of literacy experiences and instructional approaches.	The teacher's literacy instruction places a heavy emphasis on phonics and paper-pencil tasks.
14. Math instruction	Math instruction emphasizes developing understanding.	Math instruction emphasizes rote memorization, drill and practice.
15. Math assessment	Math assessment is on-going, includes a variety of formats, and is used to inform instruction.	Math assessment is formal, limited in variety, and focuses on right/wrong answers.