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The effects of teacher nodding: exploring mimicry, engagement, and wellbeing in the EFL classroom

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Introduction: This article explores teacher and student mimicry of one another's nodding in the classroom and whether it impacts teacher wellbeing. Studies have consistently demonstrated correlations between physical mimicry and various desirable outcomes, including empathy, rapport, affiliation, and personal liking. While students experiencing such emotional connections with their teachers tend to achieve more academically, teachers also benefit, showing, for example, reduced stress levels. Research exploring the link between mimicry of nonverbal communication such as nodding and teacher wellbeing is limited, however. This paper reports on a very small data set to explore the analysis of synchrony between teacher and learner in the English as a Foreign Language classroom.

Methods: Quantitative and qualitative methodologies were combined to gather both objective and subjective data. A Granger causality analysis was undertaken to understand both immediate and delayed mimicry of nodding, and cross-correlograms produced. Teacher stress levels were measured using the ratio of the low-frequency (LF) and high-frequency (HF) heartrate power bands, which was then validated with a two-dimensional model. Next, the teacher was interviewed about her wellbeing and pedagogy while watching the video data. The results were then combined and analyzed.

Results and discussion: While much immediate mimicry during active teaching sessions was evident in the video data, it was not found to be at a statistically significant level. The Granger Causality analysis showed, however, that students consistently mimicked changes in teacher nodding rate in the following dyad activity. Cross-correlation analysis between teacher and student participants during active teaching sessions and also within student dyads during pairwork activities showed strong relationships at lags spanning 0–60s. No statistical significance between student and/or teacher nodding and either teacher self-assessed wellbeing or physiological stress levels was found, however. This is explained first by the teacher evaluating her normal baseline state as *neutral* rather than *positive* (as was reflected by the LF/HF), and second by her physiological responses to the emotional regulation strategies of *surface* and *deep* acting. Qualitative observational data, however, indicated that teacher nodding positively influenced student comprehension, interest, and confidence, and the teacher's own professional wellbeing.

KEYWORDS

teacher wellbeing, nodding, nonverbal behavior, heartrate variation, physiological measurements, teacher emotions, emotion regulation, emotional self-regulation

1 Introduction

Research in educational settings often prioritizes improving student learning outcomes and overlooks the crucial issue of teacher wellbeing. Student academic achievement and teacher wellbeing are not mutually exclusive, however, with both groups benefitting from a positive teacher-student relationship. Research demonstrates that when the relationship is good, students learn more (Allen et al., 2018; Mainhard et al., 2018; Holzberger et al., 2019), and teachers enjoy increased levels of wellbeing (Spilt et al., 2011), reduced stress levels (Gugliemi and Tatrow, 1998), and more positive emotional experiences in the classroom (Hagenauer et al., 2015). Correlations have also been found between positive teacher wellbeing levels and student achievement (Arens and Morin, 2016; Burić and Frenzel, 2020; Granziera et al., 2023). It is important, therefore, to understand more about wellbeing in the classroom and how teachers perceive it (Talbot and Mercer, 2018). This is particularly important for language teachers, who face unique challenges negotiating boundaries between cultures, supporting learners with different levels of language proficiency, and employing high-energy instructional techniques in classroom environments that are often emotionally demanding (MacIntyre et al., 2022).

This study explores how teacher wellbeing levels are affected by student mimicry of teacher nonverbal behavior in an English as a Foreign Language (EFL) classroom in Western Japan. Mimicry has been shown to correlate with feelings of empathy and rapport (Chartrand and Bargh, 1999), affiliation (Lakin et al., 2003), and interpersonal liking (Salazar Kämpf et al., 2018) in classroom settings (LaFrance and Broadbent, 1976; Babad et al., 2003), all of which seem likely to affect the wellbeing of both teachers and students. Nodding, defined here as "a rhythmical vertical head motion consisting of at least one down-up trajectory" (Stivers, 2008, p. 37) by a person either speaking or listening, was the nonverbal behavior chosen for this study. Nodding has been found to increase perceptions of likeability and approachability (Osugi and Kawahara, 2018). It is almost universally understood to be a positive signal (Helweg-Larsen et al., 2004), which reduces the complexity of its interpretation, important in the intercultural context of this study. As a quantifiable, unambiguous movement, the choice of nodding also reduces the possibility of coding or inter-coder error during the coding process.

This paper aims to contribute to a more comprehensive understanding of the connection between student mimicry of teacher behaviors and language teacher professional wellbeing and uses both qualitative and quantitative methodologies and seeks to answer the following research questions:

1 Do teacher nodding behaviors affect learner nodding behaviors?
2 Do learner nodding behaviors affect teacher nodding behaviors?
3 Is there a correlation between nodding behavior and teacher wellbeing level?

Before the study was undertaken the researchers expected that both teacher and learners would mimic one another's nodding behaviors. This mimicry was predicted to correlate positively with the teacher's wellbeing level as shown by physiological stress and subjective measurement.

2 Literature review

The following section first examines nodding as an expressive gesture and as a form of backchanneling, then explores the dynamics of interpersonal coordination, including the effects of mimicry. Next it focusses on teacher wellbeing and examines research that establishes a connection between wellbeing and rapport between teachers and students. The ways that teachers regulate their emotions in the classroom and the ways that this impacts wellbeing are discussed. Finally, literature exploring how physiological signals can be used to monitor emotional state is presented.

2.1 Nodding

When people interact and communicate with one another, in instructional settings as anywhere else, gestures accompany speech. Gestures help listeners understand what is being communicated (Kendon, 1994), and help speakers produce the words they need to express themselves (Alibali et al., 2000). Nodding by speakers is considered here to be a type of gesture (sometimes termed *gesticulant* or *gesticulation*) which McNeill (2006) defines as "motion that embodies a meaning relatable to the accompanying speech. […] It is made chiefly with the arms and hands but is not restricted to these body parts. The head can take over as a kind of third hand (p. 58)." When nodding is used as an emblematic gesture it carries the intended meaning *yes* (Manusov, 1992), but it has many other functions. Speakers use nodding to give visual support to either concrete or abstract concepts, to point to something being talked about, or to denote speech rhythms (McNeill, 1992, p. 80). It can also be used to introduce a quote (McClave, 2000), for self-affirmation, or to help the speaker find or organize what to say or the words to express it (Boholm and Allwood, 2010). Because when the jaw moves, the head moves in the vertical axis, some research has found that people speaking nod constantly (Hadar et al., 1983). While motion at this level is important in, for example, the programming of avatars, virtual agents, or robots, here *nodding* refers to nodding behaviors rather than movements connected to sound production.

Although gestures are made by both speakers and listeners, listeners tend to use them to regulate the speech of the person they are interacting with (Allwood and Cerrato, 2003; Hale et al., 2020). While listeners can use words such as "yes" and "uh-huh," complete interlocutor's sentences and make requests for clarification, they can also use nodding to perform these functions (Maynard, 1997; Bavelas and Gerwing, 2011), which are termed *backchanneling* (Yngve, 1970). "A nod can signify that someone should keep talking; rapid nodding can indicate that the nodder wants to speak" (Oxford, 2020). Nodding, therefore, is here described as either *gestural* or *backchanneling*, depending on whether the person nodding is speaking or listening when the nodding occurs.

Nodding has previously been separated into nods that begin with an upward movement, sometimes called *jerks*, found to be connected to a change in the listener's cognitive state. Those beginning with a downward movement have been found to show that the listener had previous knowledge of the information (Mori et al., 2022). Single and repetitive nods have also been distinguished, Boholm and Allwood (2010) defining more than a single cycle (up, then down, or down, then up) as *repetitive* and finding such repetition connected to communicative feedback.

While cultural differences may not significantly alter basic turn-taking principles (Sidnell, 2001), Japanese backchanneling patterns, termed *aizuchi* (Kennett and Nagata, 2017), have been studied for some four decades (Allen, 2019). Japanese use speech, nods and smiles to maintain harmony in conversation as they speak and listen (Kogure, 2007). They use visual methods of backchanneling much more than Western listeners, who prefer to respond orally (Maynard, 1997). While some research has posited that *aizuchi* is different from other forms of backchanneling, this has not been fully quantified (Clancy et al., 1996; Ohama, 2006). Differences seem to rest in timing, function, and frequency, with specific concerns about the extent to which *aizuchi* indicate agreement rather than comprehension (Tada, 2014), and frequency, Maynard (1986) finding a 3:1 ratio of Japanese *aizuchi* to American backchannels in non-intercultural communication. Differences in backchanneling patterns did not occasion misunderstandings between Japanese study participants and their American interlocutors, however, in a study undertaken by White (1989). That study with found correlations between higher levels of backchanneling and high evaluations of the Japanese participants' comprehension, interest and encouragement, and perception of them as patient, polite, and attentive (74). More recent work (e.g., Cutrone, 2005), however, has found mismatches in backchanneling styles problematic for intercultural communication.

Speakers carefully construct their utterances for the people they are speaking to, called *audience design* (Clark and Murphy, 1982). Interlocutors have also been shown to affect speaker's narratives (Norrick, 2012; Tolins and Fox Tree, 2014) and language use (Beukeboom, 2009) with the type, amount, and quality of backchanneling that they provide (Bavelas et al., 2000; Clark and Krych, 2004). Backchanneling is especially helpful for presenters (and by extension, teachers and lecturers), with specifically a lack of nodding helping speakers to recognize when audience members are confused (Murali et al., 2021). This allows them to then respond to audience members' non-verbal signals (facial expressions of incomprehension, boredom or somnolence) by adding further explanation or example (Wales, 2001, 147).

2.2 Interpersonal coordination

Observation shows that people interacting with one another coordinate the ways that they move their heads and bodies (Kendon, 1970; Ramseyer and Tschacher, 2011). This is an example of the accomodation strategy *convergence*, in which people make their linguistic, paralinguistic or non-verbal behaviors similar to the person with whom they are interacting so as occasion in them feelings of approval or respect (Giles and Ogay, 2007). Such accomodation is often performed unconciously: although people may try to occasion feelings of similarity and warmth in their interactional partners, the processes that they use to do so seem largely automatic (Burgoon et al., 1993).

Interpersonal coordination, which includes both mimicry and synchronization (Bernieri and Rosenthal, 1991; Hove and Risen, 2009), has been found to increase interpersonal bonding, compatibility, togetherness, and social interaction (Bavelas et al., 1988). There are many different terms for this coordination: Early observational work focused on *postural sharing*, which occurs when people emulate one another's torso posture or arm position concurrently, either on the same side of their body (*congruence*) or on the other (*mirroring*) (LaFrance and Broadbent, 1976; LaFrance, 1979; Kennedy et al., 2022). The intention behind both synchronization and mimicry has also been widely explored, with some research defining the synchronization to stem from "spontaneous expressions of internal states" (Manusov, 1992, p. 70) in contrast with mimicry, defined by the same author as connected to deception, impression management or relational messages. The difference between mimicry and motor mimicry, where people display non-verbal behavior reflecting not their own circumstances but rather that of their interactional partner, the wince occasioned by a partner's painful anecdote, or the smile by a happy one (Bavelas et al., 1988), is also important to note. Mimicry has been divided into "traditionally observed mimicry" and "rapid and reactive mimicry (with lags under 1 s)" (Hale et al., 2020, p. 63). Chartrand and Bargh (1999, 897) found, in effect, a feedback loop: "Perception causes similar behavior, and the perception of the similar behavior on the part of the other creates shared feelings of empathy and rapport."

Recent meta-analyses have substantiated these effects in both verbal and nonverbal communication (Vicaria and Dickens, 2016; Mogan et al., 2017). The ways that mimicry of head movements specifically occasions feelings of affiliation have also been confirmed for interactions both in virtual reality with avatars (Sun et al., 2019; Wakabayashi et al., 2023) and with virtual agents (Bailenson et al., 2005; Aburumman et al., 2022). Some research has also found that being mimicked occasions such feelings not only toward interactional partners but also toward others in general. Ashton-James et al. (2007), for example, found that mimicked participant self-construal became more interdependent and oriented toward unspecified others, and also raised participant perception of interpersonal closeness with said unspecified others.

2.3 Teacher wellbeing

Teacher wellbeing is defined here as "an individual sense of professional fulfillment, satisfaction, purposefulness and happiness, constructed in a collaborative process with colleagues and students" (Acton and Glasgow, 2015, p. 102). It has often been examined through the lens of burnout and its causes. Research identifies a low-quality relationship between teachers and their students as a precursor to such feelings of despair and cynicism (Grayson and Alvarez, 2008; Corbin et al., 2019). When teachers feel disconnected from their students, both their professional and personal wellbeing suffer (Hargreaves, 2000). Positive relationships with students, however, have been found to alleviate stress for teachers (Gugliemi and Tatrow, 1998), and shape their emotional experiences in the classroom (Hagenauer et al., 2015). This has often been overlooked as a significant component of teacher wellbeing (Spilt et al., 2011; Corbin et al., 2019).

2.4 Emotional regulation

The ways that teachers nod, smile, and move their hands convey their mood and intentions (Stevick, 1982; Negi, 2009; Kesevan et al., 2020). In the same way that cabin attendants are expected to be friendly, nurses to be kind, and bank employees to be calm (Zapf,

2002), there is a perceived need for teachers to reduce negative emotions in the classroom and amplify positive ones (Schaubroeck and Jones, 2000; Sutton, 2004). Many teachers therefore work to regulate their own emotions in these ways (Schaubroeck and Jones, 2000; Oplatka, 2009; Taxer and Frenzel, 2015). While this has been found to benefit both teachers (Oplatka, 2009) and learners (Wang et al., 2023), it also places the body under stress (Hochschild, 1979; Zapf, 2002). When employees either display an emotion that they do not feel or hide one that they do (termed *emotional dissonance*; Grandey, 1999), research finds negative health outcomes (Zapf, 2002).

There are three different processes by which emotions are regulated: *automatic,* whereby a person acts spontaneously and genuinely, *deep acting* in which workers modify their feelings using cognitive strategies such as refocusing their attention (Grandey and Sayre, 2019) or reminding themselves of their role (Briner, 1995), and *surface acting* (Hochschild, 1983), in which workers display appropriate emotions without regard to how they feel (Wang et al., 2011; Grandey and Melloy, 2017). Where people regulate their emotions automatically there is little stress to report, but both surface and deep acting have very different effects on wellbeing levels. Näring et al. (2006), for example, found correlations between surface acting and teacher burnout, Zahn et al. (2015) between surface acting and emotional exhaustion, and Lee and Madera (2019) between surface acting and an increase in perceived workload. Conversely, positive relationships were found between deep acting and positive affective states (Scott and Barnes, 2011) and wellbeing (Johnson and Spector, 2007), and negative correlations with stress (Lee and Madera, 2019).

2.5 Heartrate variability

Combining physiological data with observational data allows for a more thorough understanding of the phenomenon and context being studied. It is of particular use when exploring emotional states. Heartrate variability (HRV), the natural variation in the time interval between individual heartbeats in a normally functioning heart (Johnston et al., 2020) is of interest here in that the ratio of the low- (LF) and high-frequency (HF) power bands can be used to assess sympathovagal balance, where LF shows the activation level of the sympathetic nervous system and HF the parasympathetic nervous system (Pagani et al., 1986). The larger the ratio of these indices, the higher participant stress levels. While research such as that undertaken by Shiga et al. (2021) exploring subjective wellbeing and LF/HF ratio among office workers shows consistent results, interpreting LF/HF data has been judged by some to be complex, as the effects of both stress or intellectual attention can be easily confused with the effects of physical movement (Tsunoda, 2019). Some studies therefore question the validity of LF/HF to measure stress (Billman, 2013). Recent work, for example Zang et al. (2018), demonstrates how spectrogram representations clearly delineate between emotional and physical expressions in the data. Von Rosenberg et al. (2017) suggest using a two-dimensional model to explore and validate findings from HRV and LF/HF data, and this is the approach adopted here.

Interpreting LF/HF ratio data of teachers is complicated, however, by the scarcity of such research previously conducted. Ritvanen et al. (2004), for example, investigated the autonomic profile of Finnish teachers and found markedly different stress levels as measured by LF/HF ratio during the teaching day and after increasingly sustained periods of non-teaching. They found participants to be significantly physically affected by the stress of their work. Prichard et al. (2012) found that surgeons teaching surgical procedures were under much more duress as shown by LF/HF ratio than when operating without a trainee in attendance. While such research is interesting, it does not, however represent the data clearly enough for readers to make hypotheses about other data sets.

As can be seen in the literature presented in this section, both nodding and interpersonal coordination have been found to have positive impacts on the ways that study participants feel about one another, and where teachers feel such emotional connections with their students, their professional wellbeing levels are positive. This study investigates the ways that one teacher's nodding behaviors were seemingly unconsciously mimicked by her students, both immediately during active teaching sessions and in delayed mimicry during the dyad activities that followed each of them, and how this mimicry affected the teacher's physiological stress levels and self-perceived wellbeing.

3 Materials and methods

3.1 Setting

In this Japanese first-year university EFL productive skills course, students sit in dyads and together undertake a series of conversational activities each lesson. Their teacher explains each activity during active teaching sessions, and then offers further support to dyads who need it. When all dyads have completed each activity, she calls the class to order for the next active teaching session, offers general feedback, and sets the next task. Partners are randomly assigned using a semester-long non-repeating allocation system.

Despite having studied English for six years as a compulsory core subject, and having passed the university English entrance examination, many students lack confidence in their ability to communicate in English. This is perhaps due to the teacher-centered grammar-translation method followed by most public schools (Sato et al., 2019). The students are highly motivated, however, with competition to matriculate into this national, public university, intense. Some 33% of the student body invest an extra year of independent study after high school in order to pass the entrance examinations. The class described here have an average TOEIC score of 570, approximately B1 on the Common European Framework of Reference for languages (CEFR) scale. For reference, the Japanese national average is 520 points (Educational Testing Service TOEIC, 2018). All student participants in the study are Japanese citizens, and none have studied abroad.

Their teacher, a Westerner with 20 years' experience in the EFL classroom in Japan, has previously taught the same course four times. She is a fluent Japanese speaker, familiar with Japanese cultural norms, and teaches this communication class in English as per the university course guidelines. Productive skills courses in Japan tend to be taught by native English speakers (Tsurii, 2019) from Inner Circle countries (Kachru, 1998; Tsurii, 2019). The racial and linguistic inequality inherent in this issue (Rosa and Flores, 2017) is beyond the scope of this article, however, and is not addressed here. The teacher was selected for observation because as a white caucasian, she is the most familiar type of native speaker to Japanese learners of English (Toh,

2013), and as such is least likely to occasion feelings of disapproval [as found by Chiba et al. (1995), for example]. All teachers meeting this criteria at the university where the study was to be conducted were asked to participate, then one randomly chosen among those who volunteered. The university itself was chosen because of connections between the research team and members of the English department there. Although the setting therefore constitutes a convenience sample, the university's metropolitan location in central Japan, the academic level of the students, and the large number of teachers meeting the criteria was thought to be in line with the goals of the study.

The observation was conducted in Week 18 of the 30-week course. Neither the teacher nor the students were informed as to which lesson of the semester would be recorded so as to reduce the possibility of extraordinary teaching or behavior. The researchers limited the scope of the observation to a single lesson to reduce the burden on the participants. The student participants were aged between 18 and 20 years of age, and the teacher in her 50s. No participants were aware that nodding would be the focus of this research study. Two seating positions and the dyads who happened to sit in them were randomly selected for close observation. The selection of the front left and right rear seats was not known by either teacher or participants until after the observation was concluded. The targeted students are referred to throughout by codes: YM and KT, and MH and KR. YM and KT were seated at the front left of the classroom, and MH and KR at the right rear. The teacher and all 18 class members provided written consent conforming to the university general research ethics policies, and the four randomly selected for observation for their video data to be individually coded.

3.2 Instruments

3.2.1 Video data

Four Go-Pro cameras were placed in the classroom before the participants entered. This allowed the unobstructed observation of the four target student participants, the teacher participant, and the other members of the class. The data recorded was combined into one four-panel video so that several angles could be observed simultaneously. Data were collated using ELAN 6.4 (ELAN, 2022), an annotation tool for audio and video data, and the video data then transcribed. Four observers were instructed to label the nodding behavior of the five participants, with each vertical head movement beginning with either an upward movement or a downward movement labeled as a nod, and undertook this work individually. Because nodding is an unambiguous movement, measures to address inter-coder error were not used. Instead, where differences occurred, the video was rewatched for confirmation by one of the researchers.

3.2.2 Granger causality and cross-correlations

Causal relations among groups was investigated using Granger causality analysis (Granger, 1969). Granger causality assesses whether past values of one variable can predict future values of another, thereby indicating a predictive relationship. This method helps identify temporal patterns of influence between participants. The Granger causality statistic follows an F-distribution, with values exceeding a certain critical threshold (usually 0.05 or 0.01) indicating statistical significance and the presence of predictive causality.

Cross-correlation analysis was then conducted to generate cross-correlograms, which assess the relationship between different time series variables across various time points. This method allows for the examination of potential time delays between variables and facilitates the identification of the lag with the highest correlation. Cross-correlation analysis is valuable for uncovering patterns and generating hypotheses about underlying dynamics in complex datasets. Cross-correlation values range from −1 to 1, where values near 1 or −1 indicate strong positive or negative correlations, respectively, at the corresponding lag, while values around 0 suggest little to no correlation.

3.2.3 Heart rate variability

The teacher wore an Empatica E4 wristband sensor to record fluctuations in her heartrate. The Empatica uses an algorithm to remove noise in the photoplethysmography signal to produce the interbeat interval sequence. This is then used to calculate the average heartrate values with intermittent output of 1/64 s resolution in spans of 10 s with a sampling rate of 1 Hz (Empatica, 2020). This data was then used to calculate the LF, the HF and the ratio between them to assess stress levels.

3.2.4 Teacher interview

The teacher was interviewed by one of the researchers one week after the lesson observation while watching the combined video data. The interview was audio recorded and transcribed using otter.ai. A topic guide prepared as described by Edwards and Holland (2013) was used to prompt the teacher to describe and reflect on changes in her professional wellbeing. She watched the video, assessed her own wellbeing levels throughout as either *positive, neutral*, or *negative*, and explained what occasioned these changes. It should be noted that she was not made aware of movements in the LF and HF data until after all data had been gathered.

4 Results

4.1 Nodding behaviors

The four student participants' and the teacher's nodding can be seen in Figure 1. YM nodded a total of 166 times, and KT 163 times. MH nodded the least of the student participants, at 142 times, and KR the most, at 262 times, with an average of 183.25 times. The teacher nodded 113 times, which may initially appear anomalous. When we consider, however, that dyad discussions are the focus of the course and make up a large proportion of the lesson time, it is natural that less teacher nodding was recorded overall.

4.2 Granger causality and cross-correlations

The Granger causality analysis conducted between teacher nodding during each active teaching session and the subsequent student nodding observed during dyad activities yielded statistically significant results for two of the three participants whose data were analyzed. For the third participant, KT, although the *p* values exceeded the conventional threshold of 0.05 for significance, they were relatively

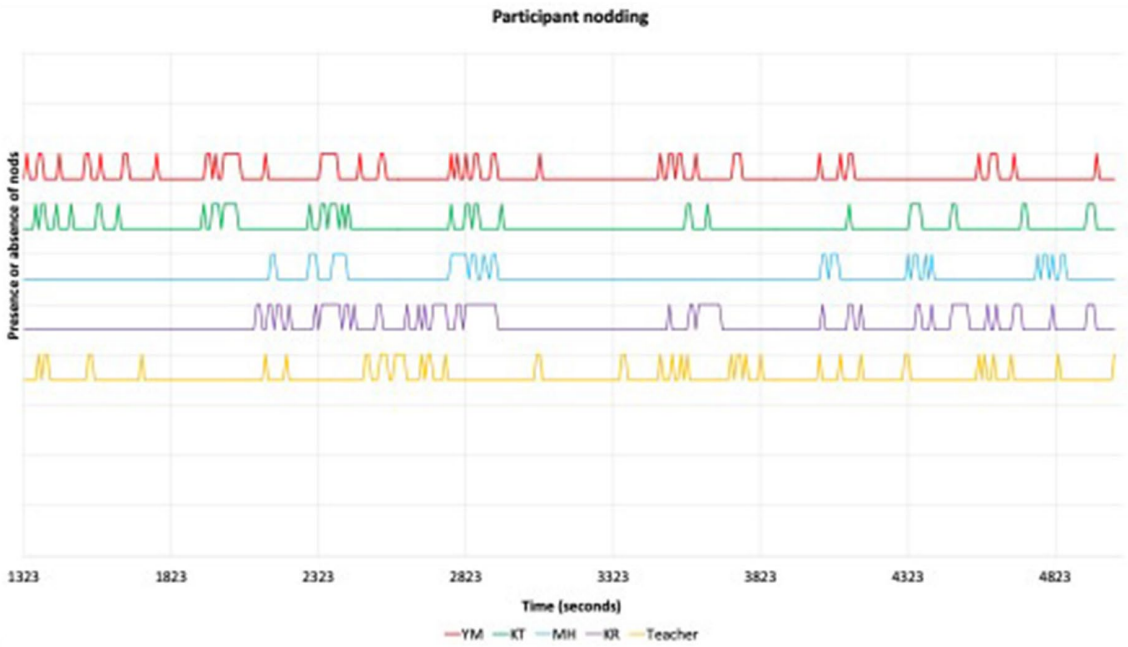

FIGURE 1
Participant nodding. The starting time for the observation reported on here is recorded as 1,323 s due to the recording equipment being set up before the observation began.

low, particularly at the first and second lags, suggesting a weaker or more nuanced potential causal relationship. Due to MH's lack of nodding during active teaching sessions, her nodding behavior during subsequent dyad activities could not be predicted. The analysis revealed a temporal causal relationship between teacher nodding and student nodding, with changes in teacher nodding preceding similar changes in student nodding in the subsequent period. The cross correlations undertaken to examine relationships in the data also found significant results for two of the four student participants.

Figure 2 shows the cross-correlations of the teacher's nodding with that of each of the student participants (KR, YM, KT, and MH) over a range of different time lags of −6 to 6 steps of 10 s. Each line represents the cross-correlation between the teacher and a student participant, and indicates how their nodding behaviors are related. A peak or trough at a specific lag suggests a temporal relationship, where a positive value indicates synchronous behavior. A positive lag indicates student mimicry of the teacher, and a negative lag teacher mimicy of students. Higher values on the vertical axis indicate more similarity between the nodding patterns at that specific lag.

There is no variation in the correlation between the teacher and MH, who, interestingly only nodded during interactions with her dyad partner. As such, there is no information about her presented in this graph. YM was the participant whose nodding most closely correlated with the teacher's. Although the maximum correlation between the teacher and YM is 0.378 ($p = 0.000000000000197$), seen at −6, the nodding correlation at step 0, with a correlation of 0.364 ($p = 0.00000000000123$) also indicates a strong positive linear relationship between their synchronized nodding behaviors, and evidence of rapid and reactive mimicry (Hale et al., 2020, p. 63). KR and KT were both found to have maximum correlations with one step lag, at 0.153 ($p = 0.0037$) and 0.103 ($p = 0.0526$), respectively.

When student participant nodding during dyad activities was examined, cross correlations found statistically significant relationships that showed clear evidence of rapid rather than delayed mimicry within pairs (Figure 3).

As can be seen in Figure 3, for each pair (KT vs. YM, KR vs. MH), the lag (x-axis) shows how the nodding of each person correlates with the nodding of their partner at different points in time. A peak or trough away from lag 0 indicates a time-delayed correlation, suggesting that the nodding behavior of one member is followed or preceded by the nodding of the other member after some time. The maximum correlation between both pairs was found to be at lag zero, with maximum correlation values of 0.287552 ($p = 0.00000003$) and 0.300260 ($p = 0.000000007$), respectively.

4.3 Heartrate variability: LF, HF, and the LF/HF ratio

In Figure 4, movements in both the LF and HF domains can be seen, with HF showing parasympathetic nervous system activity and LF showing sympathetic nervous system activity (Billman, 2013). There is much more movement in the LF, reflecting the teacher's cognitive and emotional load, than in the HF, which reflects the teacher's relaxed physical state and lack of physical exertion.

Similarly, in Figure 5, a two-dimensional scatterplot that explores movement in HRV and *positive* (shown in beige), *neutral* (shown in white) and *negative* (shown in black) levels of teacher wellbeing, much of the data is gathered in the lower left quarter of the scatterplot, with very little data in the quarter above it, and scattered data in the remaining quarters on the upper and lower right. While the *negative* data are focused in the first quarter, the teacher's neutral and positive

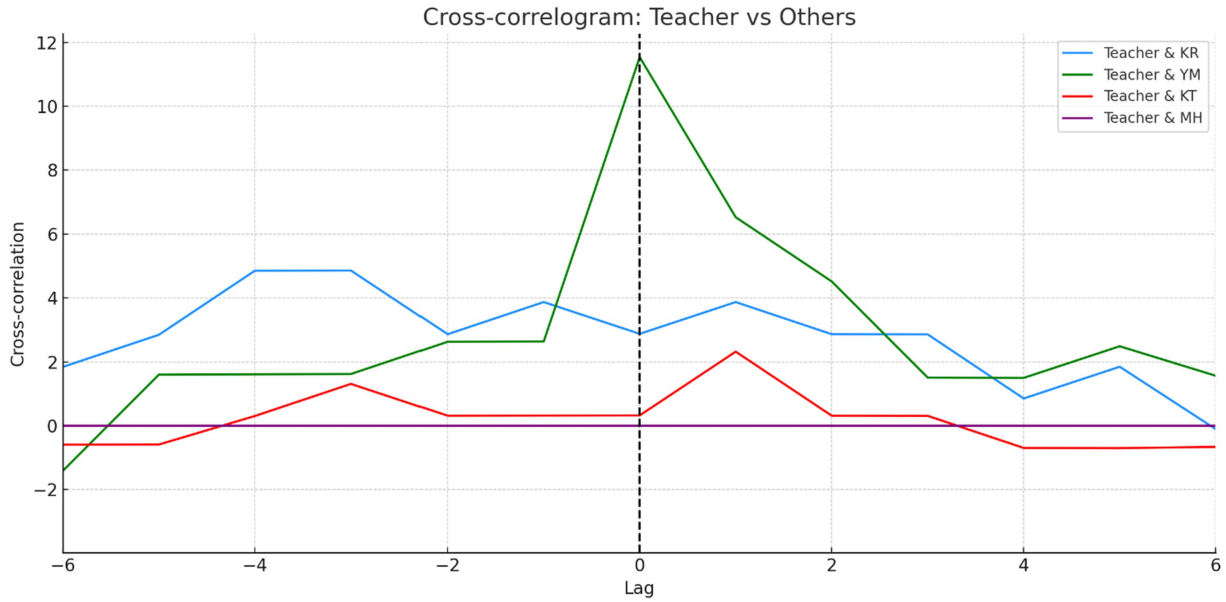

FIGURE 2
Cross-correlogram: Teacher vs. Others.

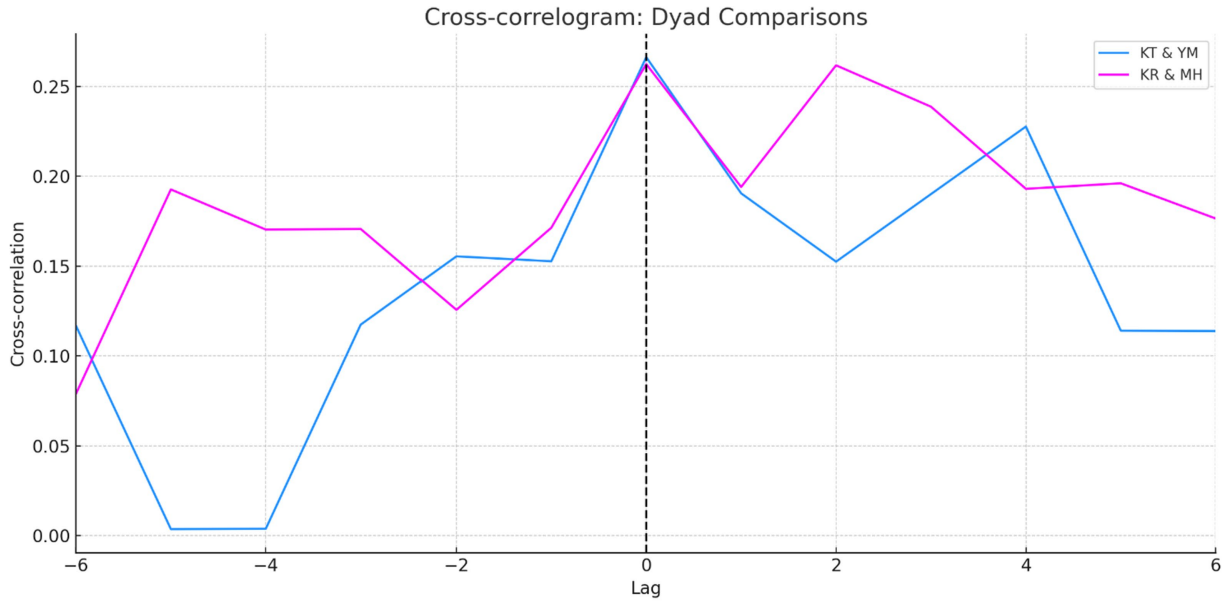

FIGURE 3
Cross-correlogram: Dyad comparisons.

wellbeing data is gradually dispersed out from the first to the third. This distribution pattern suggests a correlation between lower HRV and negative teacher wellbeing, with instances of higher HRV associated with both neutral and positive wellbeing.

In Figure 6, the relationship between the teacher's self-assessed wellbeing and her LF/HF ratio, or stress index, can be seen. Wellbeing is indicated here by the pink line on the graph and has three levels as stated above. The LF/HF ratio is inverted so that a positive, low state of stress is seen to be higher on the *y*-axis and the negative, higher state of stress appears lower on the graph to allow for easier comprehension. A 128-s window was selected to allow for detailed analysis. A 10-s sliding window was used to process the data, meaning that the LF/HF ratio data ends before the end of the observation period. As can be seen in Figure 6, the LF/HF ratio and the teacher's self-assessed wellbeing levels show little overlap, and it is difficult to identify a consistent pattern.

A total of nine downward movements, indicating surges in stress level, were seen in the LF/HF ratio. The first two of these (at 1,363 and 1,443 s) can be explained by the slightly unsettled start to the observation, in which the recording equipment made two unexpected

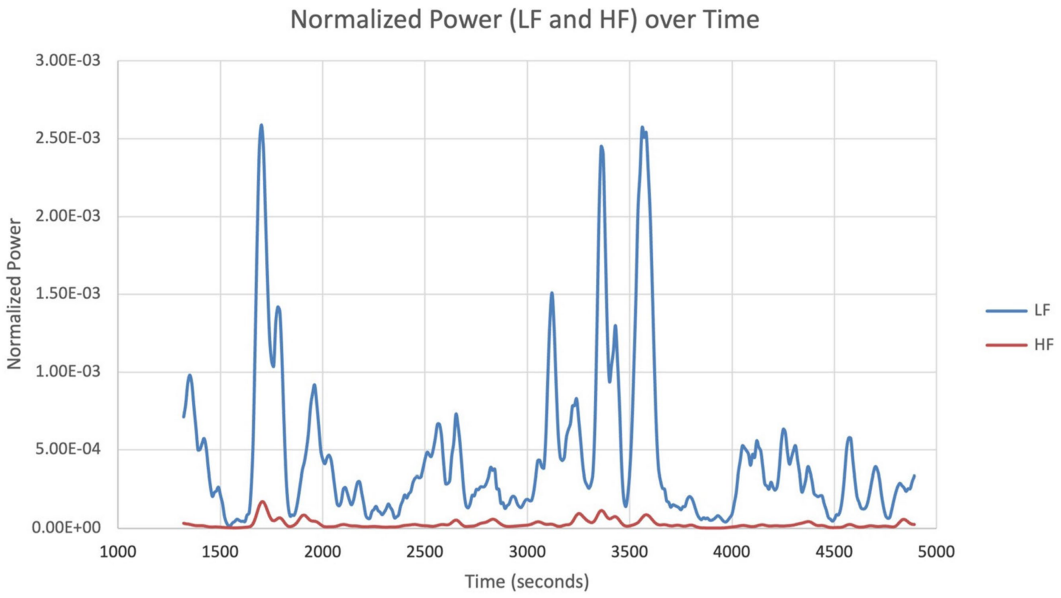

FIGURE 4
Normalized power (LF and HF) over time.

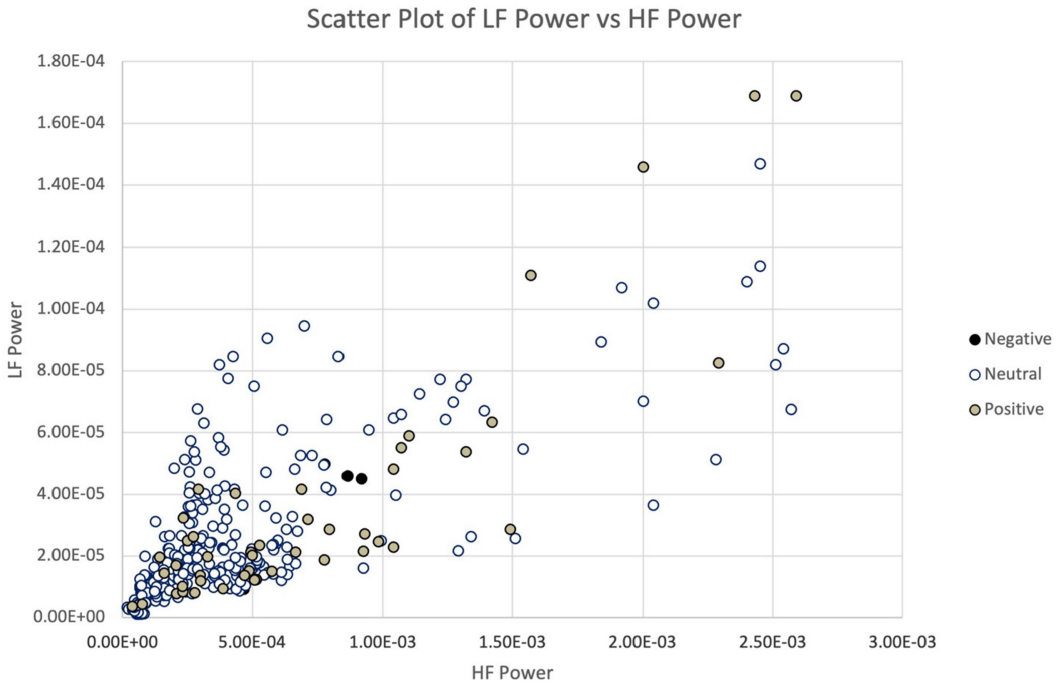

FIGURE 5
Scatterplot of LF power and HF power and teacher wellbeing levels.

loud beeping sounds. Many of the remaining seven downward movements similarly do not seem to be connected to the rapport between the teacher and the students. The third (at 2,023 s) and eighth (at 3,943 s) were directly connected to the theme of the lesson. As the teacher explained an emotionally challenging concept to the class, she illustrated it with a personal story, and later read a passage aloud. The fourth and fifth troughs, at 2,553 and 3,143 s, both occurred, as the teacher was grading student assignments on her laptop and the students were engaged in first, dyad discussions and next, silent reading. In the classroom video, tension in her forehead was evident as she wrote feedback comments. The trough at 3,943 s seems to have come as a direct result of a student's preset alarm ringing suddenly, which disrupted the teacher's *flow* (Csikszentmihalyi, 1997) as she offered feedback on the preceding dyad session.

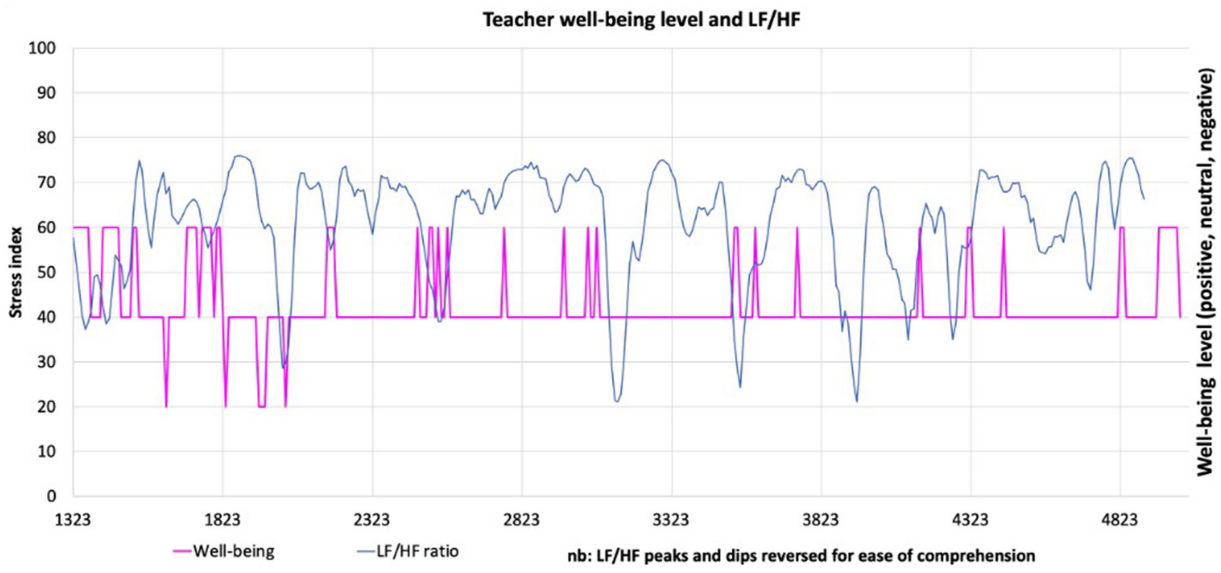

FIGURE 6
Teacher wellbeing level and LF/HF ratio.

The two remaining troughs, however, seem to be connected to the way that the students responded, or failed to do so. At the 3,553 s point, the teacher was trying, seemingly unsuccessfully, to clarify a concept that students had had difficulty with during the preceding dyad session. As she worked to clarify where they needed support, they seemed unwilling to interact. She can be seen to look off to one side, her eyes unfocussed, and then briefly shakes her head before attempting to engage them again with a new example. While the class clearly needs help, they do not proactively seek it. In a similar situation at the final stress dip at the 4,263 s point, however, the class responds actively, not only telling their teacher that they do not understand, but also how they would like her to support them. These movements in the teachers' stress index and the reasons for them will be explored in the discussion section.

5 Discussion

Because "[p]erception causes similar behavior" (Chartrand and Bargh, 1999), it is difficult to unravel the relationship between teacher and student nodding, and to assess whether nodding behaviors are gestural, a form of backchanneling, or mimicry of either one or the other. To explore this, the research questions will first each be addressed separately. Other remaining issues, including the methods used to assess the teacher's stress levels will then be addressed.

5.1 Do teacher nodding behaviors affect learner nodding behaviors?

Before this study was undertaken, the researchers expected teacher nodding behavior to affect student nodding behavior, although the patterns that this would take and their extent was not foreseen. The Granger causality analysis, the cross correlations, the teacher's recollection of student nodding during active teaching periods and a rewatching by the researchers of these sections of the video recordings all show that a large proportion of teacher nodding was quickly mimicked, sometimes by one of the four targeted student participants, and sometimes by one or more other members of the class. The role that nodding plays in grounding, "the on-going process of establishing common ground to enable the joint projects of speaker and addressee in any exchange" (Clark and Grossman, 2001, p.95) may explain much of this student nodding. Clark (1996, p. 121) defines *communal common ground* as "information based on the cultural communities a person is believed to belong to—from nationality and occupation to ethnic group and gender." *Personal common ground* is defined as "information based on personal acquaintance" (p. 121). In the foreign language classroom, teachers work to establish both communal and personal common ground to form connections with their students so that learning can take place. Clark and Grossman (2001, p. 96) posit that such grounding "underpins the process of acquisition" of language. As elements are added to the common ground, addressees recognize them as such with nods, smiles, or simple utterances (Clark and Grossman, 2001), all forms of backchanneling. In the language classroom, interlocutors also show that they have understood one another well enough (Clark, 1996) for information to be added to the common ground. As the teacher added concepts and terminology, many in the class nodded to affirm that they had understood and were ready for the next step.

This student nodding was less widespread, however, than the researchers had predicted, with only two student participants chosen for observation, YM and KR, seen to engage in immediate mimicry in a consistent manner and with statistically significant results. While Japanese have been found to offer some three times the number of backchannels of American listeners in dyadic conversation (Maynard, 1986), it seems that the Japanese societal "valu[ing of] collectivism and humility" (Richmond and Vannieu, 2019, p. 12), may have led learners to "actively try to appear modest" (Richmond and Vannieu, 2019, p. 11) and disguise understanding rather than draw attention to

themselves or stand out from their peers. In the classroom discussed here, some learners may have limited their assertions of understanding so as not to differentiate themselves from their classmates.

When the participants went on to interact in dyads, however, their nodding increased to match that of their teacher in the previous active teaching session, delayed mimicry of teacher nodding shown by all four of the students selected for observation. As also seen in Kennedy et al. (2022), dyads were positively affected by their teacher's nodding. While the student participants were aware of the need to communicate effectively with their dyad partner in order to achieve one of the course goals, the statistical correlation between each dyad's nodding behaviors indicates that their nodding behavior was not strategic, deceptive, or designed to manipulate (Buller and Burgoon, 1993).

5.2 Do learner nodding behaviors affect teacher nodding behaviors?

The cross-correlation showed a statistically significant relationship between two of the four student participants and the teacher with positive and negative lags, showing not only their mimicry of her, but also her mimicry of them. One of these participants, YM had a maximum correlation at the 60-s point, but a very similar level at the zero-lag point, which can be interpreted as not only synchronized interpersonal coordination, but also looping feedback some 60 s later. There was, however, no delayed mimicry of student nodding by the teacher found when student participant nodding within dyads was analyzed with the teacher's nodding in the following active teaching session. Rather than being unaffected by their behavior, however, the teacher may have been simply responding to both increases and decreases in the same way. Nodding has been shown to encourage additional nodding between conversational partners (Iwasaki, 1997; Kita, 1999). As people nod and provide other forms of backchanneling, the person they are interacting with does the same (Kita and Ide, 2007), creating a self-reinforcing pattern (Chartrand and Bargh, 1999). When the students nodded at the teacher, either gesturally when they were talking, backchanneling as she talked to them, or in mimicry of either her gestural or backchanneling nods, she then nodded, too. She responded similarly to decreases in the student nodding rate. Her reasons for doing so may be connected to the recognition she described when interviewed of the importance of communicating effectively with students if she is to function effectively as their teacher. She used gestures, including nodding, to help her to express her ideas, as described by Alibali et al. (2000), and to support her students to understand those ideas, as seen in Kendon (1994). She continued making such efforts until she felt satisfied that the class understood.

Participants may have also reduced their nodding behaviors to signal that they had disengaged from the lesson. Research suggests that in Japanese culture, backchanneling indicates either comprehension and/or evidence of listening (Tada, 2014). By neither backchanneling nor mimicking their teacher's nods, the students communicated to their teacher that they needed more support to understand the lesson content. Murali et al. (2021) found that presenters recognizing such signals were better able to find ways to help audience members reach comprehension. Here, the teacher became more expressive and physically animated: both the depth and number of her nods increased, she spoke more slowly, and offered more illustrative examples and accompanying gestures to help the class understand.

5.3 Is there a correlation between nodding behavior and teacher wellbeing level?

Before answering Research Question 3, it is important to clarify the ways that teacher wellbeing levels were measured. When the study was proposed, it was assumed that a combination of qualitative and quantitative measures would make any findings more robust. As such, both sensor data measuring physiological stress and interview data probing professional wellbeing were collected. When the two were combined, however, it quickly became apparent that the teacher did not always feel a *negative* sense of wellbeing when the sensor data indicated that she was undergoing physiological stress. Nor did she always feel *positive* when the LF/HF ratio indicated that she was relaxed. This does not call the validity of the sensor data into question, however. Comparable data has been presented by, for example, Von Rosenberg et al. (2017), in two-dimensional scatterplots which explore movements in HRV during meditation, resting and mental arithmetic that found data clustered in the lower left quarter of the graph to reflect low physical stress, in the upper left quarter to reflect low mental stress, and clustered around the center to reflect resting. Figure 5 shows a similar data distribution in the lower left quarter of the graph, reflecting the low physical load of classroom teaching. Less data is shown in the upper left quarter, however, than in the Von Rosenberg et al. (2017) scatterplot, reflecting the cognitive load of teaching. Similarly, as no rest was taken during the lesson, there is no data clustered around the center of Figure 5. Finally, the data in the upper right quarter reflects the highest peaks of the LF data, all occurring during calm periods in the lesson that the teacher labeled as of either *positive* or *neutral* wellbeing.

There are several possible intertwined explanations for why the teacher's self-assessed wellbeing levels were different than the sensor data. The first of these relates to the way that the teacher assessed her own wellbeing levels. Whereas 58.5% of the time, the LF/HF stress index indicates the teacher is functioning in a completely relaxed state (seen in the top 25% of Figure 6), the teacher's own assessment of her mood allocates only 14% to a *positive* rather than *neutral* or *negative* state of wellbeing. Such *positive* periods are also very brief, averaging 23 s. As such, it is natural that statistical analysis of the data should show little correlation. This is also true for movements in the LF and HF domains of the HRV (shown in Figure 2): although the LF reflects positive and neutral states of wellbeing, and the HF her minimal levels of physical exertion, the lack of *positive* self-assessed wellbeing levels limits the applicability of this data.

Periods where the teacher's own assessment of her wellbeing is opposite to her physically measured stress level allow for a more nuanced exploration of the data. As reported in the results section, the stress index indicates several periods of higher stress. Two of these occurred as the teacher marked student assignments while the class worked independently, two as she explained difficult concepts and the remaining two as she described emotional experiences. While all these sections of the lesson provoked measurable stress responses, the teacher did not perceive them to be equally stressful. She labeled her

wellbeing during each of these similar-seeming periods as *positive* or *neutral*, only assessing one as *negative*.

An explanation for this may be found in the ways that "emotion work" causes stress (Hochschild, 1979). Observation of the video data in combination with the teacher's reflective interview shows that at each of the six stress peaks discussed above, she worked to regulate her emotional responses. At 2,553 and 3,143 s, for example, though the teacher's stress index rises as she writes feedback on student essays, she does not express it. Instead, at 2,553 s she makes eye contact, nodding and smiling to a student. At 3,143 s, she nods to herself as she works. While she labeled her wellbeing during the first period as *positive* and the second as *neutral*, she also described feeling frustrated that students had not attained the desired level in the formative assessment task that she was writing feedback for, and irritation at her heavy workload. There is no evidence of such negative emotions in the video data, however. Her behavior at 2,553 s can be seen as her seeking engagement with the class. This deep acting was met with a nod of acknowledgement by one of the participants, which then contributed to her stress level returning to normal, and her assessment of this as a period of *positive* wellbeing. At 3,143 s, however, in a similar moment of stress, she nods to herself, without engaging with the class. This behavior did not positively impact her wellbeing, which then remained *neutral* for an extended period.

Whereas student mimicry of the teacher's nodding behavior at 2,553 s and the lack of such mimicry at 3,143 s can be seen to explain her *positive* and *neutral* assessments of her wellbeing independent of either deep or surface acting, the moments of stress occurring at 3,553 and 4,263 s as the class struggles to understand complex lesson content offer an opportunity to examine the effects of emotional regulation without the complication of mimicry. The teacher labeled the first of these sessions, in which the students sat unresponsive, failing to nod in either backchanneling or mimicry, as a period of positive wellbeing. As her physical stress peaks, she looks out the window and briefly shakes her head. Asked about this during her reflective interview, she described her inner dialog at this point, reminding herself of her teaching skills and length of professional experience, as a clear example of deep acting. Despite the lack of physical engagement with the class, because she is in genuine engagement with her role as their teacher, she can view the period as positive. In contrast, as her stress peaks around 4,263 s several participants engaged nonverbally with her, and one asked a question. Despite this, she labeled her wellbeing as *neutral* during this period. The teacher identified the students' apparent willingness to engage with her as due to the approaching end of the lesson and their desire for her to end the class on time. Her need to hide her awareness of what she felt to be manipulative behavior led to a superficial display of patience, which then negatively impacted both her physical stress and her conscious wellbeing.

While one of the stress peaks that occurred as she shared a personal anecdote was perceived by the teacher as being of neutral wellbeing in contrast to the stress peak shown in the sensor data (at 2,023 s) the other was perceived as negative (3,943 s), consistent with the sensor data. When asked to explain, she described two concurrent needs: to keep the classroom a positive place for her students to learn, and to bring authentic emotion to her teaching. In the first of these segments, she tried to limit the intensity of her feelings to an appropriate level, thereby surface acting. In the latter segment, when she did not regulate her emotions, instead allowing herself to feel the genuine emotions that talking about her memories prompted, her sense of wellbeing aligned with the data collected by the sensor she wore.

When the nodding behavior data and wellbeing level data (both self-perceived and HRV), were combined, no statistically significant results were obtained. This may have occurred for several reasons, the first of these because all nodding behaviors were coded together rather than separately. When the researchers realized their error, the video data was rewatched by each individually, although not recoded. It showed, however, that the teacher's non-gestural nodding (i.e., backchanneling or mimicry) increased markedly during periods with positive levels of wellbeing. Because mimicry of behavior both indicates and creates feelings of affiliation, her nodding during these periods can be seen as a physical manifestation of her positive feelings toward her students. As she then mirrors their nodding back to them, their positive feelings toward one another increase further, lifting her sense of wellbeing.

When the researchers considered the teacher's gestural nodding alongside her wellbeing levels, however, there was no such relationship evident. An explanation may rest in a pedagogical choice directly connected with teacher nonverbal behaviors. During her reflective interview, the teacher described how important she feels that it is to give energy to the students at the start of the lesson to help them transition into the foreign language that they practice in her classroom. She used the image of kindling a fire to describe this process. To paraphrase: in the same way a campfire is started with small pieces of wood and gentle, careful attention, language learners need both standard scaffolding techniques (such as gradually increasing complexity of language), and emotional encouragement. She described giving her students the energy as well as the language that they need to begin to communicate with one another at the start of each lesson. As she observes the students' increasing confidence, she gradually reduces both the amount of time that she talks to the class a whole, and the nonverbal energy that she displays as she does so. Having established the common ground necessary "to enable the joint projects of speaker and addressee" (Clark and Grossman, 2001, p. 95), which the students demonstrate through the success of their dyad sessions, she reduces the amount of what she terms *energy*. As such, any reduction in her gestural nodding may not reflect her mood, mental state, or stress level, but rather this conscious teaching choice.

While Research Question 3 focused on the interplay between nodding, mimicry of nodding and specifically the teacher's wellbeing, the teacher's reflections indicate that the learners in her classroom were also positively affected. She pointed to several specific students' nodding to signal their understanding when their partner used new terminology that she had introduced in the previous teaching session as an example of this. She also drew the interviewer's attention to dyads' lengthening engagement with tasks. This may indicate that learners were either increasingly comfortable with their dyad partner, with the tasks that they were undertaking together, or both. Kennedy et al. (2022), which compared how dyads were affected by their teacher's normal nodding behavior during active teaching sessions and when nodding was artificially increased, found that dyads began talking and mirrored one another's posture much sooner, and also leaned toward one another more as teacher nodding increased. While in that study nodding behaviors were increased for research purposes rather than naturally occurring, Arens and Morin (2016) and Granziera et al. (2023) found similar correlations between positive teacher mental states and improved student learning.

Although the teacher's recognition of this lengthening dyad interaction can be seen to contribute to her positive wellbeing levels, the subconscious emotional effects of interlocutor mimicry cannot be overstated. As noted earlier, research has shown correlations between mimicry of behavior, the perception of such mimicry, and feelings of empathy, rapport, affiliation, and interpersonal liking (Chartrand and Bargh, 1999; Lakin et al., 2003; Salazar Kämpf et al., 2018). Because both increases and decreases in her own nodding rate were clearly reflected in student participant nodding, the teacher may have been subconsciously affected by their mimicry, and thereby felt a sense of increased wellbeing.

5.4 Limitations and future directions

There are several limitations that should be noted. Because this study focuses on the nodding behavior and interactions of five members of one class for one 90-minute observation, while the findings are interesting, their generalizability is extremely limited. The focus on one teacher means that any findings may simply be unique to her rather than useful for others. Similarly, the small student sample size limits generalizability. Another failing is that, although there was an opportunity for the behaviors of all 18 class members to be statistically analyzed when this was found to be desirable, because only the four students initially targeted for observation had signed the applicable consent forms, the behaviors of other class members were not able to be quantified. Qualitative data has therefore been relied upon where other class member behavior has been discussed.

It is also important to recognize the role that culture plays in both gestural and backchanneling nodding behaviors, making the teacher and students' differing cultural identities a potentially disruptive factor. Similarly, the timing of backchanneling may be different in Japanese compared to in other languages (Cutrone, 2005) such as English or Mandarin (Kita and Ide, 2007).

Finally, while this study has explored how both teacher and student participant nodding affects teacher wellbeing, some work has found that teacher nonverbal behavior also signals teachers' existing psychological state to their students (Negi, 2009). Such findings emphasize the difficulty of correctly attributing how much of teacher wellbeing is connected to external factors, and how much is in response to the immediate interactions and behaviors within the classroom. Future research, therefore, will work to separate these issues while exploring how other nonverbal behaviors impact teacher-student interactions and wellbeing.

The study described in this article will therefore be undertaken again, with three changes made: First, a suitable sample size will be gathered so as to guarantee that the work will not be underpowered. Next, the teachers chosen for observation will be guided explicitly as to how to evaluate their wellbeing levels and gestural nodding will be analyzed separately from backchanneling nodding so that analysis will be more likely to garner statistically significant results.

6 Conclusion

This paper makes a small contribution to a more comprehensive understanding of how teachers' nonverbal behavior, especially nodding, is connected to teacher professional wellbeing, focusing on the experience of one EFL teacher as she taught a mid-semester 90-minute lesson. While the researchers originally expected that teacher and learners would mimic one another's nodding behaviors, and that such mimicry would correlate positively with the teacher's wellbeing level, how complex the interplay of cause and effect would become was not foreseen. The circular nature of the relationships between gestural nodding, nodding as backchanneling and mimicry of nodding were difficult to unravel. Students were found to mimic the teacher's nodding behaviors, both immediately toward her, and in the following dyad activity toward their discussion partner. The teacher, however, was not similarly affected by student nodding behaviors. She responded to both increases and decreases by nodding more herself due to her interpretation of student nonverbal behavior as signaling a lack of either understanding or interest. Her use of the pedagogical strategy of gradually tapering off 'energy' also contributed to this unexpected finding. When the relationship between nodding behavior and teacher wellbeing level was explored, it was found that the teacher's nodding, used initially to build student understanding and engagement, also impacted student confidence as well as the teacher's own wellbeing level. Interpretation of the teacher's LF and HF data and the LF/HF ratio, and the relationship to teacher nodding behavior was explained by the physical effects of emotional regulation strategies and their effects on wellbeing levels.

Stevick, in a guide written for teachers entering the EFL classroom in 1982, stated that:

> The body language of a teacher is the most important thing in the class…it is the way you use your eyes, the distance you stand from your students […] these unnoticeable things in the class carry important signals which create a profound effect on your students' feelings of welcome and comfort with you (6).

In 2024, some 40 years later, it is evident that in the classroom described in this article that teacher nonverbal communication affects not only the learners, but also the teacher herself. The ways that nodding functions as gesture and backchannel, supports her emotional regulation, and also encourages her when it is mimicked by students, may all be utilized by other teachers to increase their own wellbeing in the classroom.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Kyoto Institute of Technology Ethics Committee for Scientific Research Involving Human Subjects. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

OK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Resources, Visualization, Supervision, Writing – review & editing. NK: Funding acquisition, Writing – review & editing, Conceptualization, Methodology, Data curation. TN: Conceptualization, Writing – review & editing. CF: Conceptualization, 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.

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