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Berdien Vrijders: Conceptualization; Methodology; Investigation; Validation; Formal analysis; Data curation; Visualization; Project administration; Writing – original draft; Writing – review & editing.

Matteo Giletta: Conceptualization; Writing – review & editing.

Tessa Van Gucht: Data curation; Formal analysis; Writing – review & editing.

Silke Paulmann: Conceptualization; Funding acquisition; Writing – review & editing.

Netta Weinstein: Conceptualization; Funding acquisition; Writing – review & editing.

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Getting Under the Skin and Into the Heart: Effects of Parental Tone of Voice on Adolescents' Affective, Behavioral, and Physiological Stress Responses

Abstract

How parents speak (their tones of voice) may matter as much as what they say. Although the role of parental control, relative to autonomy support, has been extensively studied, far less attention has been paid to whether adolescents distinguish between controlling and autonomy-supportive tones of voice and whether such differences affect their affective, behavioral, and physiological stress responses. The present research employed an experimental, multi-method approach to address these gaps. A pilot study among Dutch-speaking adolescents in Belgium (N = 42, M age = 14.69 years; 85.7% boys) established perceptual differentiation between controlling and autonomy-supportive voices, with a controlling tone of voice causing higher self-reported stress and reduced satisfaction of basic needs for autonomy and relatedness. The main study, also conducted among Dutch-speaking adolescents in Belgium, (N = 103, M age = 14.27 years; 54.4% boys) replicated and extended this pattern by showing that a controlling tone of voice elicited higher stress, lower autonomy and relatedness satisfaction, greater defiance and increased resentment towards the speaker. Physiological findings were more tentative and limited to RMSSD (the root mean square of successive differences), a broad metric of heart rate variability (HRV), for which decreases from baseline to exposure to the controlling tone were observed. However, changes in RMSSD did not differ significantly between conditions. No robust moderation effects of perceived parenting style were observed. These findings suggest that adolescents are sensitive to tone of voice, particularly in their affective responses and behavioral intentions, with some preliminary evidence for physiological responding.

Keywords: tone of voice, adolescence, self-determination theory, heart rate variability

During adolescence, youngsters increasingly assert their independence in an effort to differentiate themselves from their parents and develop their own values, preferences, and routines (Steinberg & Morris, 2001; Zimmer-Gembeck & Collins, 2006). Although this growing independence represents a normative developmental process, it can make parental attempts to guide adolescents' behavior more challenging. Because adolescents more easily defy parental requests for cooperation (Van Petegem et al., 2015), parents may struggle to motivate their adolescent children to engage in household chores, get their homework done or clean up their room (Steinberg & Morris, 2001). From the perspective of Self-Determination Theory (SDT; Ryan & Deci, 2017, Ryan et al., 2021), the ways in which parental requests are conveyed are critical. Requests that are experienced as controlling (pressuring, coercive, or demanding) are likely to evoke resistance (Brehm, 1966), while requests that are formulated in an autonomy-supportive manner (supportive of choice and personal volition) increase the likelihood of internalization and willing cooperation (Grolnick et al., 2019; Soenens & Vansteenkiste, 2010).

The vast majority of prior research on the effects of parenting styles toward adolescents is correlational in nature, with studies examining the effects of autonomy-supportive and controlling parenting as broad, composite constructs (Bradshaw et al., 2025; Soenens et al., 2019). However, this work has paid considerably less attention to the role of specific communicative cues through which these interpersonal styles are conveyed, such as tone of voice. Focusing on tone of voice allows for a more fine-grained and experimentally controlled examination of how autonomy-supportive and controlling signals are communicated and received. In the present study, we examine the impact of parents' tone of voice by comparing the effects of a controlling versus autonomy-supportive tone of voice.

We expected that when parents formulate a request using a controlling tone of voice, adolescents' internalization of the request would be hampered, and instead, adolescents may experience greater stress, resentment towards the parent, and even defiance of the request altogether. To explore these expectations, we set up two studies. In a pilot study, we aimed to examine whether adolescents reliably differentiate between autonomy-supportive versus controlling parental voices and to establish preliminary evidence for their effect on self-reported stress and satisfaction of basic needs. The main study then formally investigated whether the effects of tone of voice manifest in a broad set of affective

outcomes (i.e., stress, autonomy and relatedness need satisfaction, resentment) and behavioral intentions (i.e., defiance) while also being reflected in psychophysiological responses (i.e., heart rate – HR - and heart rate variability – HRV). Moreover, the study investigated the extent to which these effects of tone of voice hold regardless of adolescents' perceived autonomy-supportive and controlling parenting at home.

Autonomy-supportive and Controlling Parenting

Parents frequently make requests of their adolescent children in the hope that they will follow rules and take up responsibilities. When asked to undertake non-interesting activities (e.g., household chores), adolescents may be more likely to resist requests, which can lead parents to adopt more pressuring or controlling practices in an attempt to increase compliance (Brenning et al., 2019; Sun et al., 2021). Although controlling practices may yield short-term adolescent compliance, research suggests that adolescents' cooperation is more durable when parental requests are *internalized* – that is, come to be seen as valuable and meaningful by the adolescent – rather than merely complied with (Grolnick et al., 2019; Soenens et al., 2009). This is because adolescents need to experience a sense of ownership over the request such that they engage in the activity more volitionally rather than out of obligation (Vansteenkiste et al., 2018).

Research has shown that controlling strategies, such as intrusive or guilt-inducing behaviors, undermine this internalization process because they thwart adolescents' basic psychological needs for *autonomy* (the need to feel choiceful and volitional in one's actions) and relatedness (the need to feel connected to others, including parents). Evidence for these associations has been reported across Western (Costa et al., 2015), Asian (Vansteenkiste et al., 2005), and Middle Eastern samples (Ahmad et al., 2013).

Alongside favoring short-term cooperation gains over long-term internalization, controlling parenting elicits greater resentment and behavioral resistance toward parental expectations (Grolnick et al., 1997; Vansteenkiste et al., 2014). Although relatively little research has directly examined the effects of controlling parenting on adolescents' stress, a substantial body of work indicates that controlling forms of parenting have important implications for adolescent well-being, as they have consistently been linked to a range of maladaptive outcomes, including difficulties in emotion regulation among Israeli

adolescents (Roth et al., 2009) and various markers of psychological ill-being across diverse cultural contexts that differ in degrees of individualism and cultural hierarchy (Bradshaw et al., 2025).

By contrast, experimental work has shown that internalization is facilitated when individuals are provided with choice, meaningful rationales, and acknowledgement of their perspectives (Deci et al., 1994; Jang, 2008; Savard et al., 2013), strategies that are characteristic of autonomy-supportive parenting and are supportive of adolescents' needs for autonomy and relatedness (Vansteenkiste et al., 2020). In addition to fostering internalization such autonomy-supportive parenting, has been linked to more adaptive emotional functioning in adolescents (Brenning et al., 2015) and higher child well-being (Bradshaw et al., 2025; Neubauer et al., 2021).

Importantly, although autonomy-supportive and controlling parenting strategies have broadly similar implications across cultures, their specific interpretation and relational impact may still vary depending on culturally shaped norms and socialization practices (Soenens et al., 2015). For instance, Chinese adolescents perceived guilt-inducing parental behavior as less controlling than Belgian adolescents and displayed different coping profiles, including higher levels of compulsive compliance. Nevertheless, guilt induction was perceived as more controlling than an autonomy-supportive approach and was associated with negative outcomes in both cultural groups (Chen et al., 2016).

Tone of Voice as a Paraverbal Cue of Autonomy Support and Control

A key feature of autonomy-supportive versus controlling parenting is the way parents communicate, with both verbal and paraverbal features playing a role. First, the verbal content of parental communication, that is, what parents say, may be more or less need-satisfying. For example, providing rationales (Jang, 2008) or using inviting language (e.g., "I ask you "), either when introducing tasks (Baten et al., 2020; Vansteenkiste et al., 2004) or when delivering feedback (De Muynck et al., 2017; Mabbe et al., 2018), supports adolescents' need for autonomy, thereby promoting a deeper absorption in the task at hand. In contrast, issuing commands (e.g., "eat this snack"), coercive language (e.g., "you must") or guilt-inducing language (e.g., "it is for your own good", "you'd better do this") when formulating a request rather undermines this need for autonomy (Reeve & Jang, 2006; Vansteenkiste et al., 2005; Vrijders et al., 2025), thereby hampering the acceptance of the request and instead producing only short-lived compliance and superficial involvement.

At the paraverbal level, emerging evidence suggests *tone of voice* also conveys motivational intent, which can be appraised as rather evaluative and pressuring or rather informational and inviting. Importantly, this implies that autonomy-supportive and controlling parenting practices are not only reflected in what parents say, but also in how they say it, with distinct tones of voice corresponding to these interpersonal styles. Indeed, tone of voice is processed rapidly and automatically (Zougkou et al., 2017), making it a potent relational signal that adolescents use to infer whether a request is autonomy-supportive or controlling before fully processing the semantic meaning.

When examining the acoustic characteristics that distinguish autonomy-supportive from controlling voices in Western samples, both perceptual and acoustic differences have been observed. Autonomy-supportive voices tend to sound softer or smoother, whereas controlling voices are perceived as sharper or harsher (Vrijders et al., 2025; Weinstein et al., 2020). These perceptual differences are reflected acoustically, particularly in voice quality and loudness. A recent meta-analysis of studies comparing the acoustic signature of autonomy-supportive and controlling prosody showed that controlling voices were consistently characterized by greater spectral energy in higher-frequency bands (e.g., 1000–2000 Hz) as well as increased amplitude, whereas differences in pitch and speech rate were small or inconsistent (Vrijders et al., 2026). Autonomy-supportive voices, in contrast, show lower energy in these higher-frequency ranges and a lower volume (Vrijders et al., 2026). Importantly, harsh voice quality, rather than loudness, was found to predict listeners' experienced pressure, that is, the extent to which the voice is perceived as controlling (Vrijders et al., 2025). As such, while amplitude, pitch, and speech rate may contribute to the perception of vocal control, spectral energy appears to be the more consistent acoustic correlate of motivational intent.

A small body of research further suggests that such differences in tone of voice have meaningful psychological implications. In an initial series of studies with British adolescents (Weinstein et al., 2019, 2020), exposure to an autonomy-supportive tone of voice was associated with more positive attitudinal, emotional, and behavioral experiences, including higher feelings of choice, interpersonal closeness, and willingness to cooperate. More recently, tone of voice has also been shown to shape children's basic psychological need satisfaction for autonomy and relatedness, well-being, and relational intentions towards their teachers in a UK-based sample of children and adolescents (Paulmann & Weinstein, 2023).

All of these studies relied on adolescents' self-reported experiences following brief exposure to vocal cues. Together, these findings align with broader SDT research suggesting that tone of voice operates as a micro-level interpersonal cue through which adolescents infer whether a communicator is supportive of their autonomy or exerting pressure.

Despite the promising findings emerging from this line of research, two notable gaps remain. First, it is unclear whether the impact of tone of voice extends beyond adolescents' conscious evaluations and emotional reports to include physiological stress responses. Addressing this question is critical, as controlling communication may function as an interpersonal stressor even in the absence of consciously reported feelings of stress or pressure (see Tseng & Reeve, 2011). Second, although adolescence is a developmental period characterized by an increased need for autonomy and heightened sensitivity to parental control (Soenens & Vansteenkiste, 2010; Steinberg, 2008), adolescents' vulnerability for the effects of a controlling tone of voice may depend on their exposure to a controlling and autonomy-supportive parenting style at home. We discuss both lacunae in greater detail.

Psychophysiological Correlates of Autonomy Support and Control

Because experiences of control and autonomy frustration are theorized to be inherently taxing, exposure to a controlling tone of voice may not only shape affective reactions and behavioral intentions, but also be reflected in stress-related physiological processes, such as autonomic nervous system (ANS) responses. The ANS plays a central role in regulating bodily responses to challenge or stress, including cardiovascular activity. Two commonly used cardiac indicators in this context are heart rate (HR) and heart rate variability (HRV). HR refers to the number of heart beats per minute and can increase under conditions of heightened physiological arousal. HRV refers to variation in the time intervals between consecutive heartbeats and HRV metrics (e.g., high-frequency HRV) are commonly used to characterize cardiac autonomic regulation. In stress-related contexts, increases in HR may reflect changes in autonomic cardiac regulation involving both sympathetic and parasympathetic influences, whereas under appropriate measurement conditions, decreases in HRV, especially in the high-frequency range, may reflect reduced cardiac vagal parasympathetic modulation (Laborde et al., 2017; Quigley et al., 2024; Smets et al., 2019). Although such patterns are not specific to stress alone, they provide useful indicators of rapid autonomic responses to potentially stressful interpersonal cues.

Although the vast majority of prior studies on autonomy-supportive and controlling parenting have mainly included affective, attitudinal, or behavioral outcomes only, a small number of studies have examined physiological responses, including both ANS activity (e.g., HR, HRV) and hypothalamic–pituitary–adrenal (HPA) axis functioning (e.g., cortisol). For instance, Chinese and American children exposed to higher levels of parental psychological control have been found to exhibit greater total cortisol output during laboratory-based stress tasks, reflecting heightened physiological stress (Doan et al., 2017). Importantly, not only global levels of psychological control but also specific controlling strategies appear to matter for physiological regulation. For instance, conditional regard - whereby parental attention is made contingent on adolescents' behavior (Roth et al., 2009) - has been linked to differences in autonomic functioning in U.S. samples. Specifically, negative conditional regard (i.e., withdrawing attention when expectations are unmet) is associated with lower resting levels of HRV, whereas positive conditional regard (i.e., providing attention contingent on desired behavior) is associated with higher resting HRV (Smiley et al., 2020; Sohn et al., 2024). Moving beyond parent–child contexts, experimental work in educational settings has shown that exposure to a controlling, relative to an autonomy-supportive, teaching style is associated with increased cortisol excretion (Reeve & Tseng, 2011).

Despite this growing body of evidence, experimental research directly linking autonomy-supportive versus controlling manipulations to physiological responses remains scarce, particularly with respect to cardiovascular indices such as HR and HRV. Moreover, most studies have focused on broad autonomy-supportive, relative to controlling practices (Reeve & Tseng, 2011), leaving open questions about how more micro-level interpersonal cues, such as the tone of voice of parental requests, affect adolescents' physiological and affective responses. The present study addresses this gap by experimentally manipulating parental tone of voice to examine its influence on adolescents' HR and HRV responses. We focused on these indices because they reflect autonomic stress responses that operate on a rapid timescale, responding within (milli)seconds, and are therefore well suited to capturing physiological changes elicited by social stressors during interpersonal interactions, in contrast to slower HPA-axis responses (Kim et al., 2018; Schubert et al., 2008).

The Moderating Role of Parenting Style

In addition to examining the main effects of controlling versus autonomy-supportive tone of voice, we explored whether adolescents' responses to such situational cues may depend on the broader parenting style they are accustomed to. That is, individual differences in need-relevant experiences at home may shape sensitivity to subsequent autonomy-supportive or controlling contexts. Two contrasting moderating perspectives can be distinguished. First, a (de)sensitization perspective suggests that repeated exposure to a particular parenting style shapes adolescents' perceptual sensitivity to similar cues. That is, through repeated experiences, individuals may become either more attuned to, or less reactive to, certain interpersonal signals, depending on their history of exposure. Adolescents raised in generally need-supportive environments may be especially responsive to autonomy-supportive cues, whereas those exposed to more need-thwarting parenting may be particularly sensitive to controlling events (Moller et al., 2006).

Second, a contrast perspective suggests that situational experiences that deviate from one's typical parenting environment exert the strongest effects. From this viewpoint, adolescents raised in autonomy-supportive contexts may be particularly affected by controlling cues because these violate their expectations, whereas those accustomed to controlling parenting may be less reactive to such cues, as they are normative. Conversely, autonomy-supportive cues may be especially impactful for adolescents from controlling environments, precisely because they represent a positive deviation from what is typically experienced (Gurland et al., 2012; Radel et al., 2011). Indirect evidence for such a match–mismatch pattern comes from research on physiological responding among Swiss adolescents, showing that adolescents' autonomic stress reactivity, indexed by salivary alpha-amylase, to autonomy-supportive versus controlling teaching styles depends on individual differences in autonomy-related dispositions, such that individuals respond more strongly to contexts that deviate from their personal orientation (Sieber et al., 2016). Although this work does not directly address experienced parenting style, it is consistent with the idea that need-relevant experiences shape subsequent sensitivity to autonomy-supportive and controlling cues. These competing perspectives can be understood against the background of the principle of universalism without uniformity (Soenens et al., 2015). Based on this principle, it can be argued that need-supportive contexts are generally beneficial and need-thwarting contexts are generally harmful across individuals, but that the strength of these effects and their way of

manifesting may vary depending on individuals' prior experiences and dispositions (e.g., Mabbe et al., 2016; Mouratidis et al., 2011). Given these competing perspectives and the limited prior research directly examining whether broader parenting experiences shape adolescents' responses to experimentally manipulated tone of voice, we examined the moderating role of perceived parenting style in an exploratory manner.

The Present Research

Given the daily importance of the way parents formulate requests for cooperation, we examined whether parents' autonomy-supportive, relative to controlling, tone of voice affects adolescents' affective experiences and behavioral intentions. We opted for a broad spectrum of outcomes, with self-reported experiences of psychological need satisfaction (autonomy, relatedness), perceived stress, and feelings of resentment towards the speaker serving as affective outcomes, and adolescents' intention to reject the request (i.e., defiance) serving as a behavioral intention. These outcomes were complemented with psychophysiological indicators of stress. Integrating responses across experiential and physiological levels provides a more comprehensive, and bias-free, understanding of the effects of controlling versus autonomy-supportive tones of voice on adolescents. In an exploratory set of analyses, we also examined whether these effects varied as a function of the broader parenting style adolescents are accustomed to.

Specifically, we addressed three research questions.

RQ1. First, we examined whether autonomy-supportive versus controlling tones of voice were associated with differences in adolescents' affective responses and behavioral intentions. We hypothesized that exposure to an experimentally induced controlling, relative to an autonomy-supportive, tone of voice would lead to increased stress, reduced satisfaction of autonomy and relatedness needs, and greater resentment (affective outcomes; Hypothesis 1a), while also eliciting greater defiance of the request (behavioral intention; Hypothesis 1b).

RQ2. Second, we examined whether autonomy-supportive versus controlling tones of voice were associated with differences in adolescents' physiological stress responses, indexed by changes in HR and HRV. We hypothesized that exposure to a controlling tone of voice would be associated with

elevated physiological stress responses, as reflected in increases in HR and decreases in HRV (Hypothesis 2).

RQ3. Third, building on sensitization and contrast perspectives, we explored whether the effects of tone of voice varied as a function of the parenting style adolescents are accustomed to. Specifically, we explored whether adolescents' affective, behavioral, and physiological responses differed depending on the degree to which the situational tone of voice matched versus deviated from their typical parenting environment. Given that sensitization and contrast perspectives yield opposing predictions regarding this moderation effect, no directional hypotheses were formulated for this aim.

To address these research questions, we employed a sequential design. A pilot study first validated the perception of autonomy-supportive and controlling tones of voice and provided preliminary evidence for their effects on adolescents' subjective stress and need experiences. The main study then extended these findings in a larger sample by incorporating physiological indices of stress and a broader set of experiential outcomes. Exploratory analyses examined whether these effects varied as a function of adolescents' experienced parenting style.

Pilot Study

Method

Participants

Forty-two Dutch-speaking adolescents (*M* age = 14.69 years, *SD* = 0.60, *range* = 14-16) participated in this study, the majority of whom were boys (85.7%). Most participants were enrolled in the vocational-oriented (*arbeidsfinaliteit*) educational track (92.9%), with the remainder in the academic-oriented (*doorstroomfinaliteit*) track. A simulation-based sensitivity power analysis was conducted using the fitted multilevel models. With $N = 42$, $\alpha = .05$, and 500 simulations, power to detect a medium within-person effect ($d = 0.50$) ranged from 87.0% to 90.4% across outcomes, whereas power to detect a small effect ($d = 0.20$) ranged from 25.0% to 28.2%. Thus, the pilot study was adequately powered to detect effects of approximately medium magnitude, whereas smaller effects may have remained undetected.

Procedure

Data Collection. Data were collected using an online questionnaire administered during a regular lesson at a Flemish secondary school in Belgium. The study was introduced by the teacher, who distributed an information letter to students and their parents prior to participation. Participation was voluntary and uncompensated, and students completed the questionnaire in the classroom. Informed consent was obtained from parents for their participating child, and adolescents provided assent for their own participation. The study was approved by the ethical review board of Ghent University.

Experimental Materials. Using headphones, adolescents listened to two actor-recorded audio fragments. The fragments depicted two everyday situations: a morning-before-school routine and an evening-after-school routine (see Appendix A, Table A1 for the verbal content of the audio fragments). The scripts were developed to reflect typical parent–adolescent interactions and were evaluated by parents and adolescents for ecological validity. They were designed to be sufficiently long to allow the assessment of physiological responses, while keeping linguistic content neutral. For each type of routine, versions were recorded in both an autonomy-supportive and a controlling tone of voice. Each participant heard two fragments in total – one morning fragment and one evening fragment – with one presented in an autonomy-supportive tone and the other in a controlling tone, such that tone of voice varied within participants. Which routine was paired with which tone, as well as the order of presentation, was randomized across participants.

The verbal content of the fragments was neutral and identical across tone-of-voice versions, ensuring that only vocal tone was experimentally manipulated. At the beginning of the questionnaire, participants indicated which parent they had the most daily contact with (78.60% reported the mother) and were instructed to keep that parent in mind while completing the study. Participants heard either a male or female actor corresponding to the gender of the parent they reported. For both fragments, participants were asked to imagine their parent speaking to them in this manner. The auditory stimuli were developed in collaboration with two professional actors, one male (aged 43 years) and one female (aged 40 years). Following procedures used in previous studies (Vrijders et al., 2025; Weinstein et al., 2018), the concepts of autonomy support and control were explained to the actors. However, they were instructed to deliver the sentences naturally, without being explicitly told how a controlling or autonomy-supportive voice should sound.

Measures

All self-reported items in this study were scored on a 5-point Likert scale, ranging from 1 (*totally disagree*) to 5 (*totally agree*). Self-report measures were assessed after each audio fragment.

Manipulation Check. We examined whether participants perceived differences in speech characteristics between the tone conditions. After listening to the audio fragments, adolescents were asked to indicate whether the speaker used a loud, sharp, fast, or high-pitched voice. To objectively verify the manipulation of the two types of audio recordings (i.e., controlling versus autonomy-supportive tones of voice), four acoustic measures were extracted using customized scripts in Praat software (Boersma & Weenink, 2023). These measures included pitch (i.e., fundamental frequency, measured in hertz), amplitude (measured in decibels), duration (measured in seconds), and voice quality (i.e., energy in the 1000–2000 Hz frequency band, measured in decibels).

Affective Measures

Stress. Adolescents' situational stress was assessed using three items adapted from the pressure/tension dimension of the Intrinsic Motivation Inventory (IMI; Ryan, 1982). The items were adapted to capture adolescents' anticipated feelings of tension and nervousness in response to the parent–adolescent interaction. Each item was framed as "If my parent spoke to me like this, I would …" and ended with "experience stress", "feel uneasy", or "get nervous". Scores were averaged to create a composite stress score. Internal consistency was high (Cronbach's $\alpha = .88$).

Need Satisfaction. Basic psychological need satisfaction for autonomy and relatedness was measured using the Dutch version of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS, Chen et al., 2015). The stem of the scale was adjusted to capture need experiences in the situation (see Van Petegem et al., 2015). Sample items include: "If my mother/father spoke to me like that, I would feel a sense of choice and freedom" (autonomy satisfaction), "I would feel forced to do certain things" (autonomy frustration), "I would feel that my mother/father cares about me" (relatedness satisfaction), and "I would feel rejected by my mother/father" (relatedness frustration). Composite scores for autonomy and relatedness satisfaction were calculated by combining satisfaction items with reversed frustration items. Cronbach's alpha was .86 for autonomy and .87 for relatedness satisfaction.

Analytic Strategy

Preliminary Analyses. First, we examined the effect of sociodemographic predictors (i.e., age, gender, type of education, parent gender) on all outcome variables using linear mixed regression models. Continuous predictors were centered and scaled. Non-significant predictors were removed from subsequent analyses. Subsequently, descriptive statistics and Pearson correlations were computed for all variables.

Primary Analyses. Because tone of voice was manipulated within participants, observations were nested within individuals. Accordingly, linear mixed-effects regression models were fitted using the *lme4* package (Bates et al., 2015) to examine the effects of the manipulated tone of voice.

Results and Brief Discussion

Preliminary Analyses

None of the sociodemographic variables showed significant effects (*ps* > .05). Pearson correlations showed that, at both the within- and between-person level, stress was negatively associated with autonomy (within: $r = -.60$, $p < .001$; between: $r = -.49$, $p < .001$) and relatedness need satisfaction (within: $r = -.63$, $p < .001$; between: $r = -.62$, $p < .001$). Autonomy and relatedness were positively related at both levels (within: $r = .84$, $p < .001$; between: $r = .70$, $p < .001$).

Primary Analyses

Table 1 presents participants' perceptual ratings and the equivalent objective parameters of the tone of voice manipulation. The findings for both types of outcomes produced a consistent pattern of results. Significant differences between the two tone-of-voice conditions were found for three of the four objective parameters: loudness, harshness, and pitch. All three parameters showed higher values in the controlling condition, indicating that the controlling recordings were produced with a louder voice, harsher voice quality, and higher pitch. Two of these objective differences were also perceived by adolescents, who rated the controlling tone of voice as louder and harsher compared to the autonomy-supportive tone of voice. As can be seen in the results presented in Table 3, adolescents reported less autonomy, relatedness, and more perceived stress in response to a controlling tone of voice compared to an autonomy-supportive tone.

Overall, the pilot study provided preliminary support for the effectiveness of the tone of voice manipulation and its associations with adolescents' self-reported stress and need satisfaction, although

the sample was predominantly male, limiting the generalizability of these preliminary findings across gender. In the main study, we aimed to replicate and extend these findings in a more gender-balanced sample by examining its effects on adolescents' physiological responses and a broader range of affective outcomes and behavioral intentions, thereby also addressing the potentially moderating role of parenting differences.

Main Study

Method

Participants

One hundred and seven adolescents participated in this experiment. The sample size was determined based on feasibility considerations. Four of them were excluded because the psychophysiological data was not recorded correctly. As such, the final sample consisted of 103 adolescents (M_{age} = 14.27 years, SD_{age} = .73, $range_{age}$ = 13-16), of which 54.4% were boys. Almost half of the participants were enrolled in the vocational-oriented (*arbeidsfinaliteit*) educational track (43.7%), with the others enrolled in the academic-oriented (*doorstroomfinaliteit*) track.

A simulation-based sensitivity power analysis using the fitted multilevel models (N = 103, α = .05, 500 simulations) indicated approximately 80% power to detect small within-person main effects (d = 0.20; 80.0%–83.8%) and high power to detect medium-to-large interaction effects (d = 0.50–0.80; 88.4%–100%). Power to detect small interaction effects (d = 0.20) was more limited, ranging from 48.8% to 56.8% for the physiological *phase* × *condition* interactions and from 27.2% to 62.4% for the parenting-style moderation models. Thus, small interaction effects may have gone undetected. The study was approved by the ethical committee of Ghent University.

Procedure

Data Collection. Three Flemish secondary schools agreed to participate after being contacted by email or phone. Second-grade students received a brief oral explanation and flyers with a QR code to submit their own and their parents' email addresses. Both students and parents were then sent information on the purpose of the study via email. Given the focus on cardiac autonomic functioning, the presence of cardiovascular or autoimmune diseases served as an exclusion criterion. After parents had provided online consent, students could reserve a participation time slot via an online booking tool.

Students provided assent on the day of participation. Data were collected at schools, in a quiet, dedicated room.

Experimental Design. The study consisted of seven phases (see Figure 1). Participants first completed demographic questions, indicated which parent they had the most daily contact with (81.6% mother) and completed a questionnaire assessing this parent's parenting style. They then viewed a 5-min nature video to assess cardiac ANS activity at rest. Next, participants were presented with the first of two audio fragments, identical to the ones validated in the pilot study, in which a male or female speaker used either an autonomy-supportive or a controlling tone of voice. Tone of voice was manipulated within participants, and the order of presentation was counterbalanced. After this first induction, participants completed a self-report questionnaire assessing perceived tone, defiance, resentment, autonomy and relatedness need satisfaction, and stress. The nature video was then shown again to re-establish baseline measures, followed by presentation of the second audio fragment featuring the contrasting tone of voice condition. Finally, participants completed the same set of questions, this time referring to the second audio fragment. Electrocardiogram (ECG) signals were continuously recorded throughout all phases of the study.

Measures

Depending on the phasing of the experiment, participants filled in a different set of questionnaires. As can be noticed in Figure 1, participants completed baseline questionnaires including parenting style in Phase 1 and questionnaires on manipulation checks, behavioral intentions and affective outcome measures after each experimental induction (Phases 3 and 5).

Parenting Style. Adolescents reported on the parenting style they typically experience in interactions with their parents. Perceived parental autonomy support was assessed using seven items from the Dutch version (Soenens et al., 2009) of the Perceptions of Parents Scale (POPS; Grolnick et al., 1991). Perceived psychological control was measured with the eight-item Dutch version (Soenens et al., 2009) of Barber's (1996) Psychological Control Scale. Responses were given on a 5-point Likert scale ranging from 1 (*completely disagree*) to 5 (*completely agree*). Example items include "My parent lets me choose what I do whenever possible." (autonomy support) and "My parent tries to change my

opinion" (psychological control). Internal consistencies in the current sample were α = .69 for autonomy support and α = .81 for psychological control.

Manipulation Check. Adolescents' perceptions of the acoustic characteristics of the parental voice (e.g., loudness, harshness, speech rate, and pitch) were assessed using the same perceptual measures as in the pilot study.

Affective and Behavioral Measures. Participants completed the same self-report - measures used in the pilot study (i.e., stress, need satisfaction), and also completed additional measures introduced to capture broader affective responses (i.e., resentment) and behavioral intentions (i.e., defiance). Measures used in both studies use the same self-report items as in Study 1. Reliability coefficients for the current sample are α = .92 for subjective stress, α = .89 for autonomy and α = .92 for relatedness.

Resentment. Feelings of resentment were assessed using three items (e.g., "If my mother/father spoke to me like that, I would hold it against them") derived from a scale that has demonstrated good reliability and validity in prior research within the school context (Aelterman et al., 2016). In the present study, internal consistency was acceptable (Cronbach's α = .73).

Defiance. Adolescents' inclination to disregard the parental request was assessed using four items measuring oppositional defiance (Vansteenkiste et al., 2014). An example item is: "If my mother/father spoke to me like that, I would rebel against their rules". This scale has been validated in prior research (Flamant et al., 2023; Vansteenkiste et al., 2014). In the present study, internal consistency was acceptable (Cronbach's α = .73).

Psychophysiological Measures. ECG signals were recorded using a portable 16-channel amplifier (Porti 16-channel; TMSi, Twente Medical Systems International, Oldenzaal, The Netherlands) and Polybench 1.2 software (TMSi; Van Royen et al., 2024). Two disposable Ag/AgCl electrodes (55 mm diameter) were placed below the left clavicle and below the rib, respectively. A ground electrode was placed on the dorsal side of a wristband around the participant's non-dominant hand. Participants were instructed to remain seated and as still as possible throughout the experiment to minimize movement-related artifacts and postural effects.

The ECG signal was digitized at a sampling rate of 1,000 Hz. Data preprocessing and analyses were conducted using ANSLAB, a MATLAB-based software package (Blechert et al., 2016). R-peaks

were detected, and interbeat (RR) intervals were extracted to compute HR and HRV measures. R-peaks corresponding to heartbeats were detected automatically and manually inspected for artifacts. Based on existing guidelines (Laborde et al., 2017), we examined two different HRV indices. Specifically, the root mean square of successive differences (RMSSD) was calculated as a time-domain measure and high-frequency (HF)-HRV was quantified as a frequency-domain measure using autoregressive spectral methods. To determine HF-HRV, age-specific frequency bands were applied as cutoffs (0.15–0.50 Hz; see Shader et al., 2018). RMSSD and HF-HRV were calculated for each relevant segment (i.e., during the baseline neutral movie and during the experimental condition). ECG data from the full duration of each experimental induction were used to compute HR and HRV indices.

Analytic Strategy

Preliminary Analyses. First, we examined the effects of sociodemographic predictors (i.e., age, gender, type of education, parent gender) using linear mixed regression models. Continuous predictors were centered and scaled. Second, manipulation checks were conducted to verify whether the tone-of-voice conditions differed as intended on key perceptual indicators. Third, descriptive statistics and Pearson correlations were computed for all variables. For these correlations, difference scores (experimental − baseline) were computed for the physiological measures to represent changes relative to baseline, with baseline referring to the measurement immediately preceding the experimental phase. This approach allowed the physiological variables to be represented with two condition-specific scores, consistent with the other outcome variables that were assessed once following each condition. Accordingly, linear mixed-effects models were used for all outcomes to account for the nested structure of repeated observations within individuals.

Primary Analyses. Non-significant sociodemographic predictors were removed from the models, whereas routine (morning vs. evening) and order (whether participants first heard the controlling or autonomy-supportive condition) were retained as covariates in all analyses to control for its potential influence. To examine the effects of tone of voice on adolescents' self-reported stress, need satisfaction, defiance, and resentment, which were assessed after each experimental condition (i.e., two observations per participant), we estimated linear mixed models with repeated post-condition measurements nested within participants. These models included random intercepts for participants to

account for between-person differences in overall outcome levels and fixed effects of condition, while controlling for routine and order.

To examine the effects of tone of voice on adolescents' physiological stress responses, which were assessed during both baseline and the experimental phase, we estimated linear mixed models with 4 repeated measurements (baseline and experimental phase) nested within participants. All physiological models included random intercepts for participants. Fixed effects included phase, condition, and their interaction. The phase × condition interaction was included to test whether changes from baseline to the experimental phase differed across conditions. In addition, simple effects of phase within each condition were examined to assess changes in physiological stress from baseline to the experimental phase. Prior to analysis, RMSSD and HF-HRV were log-transformed to reduce skewness. Remaining extreme values (>3 SD above the mean) were winsorized to within 3 SD from the mean. Heart rate was analyzed on the original scale, as its distribution was approximately normal; one extreme value was winsorized to reduce undue influence.

To examine whether effects of tone of voice varied as a function of parenting style, additional exploratory models were estimated including parenting style as a moderator. For emotional and attitudinal outcomes, separate models were fitted for parental autonomy support and psychological control, each including the Condition × Parenting Style interaction as the focal term. For physiological outcomes, separate models were fitted for parental autonomy support and psychological control, each including the Phase × Condition × Parenting Style interaction as the focal term. Significant interactions were probed using follow-up simple slopes analyses.

Results and Brief Discussion

Preliminary Analyses

Findings of the linear regression models showed that across both conditions, girls reported more stress (β = .24, $t(205) = 2.97$, $p = .004$) and less relatedness (β = -.22, $t(205) = -2.88$, $p = .004$) than boys, as well as a higher heart rate (β = .38, $t(387) = 3.50$, $p < .001$), lower RMSSD (β = -.33, $t(387) = -2.96$, $p = .004$) and lower HF-HRV (β = -.21, $t(387) = -2.12$, $p = .04$). Adolescents in an academic-track reported a lower heart rate (β = -.23, $t(387) = -2.16$, $p = .03$) than those in the vocational track. Moreover, adolescents reported more defiance (β = .15, $t(205) = 1.99$, $p = .05$) and had lower HF-HRV (β = -.22,

$t(387) = -2.45$, $p = .02$) when they listened to the male speaker (i.e., most daily contact with dad). No significant effects were found for the other sociodemographic variables (all $ps > .05$).

As shown in Table 1, and largely consistent with results of the pilot study, participants perceived the controlling tone of voice as louder, harsher, faster, and higher-pitched than the autonomy-supportive tone of voice. The manipulation thus successfully captured acoustic features typically associated with controlling communication, in line with prior research on prosodic cues (Vrijders et al., 2024), and provides a sound basis for interpreting the observed psychological and physiological effects.

Table 2 shows descriptive statistics and multilevel Pearson correlations for the parenting style measures and all outcome variables at the between- and within-person level. For the psychophysiological measures, correlations are based on difference scores. At the between-person level, autonomy-supportive parenting was positively related to autonomy, whereas psychologically controlling parenting was negatively related to autonomy and positively related to stress and resentment. Stress, resentment, and defiance were positively correlated with each other and negatively correlated with autonomy and relatedness, which were positively associated. Regarding physiological measures, HR was negatively associated with RMSSD and HF-HRV, which were positively related to each other. With the exception of defiance, which was positively related to HR, affective and attitudinal outcomes were unrelated to physiological measures at the between-person level. At the within-person level, similar patterns emerged for the affective and attitudinal measures, with stress, resentment, and defiance being positively correlated and negatively associated with autonomy and relatedness. For the physiological measures, HR was negatively associated with RMSSD and HF-HRV, which were again positively related. In addition, RMSSD was negatively related to stress, resentment, and defiance and positively related to relatedness, whereas HF-HRV was negatively related to defiance.

Primary Analyses

Replicating the findings from the pilot study, the linear mixed-effects regression models presented in Table 3 (bottom half), indicate that adolescents experienced a controlling, relative to an autonomy-supportive, tone of voice as more stressful and as less autonomy- and relatedness need-satisfying. Extending the findings from the pilot study, adolescents reported more resentment and a

greater intention to defy the parental request in response to a controlling, relative to an autonomy-supportive, tone of voice.

Table 4 presents the results of the linear mixed-effects models examining the Phase × Condition interaction for each physiological outcome. Although the phase × condition interaction was not significant, we examined within-condition changes to assess whether physiological stress responses differed from baseline within each condition. These analyses were theoretically motivated, given our directional hypothesis that controlling parental communication would elicit heightened physiological stress responses. Figure 2 displays the estimated marginal means of RMSSD across phase and condition. These analyses indicated that RMSSD was significantly lower during the experimental phase than during baseline in the controlling tone of voice condition ($t(287) = 2.04$, $p = .04$), whereas no significant change was observed in the autonomy-supportive tone of voice condition ($t(287) = 0.08$, $p = .94$). However, this within-condition change did not differ significantly between conditions and should therefore be interpreted cautiously. Comparable simple effects analyses for HR and HF-HRV did not yield significant differences between baseline and experimental phases in either condition (all $ps > .10$). Together, these findings indicate robust differences in adolescents' affective experiences and behavioral intentions, alongside a more limited and selective pattern of physiological responding.

Moderation analyses revealed that tone of voice did not interact with parental psychological control in predicting study outcomes. Predicting parental autonomy support, a significant interaction with tone of voice was observed for adolescents' defiance ($\beta = .20$, $t(193) = 2.54$, $p = .01$) (see Figure 3). However, given that 16 interaction effects were tested, we applied a Bonferroni correction to account for multiple testing, resulting in a corrected significance threshold of $p < .003$. The interaction between tone of voice and parental autonomy support in predicting defiance did not remain significant after this correction. Thus, the moderation analyses did not provide robust evidence that adolescents' perceived parenting style systematically moderated the effects of tone of voice on the study outcomes. In addition to these moderation analyses, a main effect of psychological control was observed for stress ($\beta = .25$, $t(193) = 3.02$, $p = .003$) and resentment ($\beta = .19$, $t(193) = 2.18$, $p = .03$), indicating that adolescents reporting higher levels of parental psychological control at home also reported higher levels of stress and resentment across conditions during the experiment.

Taken together, the findings replicate and extend the pilot study by showing that a controlling tone of voice not only hampers need satisfaction but also entails greater resentment and a greater intention to defy the parental request. Apart from increasing perceived stress, a controlling tone of voice was also associated with heightened HRV responses (i.e., decreased RMSSD) compared to baseline, although this within-condition change did not differ significantly between conditions. No moderation effects were observed.

General Discussion

The tone of voice with which a message is delivered is an integral component of everyday communication. Yet, research on parent–child interactions has largely overlooked this component. Understanding the impacts of parental tone of voice may be particularly important during adolescence, a developmental period characterized by increasing strivings for independence, during which controlling forms of communication may be especially negatively received (Steinberg & Morris, 2001). Against this background, the present study experimentally manipulated controlling versus autonomy-supportive tone of voice, with the aim of isolating *how* something is said from *what* is said, and examining its effects on adolescents' affective, behavioral, and physiological functioning. In addition, the study explored individual differences in adolescents' sensitivity to these cues by considering the habitual parenting style of parents. Taken together, this study provides a comprehensive picture of adolescents' immediate responses to different vocal communication styles.

First, consistent with Hypotheses 1a and 1b, a controlling tone of voice was associated with higher perceived stress, lower satisfaction of autonomy and relatedness needs, stronger feelings of resentment and a greater inclination to defy parental requests, indicating that adolescents were affected at both the affective level and in their behavioral intentions. Together, these responses suggest "irritated resistance", rather than acceptance of parental requests, suggesting that controlling vocal cues may undermine adolescents' willingness to internalize parental requests. These findings align with earlier work indicating that controlling communication styles are experienced as pressuring and undermining, whereas autonomy-supportive communication fosters acceptance of parental requests by supporting a greater sense of volition (Vansteenkiste et al., 2014). The findings are also consistent with prior research on motivational prosody among British adolescents, which has shown that adolescents perceive

controlling tone of voice as pressuring and report more negative affect and less cooperation after hearing parents intoning controlling messages (Weinstein et al., 2019, 2020).

Second, Hypothesis 2 was not supported with the Phase × Condition interactions being non-significant across all three physiological indices. Nevertheless, a more specific pattern emerged for RMSSD, which decreased from baseline to the experimental phase in the controlling condition, whereas no significant change was observed in the autonomy-supportive condition. This within-condition finding provides tentative evidence that exposure to a controlling tone of voice may be accompanied by changes in short-term cardiac variability, but should not be interpreted as evidence of a robust differential physiological response between conditions. To our knowledge, this is the first study to examine whether adolescents' autonomic regulation is sensitive to differences between controlling and autonomy-supportive tones of voice. The present findings do not establish such sensitivity, but the RMSSD pattern suggests that the question merits further investigation with designs better powered to detect between-condition effects. It may be tentatively speculated that the frustration of adolescents' basic psychological may underlie these cardiac responses (Vansteenkiste & Ryan, 2013). Specifically, a controlling tone of voice may frustrate adolescents' need for autonomy and relatedness by signaling a threat to their sense of volition and interpersonal connection, thereby potentially manifesting through changes in physiological responding.

Earlier experimental work has linked autonomy-supportive versus controlling interpersonal styles to physiological stress markers, with studies among U.S. university students showing that autonomy-supportive teaching is associated with lower cortisol responses, whereas controlling contexts predict heightened cortisol reactivity (e.g., Reeve & Tseng, 2011). Event-related potential (ERP) evidence further shows that controlling tone of voice is processed rapidly at the neural level (Zougkou et al., 2017). Those findings underscore that such vocal cues may be detected quickly and largely automatically. Against this background, the present RMSSD findings tentatively suggest that specific, micro-level parenting practices such as tone of voice may also be accompanied by changes in cardiac activity. This pattern was selective rather than consistent across physiological measures, and we did not observe the between-condition difference that this earlier work would lead one to expect.

Indeed, neither HR nor HF-HRV significantly changed in response to a controlling tone of voice. These null findings are theoretically informative, as they suggest that the effects of controlling tone of voice observed at the self-report level were not accompanied by consistent corresponding changes in these physiological indices. Specifically, the absence of an effect for HF-HRV is important for interpreting the decrease in RMSSD. Although RMSSD is strongly influenced by cardiac parasympathetic activity, it is also affected by sympathetic influences and it represents a broader measure of HRV than HF-HRV (Quigley et al., 2024). Thus, because the within-condition effect emerged for RMSSD but not HF-HRV, such findings are unlikely to specifically reflect parasympathetic withdrawal. Moreover, respiration was not assessed, limiting the interpretation of our HRV metrics as markers of cardiac vagal parasympathetic activity relevant to regulatory processes. Taken together, the physiological findings should therefore be interpreted cautiously and as preliminary and measure-specific rather than as confirmation of a generalized autonomic stress response. Future research with larger samples and more comprehensive autonomic measurement, including respiration, is needed to replicate and extend these findings.

Notably, the association between adolescents' self-reported stress and physiological responses (RMSSD) was modest ($r = -.25$), suggesting that subjective and physiological indicators of stress show some convergence, but also capture distinct aspects of adolescents' responses during the experimental interaction. This finding is not new; prior research indicates that psychological and physiological stress responses are often only modestly aligned, reflecting both shared and distinct underlying processes (e.g., Campbell & Ehlert, 2012; Mauss et al., 2005). Together, these findings highlight the importance of considering both affective and physiological measures to obtain a more comprehensive understanding of adolescents' responses to interpersonal cues.

Finally, in an exploratory set of analyses, we examined whether adolescents' responses to tone of voice varied as a function of the parenting style they are accustomed to. Only one of sixteen interactions reached significance before correction for multiple testing, and this effect did not hold after applying a Bonferroni correction. Thus, we found no robust evidence that adolescents' responses varied systematically across different levels of perceived parental autonomy support and psychological control. One possible explanation is that the use of unfamiliar actors, despite instructions to imagine one's own

parent, may have reduced the personal salience of the messages and attenuated the role of adolescents' broader parenting experiences. At the same time, psychological control predicted a higher stress response and higher resentment, regardless of condition assignment. Further, the somewhat lower internal consistency of the parental autonomy support measure (α = .69) may have reduced sensitivity to detect moderation effects involving this construct. At the same time, sensitivity analyses indicated limited power to detect small moderation effects, although power was high for medium-to-large interaction effects. Thus, smaller moderation effects may have remained undetected, and these findings warrant replication in larger samples.

Strengths and Limitations

This study has several strengths worth noting. A central contribution lies in its ability to experimentally isolate tone of voice as a relational cue, disentangling it from the confounding signals that typically accompany it in natural interaction. By holding verbal content constant and manipulating only the paralinguistic delivery, the study provides a stringent test of whether *how* a message is conveyed is sufficient to shape adolescents' affective and physiological responses, as well as behavioral intentions. This level of experimental precision is rarely achieved in research on parent–adolescent communication and is further strengthened by the inclusion of a pilot study, which allowed for an internal replication of the perceptual distinctiveness of the tone-of-voice manipulation. Together with the multimethod assessment strategy, this design enables strong inferences about adolescents' immediate responses to controlling versus autonomy-supportive vocal cues. As a next step, future research could explore how tone of voice and verbal content operate independently and in combination within parent–adolescent interactions, with both channels of communication possibly jointly shaping adolescents' responses (see Vrijders et al., 2024).

At the same time, the very features that enabled this precision also impose limitations on the ecological validity of the paradigm and, consequently, on the scope of the conclusions that can be drawn. To reliably record HRV responses, the experimental fragments included relatively long, continuous auditory stimulation consisting of extended monologues lasting about 2-3 minutes. While necessary for capturing physiological responses, such uninterrupted speech is less representative of everyday parent–adolescent interactions, which typically unfold as dynamic, reciprocal exchanges. Moreover, the

extended nature of these monologues may have made the exchanges feel more structured or directive than is typical in everyday parent–adolescent communication. Similarly, although the present manipulation was designed to convey autonomy-supportive versus controlling motivational intent and its acoustic profile is consistent with broader evidence on autonomy-supportive and controlling prosody (e.g., Vrijders et al., 2026), related interpersonal meanings such as hostility, anger, or dominance were not assessed separately and therefore cannot be fully disentangled. At the same time, such meanings may naturally co-occur in everyday communication, such that some degree of overlap may reflect the interpersonal complexity of controlling communication rather than a distinct confound.

The use of actors rather than adolescents' actual parents represents a further limitation to ecological validity. Although this choice ensured standardization of the stimuli, it may have attenuated the role of relational history and familiarity that characterizes real-life family communication. At the same time, the fact that adolescents responded to tone-of-voice manipulations even when delivered by unfamiliar actors underscores the potency of tone of voice as a communicative cue. As a result, the present findings are best interpreted as demonstrating the potential that tone of voice, in isolation, has to elicit stress-related and motivational responses, rather than as a direct evaluation of naturalistic parent–adolescent interactions. In terms of generalizability, these findings should be considered most directly applicable to Dutch-speaking adolescents in Belgium who are exposed to brief, experimentally manipulated parental messages. Future research is needed to examine whether similar effects emerge among adolescents from other linguistic, cultural, and socioeconomic backgrounds, and in more naturalistic interaction contexts. Future research could also build on this work by examining tone of voice within other relational contexts in which a single speaker addresses multiple listeners, such as classrooms or sports settings, where the use of real-life speakers may be more feasible.

Conclusion

The present findings identify tone of voice as a consequential feature of parent–adolescent communication that can shape adolescents' affective responses and behavioral intentions, with more tentative evidence for physiological responding. Even in the absence of differences in verbal content, controlling versus autonomy-supportive tones of voice were associated with distinct affective experiences, behavioral intentions, and, to some extent, physiological responses in adolescents. These

results underscore that *how* parents speak to adolescents may meaningfully shape adolescents' moment-to-moment experiences and may, over time, have implications for the quality of the parent–child relationship and adolescents' well-being.

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Table 1. *Descriptive Statistics and Results of Linear Regressions for Acoustic Cues*

Table 2. *Descriptive Statistics and Within- (above diagonal) and Between- (below diagonal) Person Pearson Correlations for Study 2*

Table 3. *Means and Standard Deviations per Condition and Results of Linear Mixed Models for Situational Outcomes*

Table 4. *Results of Linear Mixed Models for Physiological Outcomes (Study 2)*

Figure 1. Experimental design.

Figure 2. Estimated Marginal Means of RMSSD Across Phase and Tone of Voice Condition

Figure 3. Estimated Marginal Means of Defiance by Condition and Parental Autonomy Support

Appendix A

Experimental Stimuli Used in Pilot and Main Study

Table A1.

Audio Excerpt Presented to Adolescents

Morning routine	Evening routine
It is Monday morning. The weekend is over and a new school week begins. Good morning. It's time to wake up and get back into the school routine. It's already half past seven, so we need to pick up the pace a bit. Get out of bed and start your day. Don't forget to open the curtains as well, so some daylight can come into your room. And open the windows too, to let in some fresh air. It's important to ventilate your room properly. I'm going downstairs now to set the table for breakfast. Will you come downstairs as well so we can have breakfast together? It's a good way to start the day and get some energy for the school day. We can also briefly talk about what's on the agenda and make sure you're ready for a new week.	**The day has passed. You come home in the evening after school.** How was your day today? Did you experience anything interesting at school? Will you put your things away? Your shoes belong in the shoe cabinet, and your bike should be put in the garage. Make sure you empty your backpack and put it neatly in its place. You can put your lunch box on the counter. If you feel like it, there is some cake in the fridge. Or you can take a piece of fruit. I also just made some tea, so go ahead and have a cup. After you've had a moment to unwind, you can start on your homework. It's important to do that on time; then you'll have the rest of the evening free.
It's time to have breakfast… Will you come to the table? Breakfast is ready. Put your smartphone away for a moment. It's too early to already be scrolling. All that screen time isn't very healthy. It's time to eat now. You can take whatever you feel like, but don't forget to drink at least a glass of water. It's important to stay well hydrated, especially on school days. So make sure you don't forget to take your water bottle with you to school today. And speaking of lunch, remember to prepare your sandwiches. Try to make a balanced choice, and not just go for chocolate spread, okay? I bought cheese especially for you. You'll need your lunch box for that. I saw that it's still in the cupboard, so go and get it. It would also be a good idea to take some fruit	**Your mom/dad wants you to start working on your homework.** You really need to start your homework now. Putting it off doesn't help; you'll have to do it anyway. So it's better to get started right away, even if you're not looking forward to it. It's understandable that homework isn't always the nicest part of your day, but it's simply part of it. Do you remember everything you need to have finished by tomorrow? If not, take a look at your planner. It's useful to have an overview of what needs to be done and how much time it will take. It's good to have a realistic schedule, so you don't stay up too late and get enough rest. I see that you have a test tomorrow, so it's definitely important to get started. If you find something difficult, that's okay. It means

with you for the break. There are apples and bananas in the fruit bowl on the counter. It's a healthy addition to your lunch and gives you some extra energy. Could you pick up the pace a bit? If you keep going at this speed, you might end up being late for school. Remember to put your plate and knife in the dishwasher when you're finished, that makes cleaning up a bit easier. If you brush your teeth afterwards, you'll be almost ready to leave. They're predicting bad weather today, so put on an extra sweater as well. Backpack with you? Okay, see you this evening!	you're learning something new. If you really don't understand it, you can ask a classmate or the teacher tomorrow. Or I can also try to help you. After your homework, we'll have dinner together. It's important to find a good balance between work and relaxation. So let's make sure you finish your homework efficiently, so that afterwards we can enjoy a pleasant meal together. **You have finished your homework. It is now time for dinner.** It's time to eat. Will you come and sit at the table? How did your homework go? Are you ready for the test tomorrow? Go ahead and serve yourself. Just make sure you eat what you take. And don't forget to take enough vegetables; they're good for your health. Put your smartphone away during dinner. What could be so important that it can't wait? You can always reply to your friends again after dinner. It's good to take some distance from screens from time to time and really enjoy the moment. Will you clear the table before you leave? Put the plates in the dishwasher. The glasses can go in the sink; they still need to be washed. It's a small task, but it helps keep things tidy. Afterwards, you can watch TV.

Note. The original audio fragments were presented in Dutch. The texts below provide English translations of the verbal content