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An Investigation of Patients' and Doctors' Autonomic Nervous System Responses Throughout News-Focused Medical Consultations

Marta Vigier[a,b*], Katherine R. Thorson[c*], Elisabeth Andritsch[d], and Andreas R. Schwerdtfeger[a,e]

[a]Department of Psychology, University of Graz; [b]Department of Neurobiology, Linköping University; [c]Department of Psychology, Barnard College of Columbia University; [d]Division of Oncology, Medical University Graz; [e]BioTechMed

ABSTRACT

Although it is clear that people experience physiological arousal in anticipation of news-focused medical consultations, our knowledge of people's experiences during and throughout these consultations is scarce. We examine interbeat interval responses (IBI) of patients and doctors during real-life medical consultations to understand how the experiences of both parties change throughout these encounters and whether they differ from each other. We also examine how the type of news delivered affects responses. We measured the IBI responses of patients and their oncologists throughout 102 consultations in which providers delivered news (classified as good, bad, or status quo) to patients about a recent computerized tomography scan. We observed two distinct phases of consultations: an initial "news" delivery phase and a subsequent "information" phase. During the news phase, on average, patients' IBI responses rapidly increased–indicating less autonomic arousal over time – whereas doctors' responses did not change over time. In contrast, throughout the information phase, on average, both patients' and doctors' responses remained steady. During the information phase, responses differed based on news type: on average, status quo consultations involved an increase in autonomic arousal, whereas good and bad news consultations involved no changes. Lastly, we observed significant variability in patients' responses during both phases. In sum, on average, patients (but not doctors) experience decreases in autonomic arousal while news is being delivered, suggesting that anticipatory distress regarding these consultations wanes quickly. However, our results also indicate that patients' experiences vary from one another, and future research should focus on factors explaining this variability.

Consultations between patients and their doctors can be psychologically distressing for both parties, especially when doctors have to deliver news to patients about their health (Bensing et al., 2008; Del Piccolo et al., 2019; Van Dulmen & Bensing, 2002). Leading up to such consultations, patients worry about the kind of news they will receive, and doctors worry about how they will deliver the news and manage patients' emotions (Brown et al., 2009; Del Piccolo et al., 2019; Howell & Sweeny, 2016; Shaw et al., 2013; Van Dulmen et al., 2007). Although it is clear that people experience distress and physiological arousal in anticipation of news-focused medical consultations (Hoscheidt et al., 2014; Van Dulmen et al., 2007), our knowledge of people's experiences during and throughout these consultations is scarce. Understanding these experiences is important for developing techniques that support patients' accurate receipt of news, as well as patients' and doctors' emotional well-being both during and after such consultations (Hoscheidt et al., 2014; Jagosh et al., 2011; Ong et al., 2000; Schwabe et al., 2012; Street et al., 2009; Tyng et al., 2017).

Some research on this topic has examined simulated medical consultations, during which real doctors or medical students interact with standardized patients (people playing the role of patients, potentially with scripted language) or are viewed by analog patients (people instructed to take the perspective of real patients, while rating videotaped medical consultations between doctors and actors in the roles of patients), but these studies are limited. For one, the responses of standardized and analog patients are unlikely to be exactly the same as those of real patients, given that people's expectations about how they will feel and act in response to hypothetical social situations do not always align with their experiences and behaviors in response to the real social situations themselves (Eastwick et al., 2008; Kumar & Epley, 2021; Moore et al., 2019). Secondly, past work on the experience of health care providers when delivering news to standardized or analog patients is unlikely to have fully captured the experiences of health care providers when delivering real news to real patients. Indeed, research on medical consultations in general suggests that providers' experiences are more intense when interacting with real patients (Bokken et al., 2009).

Therefore, to improve our understanding of both patient and provider experiences during news-focused medical consultations, in the current work, we examine the autonomic nervous system (ANS) activity of patients and their oncologists throughout 102 consultations in which providers delivered

CONTACT Marta Vigier marta.vigier@edu.uni-graz.at Department of Psychology, University of Graz, Universitätsstraße 27/1, Graz 8036, Austria; Katherine R. Thorson kthorson@barnard.edu Barnard College, Columbia University, 3009 Broadway, New York, NY 3009

The method section of this manuscript contains some parts that appeared in our previous work (Vigier et al., 2021).

*Shared first co-authorship.

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news to patients about a recent computerized tomography (CT) scan. We focus on the ANS responses of patients and doctors because they are responsive to quick changes in psychological experiences. They can also be measured continuously and unobtrusively throughout doctor-patient consultations, and they do not require people to consciously assess their psychological experiences, which would be particularly challenging while engaging in an ongoing social interaction (Blascovich et al., 2011). We measure cardiac interbeat intervals (IBI), which indicate general autonomic arousal. We investigate whether patients' and doctors' ANS responses change over the course of these consultations and whether response trajectories differ as a function of the type of news being delivered (good, bad, or status quo). We elaborate on these questions below.

Changes over the course of consultations

In this work, we examine whether and how patients' and doctors' ANS responses change over the course of news-focused medical consultations. Although it is clear that patients and doctors experience significant physiological arousal directly prior to consultations and during consultations, relative to a baseline period (Deinzer et al., 2019; Pottier et al., 2011; Van Dulmen et al., 2007), it is not clear how patients' and doctors' ANS responses change throughout these consultations. We examine these temporal trends because knowledge about the trajectory of patients' physiological responses could inform and guide providers during these consultations. For example, if patients show similar levels of autonomic arousal throughout an entire news-focused consultation, this may suggest that they are not recovering psychologically from the stress of anticipating or receiving news. Thus, providers may find it best to simply deliver news and then help the patient cope with the news rather than, for example, ask the patient to make decisions about future treatment plans (Morgado et al., 2015). Knowledge about the trajectory of doctors' responses could also be useful. For example, during high-arousal states, doctors often tend to ignore patients' emotional cues (Helft & Petronio, 2007). Thus, understanding when and whether doctors recover from the high-arousal moments of news delivery might help structure the rest of these consultations in ways that maximize doctors' recognition of patients' emotions.

Only a few studies examine how people's responses change over time during news-focused medical consultations. This work has compared people's physiological responses during the "news" phase of consultations (the first few minutes when news is being delivered) to the "information" phase of consultations (the rest of consultations when doctors provide more information about future treatment options). For patients, there is one study that takes this approach, using analog patients. Here, the evidence for changes across these phases is mixed. Although skin conductance levels and systolic blood pressure declined from the news phase to the information phase, heart rate increased from the news phase to the information phase (Visser et al., 2016). For doctors, two studies documented significant decreases in heart rate and skin conductance between the news and information phases (Meunier et al., 2013; Shaw et al., 2015). We aim to build on this work by using a relatively large sample of real patients and doctors during real consultations to examine how people's ANS responses change from minute-to-minute (and not just from one phase of a consultation to the next) throughout these interactions.

In addition, we build on past work by examining whether the type of news that is being delivered affects the trajectory of patients' and doctors' ANS responses. We investigate three news types: 1) "good" news, when doctors informed patients about positive evolution in their health status, like for example tumor-shrinking; 2) "bad" news, when the disease progressed or metastasized to other organs, often involving a transition to palliative, instead of curative care, and 3) "status quo" news, when the disease was classified as stable, for example, with a tumor neither shrinking nor growing since the last scan. These news types differ in the ways they are communicated and received (e.g., Maynard et al., 2016; Shaw et al., 2013), but, to our knowledge, no research has examined whether they differ in patients' autonomic experiences. Several studies on simulated consultations have investigated doctors' responses when delivering bad news relative to delivering good news or no news at all (for example, during history taking (Shaw et al., 2013). In general, doctors tend to show stronger sympathetic nervous system arousal (e.g., higher heart rate, higher cardiac output, and higher systolic blood pressure) when they have to report bad news (Hulsman et al., 2010). This occurs both in anticipation of consultations and while delivering the news (Brown et al., 2009; Cohen et al., 2003; Meunier et al., 2013; Van Dulmen et al., 2007). We build on past work by examining all three news types in comparison to each other, and we examine the influence of news type for both patients and doctors.

Overview of current research

As noted above, we examine the ANS activity of patients and their oncologists throughout 102 real consultations in which providers delivered news to patients about a recent CT scan. We measure ANS responses via cardiac interbeat intervals (IBI; the amount of time in between successive heartbeats). In general, medical consultations have a well-established structure with a typical sequence of events: 1) openings/greetings, 2) discussion of symptoms, 3) discussion of results, 4) discussion of treatment options, and 5) closings/end (Byrne & Long, 1978; Heritage & Maynard, 2006; Robinson, 2003). News-focused medical consultations, in particular, tend to differ from the typical structure of medical consultations more generally and often include two phases: a "news phase", in which doctors deliver results from the CT scan and an "information phase", in which doctors provide further details about future treatment options (Shaw et al., 2013; Visser et al., 2016). Two reasons for this difference are that, in news-focused medical consultations, 1) the focus is explicitly on news delivery (and not on symptoms, for example) and 2) both providers and patients are eager for news delivery to occur (which means that openings and greetings are often extremely brief (Espinosa et al., 1996; Shaw et al., 2015). Therefore, mirroring past work on news-focused medical consultations specifically, in the current work, we anticipated two distinct portions of consultations: the news

and information phases. We examine changes in patients' and doctors' physiological responses throughout the news and information phases, as well as whether the trajectories of responses in these phases differ from each other.

News phase

We assumed that both patients and doctors would begin consultations with greater autonomic arousal than is typical of a resting level, given the anxiety and uncertainty that often characterizes waiting periods (Shaw et al., 2015; Sweeny, 2018; Sweeny & Cavanaugh, 2012). For patients, we predicted that this arousal would quickly dissipate once the consultation actually began, uncertainty was reduced, and patients were in the presence of their doctor who could provide information and potentially help regulate their emotions. Thus, we predicted increases in IBI responses (corresponding to less ANS arousal) during the news phase for patients. We explored whether these responses for patients varied as a function of news type, but, given the lack of prior data, we did not have strong hypotheses. For doctors, we expected that their IBI responses would differ as a function of news type during the news phase. Given prior work, we predicted that doctors' IBI responses would show an upward trajectory (corresponding to less autonomic arousal) when delivering good news relative to bad news or status quo news (Brown et al., 2009; Cohen et al., 2003; Meunier et al., 2013; Van Dulmen et al., 2007), as doctors might be able to relax a bit while delivering good news that hopefully calmed patients' worries.

Information phase

Given mixed evidence (Visser et al., 2016), we did not have strong hypotheses about patients' IBI responses during the information phase. For doctors, we expected that, on average, their IBI responses would increase (reflecting a decrease in their arousal) during the information phase, knowing that doctors' arousal tends to decrease after they deliver news to patients (Meunier et al., 2013; Shaw et al., 2015). We explored whether patients' and doctors' responses during the information phase varied as a function of news type, but, given the lack of prior data, we did not have strong hypotheses.

Variability in temporal trends

Lastly, we examined whether there was significant variability in how patients' and doctors' ANS responses unfolded over time, after accounting for the roles of time and news type. In other words, are there meaningful between-person differences in how patients and doctors respond over time? For example, do all patients follow a similar trajectory of IBI responses throughout their consultations? Or do their trajectories vary from one another? We used multilevel models to quantify variability in responses over time (Bolger et al., 2019). Understanding whether variability exists in average temporal trends has several key benefits. One, it can indicate whether other factors might be associated with how people's responses change over time (Dart et al., 2002; Hu et al., 2017). Identifying those sources can then help improve the explanatory and predictive power of theoretical models. Two, this information provides useful context for applying knowledge. For example, if patients vary in their arousal across the course of consultations, this suggests that some patients may need greater regulatory help from their doctors. Identifying the factors that distinguish patients who need extra regulatory help from those who do not would then be an important next step before applying knowledge about these temporal trends in real-life consultations.

Method

Study method and results are reported following the Strengthening the reporting of observational studies in epidemiology checklist (STROBE).

Participants

Participants were recruited from the oncology unit of University Hospital Graz, Austria. Inclusion criteria included fluency in German or English and being 60 years of age or younger, given age-related differences in ANS activity (Lipsitz & Novak, 2013). Exclusion criteria included a diagnosis of cardiovascular disease, diabetes, or pregnancy. We selected eligible patients from a database of patients at the unit and sent them an informational recruitment letter. We also called the patients a few days later to ask if they were interested and/or had any questions. Interested patients participated during the consultation that followed their next CT scan. During a weekly doctors' meeting, we also presented information about the study to eligible doctors. Only doctor-patient dyads in which both the doctor and patient agreed to partake in the study were enrolled.

Doctors and patients were matched based on which doctor was available at the time of the patient's appointment. Patients did not select a doctor when making an appointment, nor did they know ahead of the appointment with whom they would be meeting. Between April, 2017, and March, 2018, we recruited and collected data from 150 patients and 18 doctors.

The data from 48 doctor-patient combinations were excluded because there were excessive artifacts in the physiological data (see below), we experienced technical problems obtaining the data, or the doctor-patient consultations lasted fewer than five minutes. The final dataset includes 18 doctors (M_{age} = 41.06, SD_{age} = 7.83; 61.1% male; 38.9% female; 100% White European) and 102 patients (M_{age} = 52.12, SD_{age} = 6.42; 39.2% male; 60.8% female; 99% White European, 1% Asian), yielding data for 102 unique doctor-patient dyads. Information regarding sample socioeconomic status was not collected.

Procedure

Prior to consultations, participants were fitted with an electrocardiography (ECG) Holter monitor (Schiller Holter MedilogAR). Three Ag/AgCl electrodes were placed on the distal end of the right clavicle, lower left rib cage chest, and lower abdomen. Given the nature of doctors' schedules (fast-paced, with little to no time in between consultations), we were not able to collect resting "baseline" responses prior to consultations. In addition, given the stress that patients feel even upon arrival at the hospital (prior to any consultation even starting), any responses collected prior to the consultations would be unlikely to be true resting responses anyway. We continuously recorded ANS responses from patients and

doctors during their consultations, which ranged between five and thirty-three minutes. We allowed all consultations to unfold naturally and did not intervene during the consultations at all–for example, we did not request or require that doctors and patients follow a specific sequence (e.g., news delivery and then discussion) during the consultations. Senior doctors, who supervised all other doctors in the hospital unit in which these data were collected, confirmed that all consultations involved presentation of news regarding the most recent scan within the first few minutes (the "news phase") and then discussion of that information for the rest of the consultation (the "information" phase). On average, consultations lasted 13.54 minutes ($SD = 7.12$; $Min = 5.0$, $Max = 33.0$).

Both doctors and patients were seated during the interactions. Doctors completed a demographics questionnaire upon enrolling in the study, and patients completed this questionnaire after their consultation. The ethics committee of the Medical University of Graz approved the study (EK-Number: 29–287 ex 16/17). Participants provided informed consent prior to data collection.

Measures

Interbeat interval responses

Data were sampled at a rate of 1,000 Hz. We analyzed the ECG data with Kubios HRV Premium software (version 3.3.1 (Tarvainen et al., 2014)) in one-minute intervals. Visual artifacts correction was performed on the IBI series, and, if needed, an automatic correction algorithm was applied. Intervals containing more than 5% of artifacts or excessive ectopic beats were excluded. In total, 12.6% of IBI responses were marked as missing. We report raw IBI responses.

News valence

Doctors classified the news delivered in the consultation as bad (11.8%), good (52.9%), or status quo (32.4%; 2.9% missing data). Doctors categorized information as "bad" when a CT scan revealed metastases (i.e, the spread of disease to another part of the body) or that a patient's status had changed from curative to palliative (i.e., there was no chance for remission). The doctors labeled the news as "good" when the results confirmed an improvement in a patient's health status (e.g., a positive change in cancer staging due to a tumor shrinking). The doctors gave status quo news to patients remaining in similar health status, meaning that no change due to treatment or evolution of the disease was observed.

Covariates

In a sensitivity analysis, we examined whether effects were robust when adjusting for gender, age, smoking status, and exercise status, all of which can influence ANS activity (Dart et al., 2002; Hu et al., 2017; Lipsitz & Novak, 2013) We also adjusted for patients' cancer stage, cancer type, and the number of times that a patient had met with a particular doctor.

Smoking status. Participants were identified as ex-smokers (5.6% of doctors; 25.5% of patients), smokers (27.8% of doctors; 24.5% of patients), or nonsmokers (66.7% of doctors; 50.0% of patients).

Exercise status. Participants answered the following questions: "During a normal week, do you practice regular physical activity (e.g., brisk walking, jogging, cycling) long enough to work up a sweat? If yes, how many hours on average per week?" We categorized participants' answers as no exercise at all (16.7% of doctors; 53.9% of patients), fewer than 3 hours weekly (44.4% of doctors; 0% of patients), between 3 and 6 hours weekly (27.8% of doctors; 26.5% of patients), more than 6 hours weekly (11.1% of doctors; 19.6% of patients).

Cancer stage. Patients' cancer stages were classified by doctors based on TNM (Rosen & Sapra, 2023) classification as follows: stage 1 (44.1%), stage 2 (4.9%), stage 3 (17.6%), and stage 4 (33.3%).

Cancer type. Doctors classified patients' cancer types as follows: colorectal (46.1%), breast (39.2%), pancreatic (8.8%), lung (3.9%), and prostate (2%).

Relationship length. We measured the number of times that a patient had met with a particular doctor via patient records ($M = 3.5$, $SD = 2.8$). The minimum relationship length was one consultation, meaning that the consultation during which we measured physiological responses was the first consultation between a particular patient and doctor. The maximum relationship length was 12 consultations.

Results

Additional analytic details and results are provided in the Supplemental Material (SM). At the request of doctors who participated in the study, all participants were told that raw data would remain confidential and would not be shared; however, the analysis syntax for all models is available at https://osf.io/qhuwt/. Higher numbers for IBI responses indicate more time in between successive heartbeats and less autonomic arousal; therefore, increases in raw IBI responses indicate decreases in autonomic arousal and vice versa.

First, we visually examined mean IBI responses for doctors and patients across each time point of the consultations. Corresponding to our hypotheses, we noticed an initial trend for patients (minutes 1 through 3) that clearly differed from the trend throughout the rest of consultations (see SM). Doctors also appeared to have this pattern (with an initial response that peaked around minute 2), though it was not as strong. To best approximate these different trends in our model, we used a piecewise regression model, also called a spline, segmented, or broken-stick regression, in which we estimated different slopes for different phases of consultations. This approach is useful when there are non-linear longitudinal trends in data that cannot be approximated using polynomials alone.

While inspecting our data, we also noticed that responses after 20 minutes seemed to follow a different pattern relative to the initial phase, and we noted that fewer than 20% of participants had consultations lasting longer than 20 minutes. Given this information, we chose to analyze the first 20 minutes of consultations only. We did this to ensure that the different trends which seemed to occur from minutes 21 to 33 (and which represented data from fewer than 20% of our

participants) would not unduly influence the average estimate that was provided for all participants across minutes 3 through 20.

Thus, given our visual inspection of the data, we estimated one slope for minutes 1 through 3 (the "news" phase; three timepoints) and one slope for minutes 3 through 20 (the "information phase;" 18 time points). Instead of one linear term for time, this means that we estimated two linear terms for time: one during the news phase and one during the information phase. We also conducted a sensitivity analysis to see whether our results were consistent if we estimated the news slope from minutes 1 through 2 and the information slope from minutes 2 through 20, given that this also seemed a plausible way to differentiate the two temporal trends in the raw data. Results were consistent across both specifications (see below).

We conducted two sets of analyses. First, we tested whether the slopes for the news and information phases were significantly different from zero (i.e., whether there was evidence of change over time), as well as whether role (patient or doctor) and type of news (bad, good, or status quo) affected these slopes (see the SM for details on slope coding). We did this by entering news phase, information phase, role, and news type as predictors, as well as the following interaction terms: role*news phase, role*information phase, news type*news phase, news type*information phase, news type*role*news phase, and news type*role*information phase. For ease of understanding, we report the results for each phase separately.

Second, we tested whether the slopes for the news and information phases were significantly different from each other (i.e., whether there was a different trajectory over time in the news phase relative to the information phase), as well as whether role and type of news affected the difference between these phases. To do this, we use the same terms as above, but change the coding of the information phase slope (see the SM for details).

Finally, we tested whether people exhibited significant variability in their slopes during the news and information phases – in other words, is there significant variability in the temporal trajectory of people's IBI responses over time?

We used multilevel modeling with PROC MIXED in SAS 9.4 to adjust for nonindependence in responses between patients of the same doctor and between the same doctors (similar to the reciprocal one-with-many-design with indistinguishable partners described in (Hagiwara et al., 2014; Kenny & Kashy, 2011), between members of the same doctor-patient dyad, and across time for each person. We describe the variance-covariance parameters we used in the supplement. We use the results of these variance parameters to address our questions about variability in temporal trends of IBI responses (i.e., whether there is significant variability in the extent to which IBI responses change over time). We report this information for each phase separately.

News phase

Participants' IBI responses significantly increased across the first three minutes of consultations ($b = 23.97$, $SE = 3.16$, $t(112) = 7.58$, $p < .0001$, $R^2 = 33.9\%$; see Figure 1). However, these trends varied significantly by role (patient vs. doctor; see Figure 1; $F(1, 70.7) = 43.84$, $p < .0001$, $R^2 = 38.3\%$). Patients' IBI responses significantly increased across the first three minutes of consultations ($b = 42.59$, $SE = 4.38$, $t(84.3) = 9.73$, $p < .0001$, $R^2 = 52.9\%$) but doctors' responses did not change ($b = 5.34$, $SE = 4.08$, $t(28.5) = 1.31$, $p = .20$, $R^2 = 5.7\%$). The trajectory of IBI responses in the news phase did not vary by news type ($F(2, 216) = 0.48$, $p = .62$, $R^2 = 0.4\%$) nor by an interaction between news type and role ($F(2, 137) = 0.52$, $p = .60$, $R^2 = 0.8\%$).

The variance parameters showed significant variability in the temporal trajectory of patients' IBI responses in the news phase – in other words, patients varied significantly in the extent to which their IBI responses changed across the first three minutes of their consultations ($\tau = 471.84$, $SE = 159.15$, $Z = 2.96$, $p = .002$; see Figure 2). This result indicates that there were differences, from patient to patient, in how IBI responses changed over time during the news phase. There was no

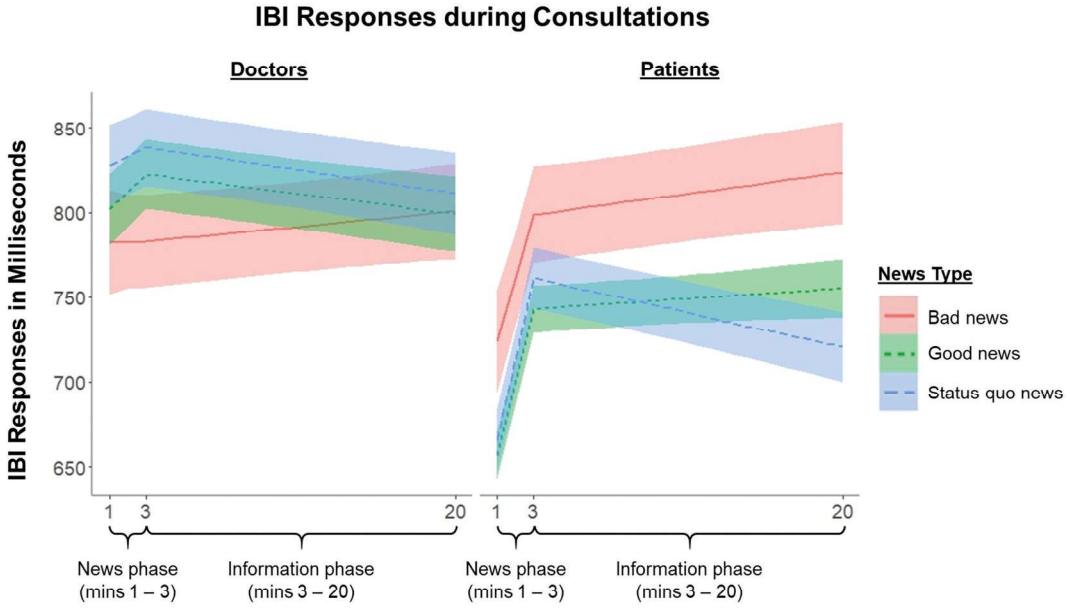

Figure 1. Average model-predicted temporal trends for patients and doctors. Note. Bands indicate standard errors.

significant variability in how doctors responded over time during the news phase but because our sample size of unique doctors was low ($n = 18$), we advise caution with these findings. There was no significant variability in doctors' responses, averaged across all of their patients, over time: $\tau = 54.30$, $SE = 66.11$, $Z = 0.82$, $p = .21$, nor was there significant variability in doctors' responses, from one dyadic interaction to another dyadic interaction, over time: $\tau = 2.35$, $SE = 79.93$, $Z = 0.03$, $p = .49$, see Figure 2.

Information phase

Participants' IBI responses, on average, did not significantly change during the information phase of consultations ($b = -0.36$, $SE = 0.37$, $t(152) = -0.97$, $p = .33$, $R^2 = 0.6\%$). In contrast to the news phase, this pattern did not vary by role (patient vs. doctors, $F(1, 95.7) = 0.81$, $p = .37$, $R^2 = 0.8\%$). However, this trend did vary by news type ($F(2, 156) = 5.88$, $p = .004$, $R^2 = 7.0\%$). During consultations in which good or bad news was reported, people's IBI responses did not change over time (good news: $b = -0.34$, $SE = 0.56$, $t(194) = -0.60$, $p = .55$, $R^2 = 0.2\%$; bad news: $b = 1.26$, $SE = 0.74$, $t(118) = 1.71$, $p = .09$, $R^2 = 2.4\%$). However, during consultations in which status quo news was reported, people's IBI responses declined over time (indicating greater autonomic arousal; $b = -1.99$, $SE = 0.61$, $t(184) = -3.27$, $p = .001$, $R^2 = 5.4\%$). These patterns did not differ as a function of role (meaning that news type did not also interact with role to predict the change in IBI responses across the information phase of consultations [$F(2, 98.4) = 2.07$, $p = .13$, $R^2 = 4.0\%$]). The pattern of responses over time during status quo consultations significantly differed those during good news consultations ($F(1, 189) = 4.04$, $p = .046$, $R^2 = 2.1\%$) and during bad news consultations ($F(1, 141) = 11.55$, $p < .001$, $R^2 = 7.6\%$).

The variance parameters we estimated showed significant variability in the temporal trajectory of patients' IBI responses in the information phase – in other words, patients varied significantly in the extent to which their IBI responses changed across the information phase of their consultations ($\tau = 4.88$, $SE = 2.74$, $Z = 1.79$, $p = .037$; see Figure 3). This result indicates that there were differences, from patient to patient, in how IBI responses changed over time during the information phase. We did not find significant variability in how doctors responded over time during the information phase; we could not estimate variance in the information phase slope for doctors as a parameter (neither for variability from doctor to doctor nor for variability from one dyadic interaction to another dyadic interaction) so, in the predicted model, all doctors had the same slope over time in the information phase. However, again, we caution against over-interpreting these findings as our sample size of unique doctors was low ($n = 18$).

News phase relative to information phase

In a second set of analyses, we examined whether the trajectory of people's IBI responses during the news phase differed from the

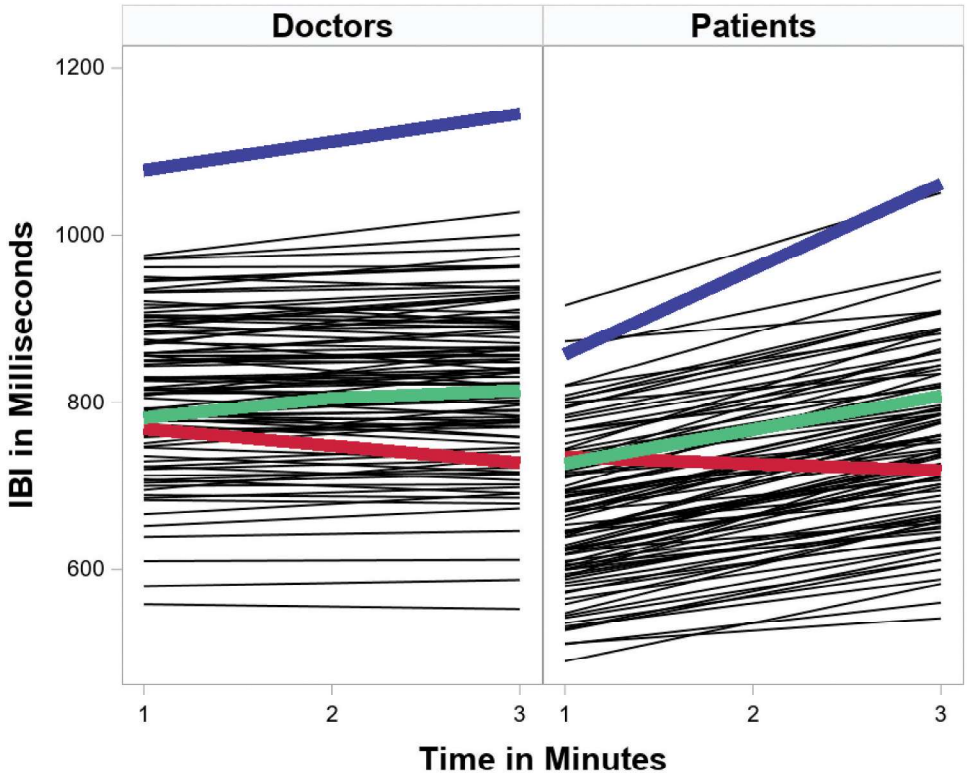

Figure 2. New phase: Spaghetti plot showing model-predicted temporal trends for individual patients and doctors. Note. Each line indicates the model-predicted trajectory for an individual participant during the news phase. The slopes in color represent the most positive slopes over time (blue), median slopes over time (green), and most negative slopes over time (red).

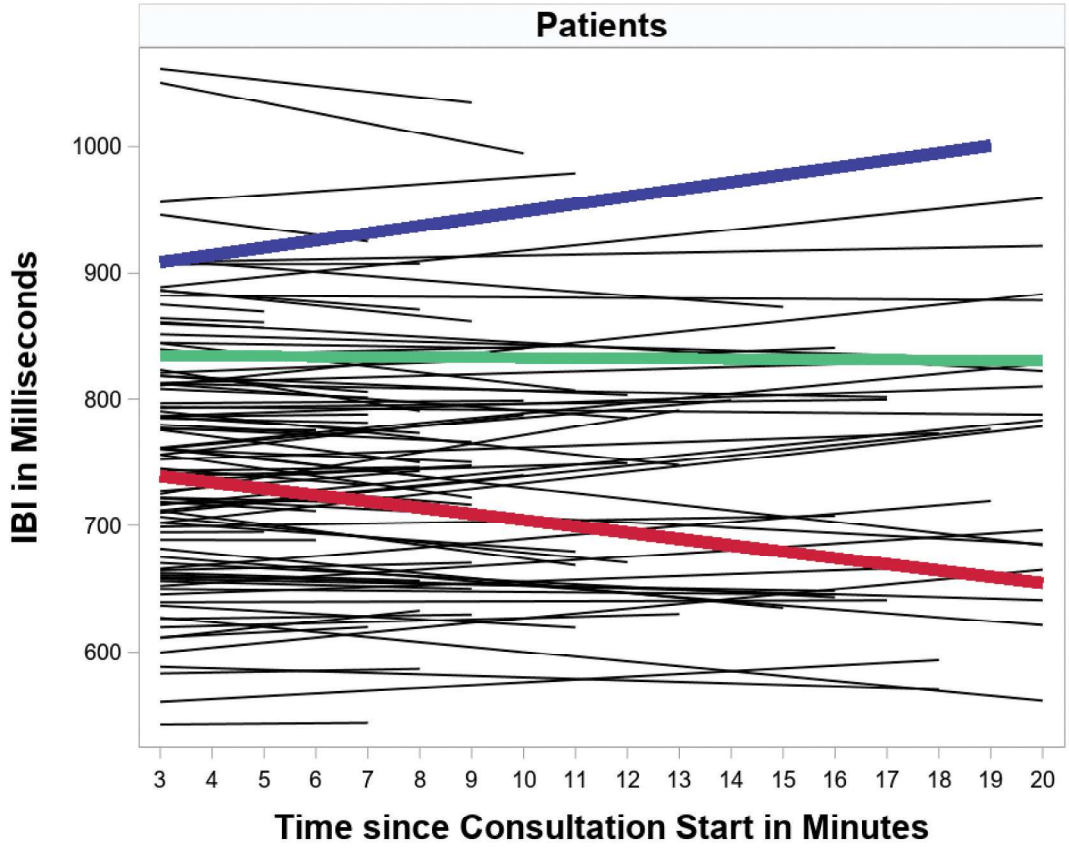

Figure 3. Information phase: Spaghetti plot showing model-predicted temporal trends for individual patients. Note. Each line indicates the model-predicted trajectory for an individual patient during the information phase. The slopes in color represent the most positive change over time (blue), median change over time (green), and the most negative change over time (red).

trajectory of people's IBI responses during the information phase. This is different from the prior set of analyses in that the following analyses test whether there was a significant change in the slope from the news phase to the information phase (i.e., are people's responses over time different in the news phase relative to the information phase), whereas the prior analyses test whether the news and information phase slopes were significantly different from zero (i.e., do people experience significant changes over time in either the news or information phases).

The average trajectory of IBI responses during the news phase differed from the average trajectory of IBI responses during the information phase ($F(1, 262) = 62.85$, $p < .0001$, $R^2 = 19.3\%$), and this difference was moderated by role (patient vs. doctor: $F(1, 167) = 43.55$, $p < .0001$, $R^2 = 20.6\%$). For patients, the change in slope from the news phase to the information phase was significant, $b = -42.65$, $SE = 4.52$, $t(85.1) = -9.42$, $p < .0001$, $R^2 = 51.0\%$; a positive slope characterized the news phase ($b = 42.59$, $p < .0001$) whereas a steady slope characterized the information phase ($b = -0.07$, $p = .90$). For doctors, the change in slope from the news phase to the information phase was close to a conventional level of statistical significance but did not surpass it ($b = -6.77$, $SE = 3.71$, $t(736) = -1.83$, $p = .068$, $R^2 = 0.4\%$); a steady slope characterized both the news phase ($b = 5.34$, $p = .20$) and the information phase ($b = -0.65$, $p = 0.15$). The difference in the average trajectory of IBI responses during the news phase relative to the average trajectory during the information phase did not differ significantly as a function of news type ($F(2, 263) = 0.77$, $p = .46$, $R^2 = 0.5\%$) nor as a function of news type by role ($F(2, 168) = 0.82$, $p = .44$, $R^2 = 0.9\%$). In sum, the primary change that occurred from the news phase to the information phase was that the trajectory of responses for patients leveled out. Although we found that the trajectory of IBI responses did not differ by news type in the news phase but did differ by news type in the information phase, this difference was not statistically significant.

Sensitivity analyses

In one sensitivity analysis, we examined whether effects were robust when adjusting for people's gender, age, smoking status, and exercise status, as well as patients' cancer stage, patients' cancer type, duration of the appointment, and the number of times that a patient had met with a particular doctor. When including these covariates, all results are consistent with the ones presented above; full results are listed in the SM.

In a second sensitivity analysis, we estimated the news slope from minutes 1 through 2 and the information slope from minutes 2 through 20. We did this because this also appeared to be a plausible way to differentiate the two temporal trends in the data. All results were consistent with the ones presented above; full results are listed in the SM.

Discussion

In the current work, we examined changes in ANS activity of patients and their oncologists during real-life medical consul-

tations in which doctors reported and discussed patients' recent scan results. We investigated whether responses changed over time during two phases of the consultations (the news phase and the information phase) and whether the changes varied as a function of role (patient vs. doctor) and the type of news that patients received (bad, good, status quo). Three primary findings emerged. One, patients' arousal diminished during the news phase and was then steady throughout the information phase, whereas doctors' responses were steady during both of these phases. Two, people showed significant differences in arousal trajectories in the information phase based on news type. Responses declined (indicating greater autonomic arousal) after the delivery of status quo news, but remained steady after the delivery of good and bad news. Three, there was significant heterogeneity in patients' responses during both the news and information phases, meaning that patients varied in the extent to which their physiological responses changed across these phases; we did not observe significant heterogeneity among doctors in their responses in either phase of the consultations.

Regarding the first primary finding – that patients' arousal diminished during the news phase – we think this reflects a change in patients' anticipatory anxiety and uncertainty, which dissipate once news is delivered. In combination with other work documenting the anticipatory anxiety that patients feel leading up to news-focused medical consultations (Falkenstein et al., 2020; Sweeny & Falkenstein, 2015), these data suggest that patients experience a rapid release from these high-arousal, anticipatory states. It is almost as though patients "recover" from their anticipatory stress during these first few minutes, somewhat similar to the way that people recover from a stressor in the lab (Buske-Kirschbaum et al., 2002; Childs et al., 2006). Future research might try to more precisely target the factors that cause these quick changes. For example, are these decreases in ANS arousal facilitated by the presence of patients' doctors (after waiting alone) or by feeling more certain once news is received? Regardless of the cause, these results suggest that doctors should wait to deliver additional information, for example, about changes in treatments, or to ask patients to make important decisions until after this initial arousal has subsided, as patients may better process information at that point (Medendorp et al., 2017; Sep et al., 2014; Visser et al., 2017).

For doctors, the steady trends throughout consultations probably indicate that they remain at a similar level of attentiveness and vigilance throughout the entire consultation. Future work might consider whether these trends match people's subjective experiences and whether they are associated with short- and long-term emotional well-being surrounding treatment (for patients) and their profession (for doctors).

In the information phase, we observed that both patients' and doctors' responses did not significantly change over time. We interpret this finding to mean that once initial news has been delivered to patients, on average, patients' and doctors' arousal does not fluctuate during the rest of this type of consultation. In addition, we found some evidence that people's experiences varied as a function of news type during the information phase. Specifically, patients' and doctors' arousal increased over time when status quo news was discussed, compared to good and bad news, where arousal remained steady. This may be because status quo news carries greater uncertainty about what to do next, which can be anxiety-provoking (Beach, 2021). Status quo news may also be associated with greater cognitive load, as patients and doctors carefully consider which path to take next. We are cautious about overinterpreting these findings regarding news type during the information phase, though, because we did not observe that news type played a significantly different role in the news phase vs. the information phase.

Our second primary finding – differences in arousal trajectories in the information phase based on news type – aligns with research showing that the delivery of status quo news often differs from the delivery of both good news and bad news. One reason for this is that good and bad news tend to be perceived similarly by everyone: good news is desirable; bad news is undesirable. Status quo news, on the other hand, tends to be perceived differently by doctors and patients: doctors consider status quo news as similar to good news, but patients do not (Beach, 2021; Maynard et al., 2016; Singh et al., 2017). Disagreement over the meaning of status quo news, along with the inherent uncertainty of status quo news, mean that status quo consultations can be difficult to navigate. For instance, doctors try to present status quo news in a positive light, trying to convince patients that it is positive, while recognizing that patients are unlikely to see it that way (Maynard et al., 2016; Singh et al., 2017). In response, patients can resist and question doctors' perspectives, expressing uncertainty and confusion about the meaning of the news and future courses of action (Beach, 2021). Thus, the finding we observed here – that autonomic arousal increased over time for status quo consultations but remained steady for good news and bad news consultations – may be due to the increased interactional complexity of status quo consultations. Future work might attempt to directly tie certain interactional features (e.g., more question-asking on the part of patients) to changes in autonomic responses to better understand this association. In addition, future work might explore whether the level of agreement between doctors and patients in their perception of news shapes autonomic responses. In the current work, doctors classified news, but the extent to which doctors and patients differ in their classifications might also be tied to people's responses.

Regarding our third primary finding – specifically, that patients exhibited significant variability in their responses over time in both the news and information phases–there are several factors that might contribute to this variability. Stress appraisals, social support, length of illness, and uncertainty tolerance may all play a role in how patients' experiences unfold during these consultations and are all worthwhile targets for future research on this topic (e.g., Blascovich & Mendes, 2000; Goodyke et al., 2021). One goal of such research might be to search for predictors of reduced arousal, in order to develop interventions that, alongside reducing ANS arousal, might also help improve patients' recall of information received during the consultation, their prognostic awareness, and their emotional well-being (Danzi et al., 2018; McColl-Kennedy et al., 2017; Van Osch et al., 2014). Regardless of the factors associated with changes in ANS arousal, the finding

that there is significant variability in patients' experiences is important because it suggests that a "one-size-fits-all" approach is not appropriate for doctors when thinking about how to communicate news to patients (for example, see also Lee et al., 2002; Van Dulmen, 2011). The variability shown here means that patients react to news quite differently and doctors must take that into consideration when approaching these consultations.

Strengths and limitations

A major strength of this study is that we examined trends in doctors' and patients' arousal throughout real-life consultations in a highly distressing context (oncology appointments). To our knowledge, this is the first study that examined real patients' responses during real consultations and which examined real doctors' responses while interacting with real patients. We consider this worthwhile because what happens in real social interactions where the stakes are high is often very different from what happens in imagined, scripted, or hypothetical social interactions (Carey et al., 2020; Kumar & Epley, 2021; Moore et al., 2019).

Another strength of this work is that we evaluated how people's ANS responses change from minute-to-minute throughout news-focused consultations. This is in contrast to previous work which has averaged physiological responses across the entire consultation or across different phases (Meunier et al., 2013; Shaw et al., 2015; Visser et al., 2016). By taking a more fine-grained approach, we were able to investigate not only how people's physiological responses changed between different phases of the consultation but also how their responses fluctuated throughout those phases as well. This is important given that changes in people's responses may be stronger predictors of their future affect and behavior than average levels of those experiences (Carver & Scheier, 1990).

Lastly, by using a multilevel modeling approach to analyze these data, we were also able to examine variability in the primary effects that we reported. This is important because it highlights important targets for future research: given that patients exhibit significant variability in their physiological responses over time during these consultations, future research would do well to examine the kinds of factors that create this variability.

Of course, our study also has several limitations. First, the type of news that patients received was only classified by doctors; thus, patients' experience regarding the valence of this information might differ (Beach, 2021; Christakis & Lamont, 2000; Cupit-Link et al., 2018; Singh et al., 2017). Second, we did not evaluate subjective experiences – like stress, negative affect, perseverative thinking, or prognostic awareness – and so we do not know whether changes in physiological arousal were associated with changes in subjective experiences as well (Blascovich & Mendes, 2000; Brown et al., 2009). Third, due to the nature of the clinical routine, we were not able to collect resting "baseline" responses prior to consultations, however, given the stress that patients feel even upon arrival at the hospital (prior to any consultation even starting (Okazaki et al., 2009), any responses collected prior to the consultations would be unlikely to be true resting responses anyway. Fourth, in our data, 20% of consultations lasted longer than 20 minutes. Although we did not have the statistical power to examine what happened at the ends of these longer consultations, future work might consider doing that.

Lastly, based on research on news-focused medical consultations specifically, we anticipated two distinct phases of consultations: a news phase and an information phase. We observed evidence of these two distinct phases within the average trajectories of physiological responses over time. We also confirmed with senior doctors in the hospital unit in which these data were collected that all consultations focusing on the results of CT scans include these two phases in that order. However, future work should use additional methods (e.g., audio recordings or detailed post-consultation reports from doctors and patients) to get more specific information about what happened during the consultations, the length of the different phases for each individual consultation, and whether additional phases (e.g., discussion of symptoms) existed and, if so, when.

Conclusion

In this study, we examined trends in patients' and doctors' ANS activity throughout news-focused medical consultations. We found that patients' arousal decreased over the news phase and remained steady during the information phase, whereas doctors' physiological responses remained rather stable across both the news and information phases of the consultations. Moreover, patients showed significant heterogeneity in their responses during both the news and information phases. These results indicate that patients and doctors experience news-focused medical consultations differently from each other and that patients' experiences change dynamically over the different phases of the consultations. These data suggest that consultations should consider how patients' physiological responses change across sessions in order to allow optimal delivery of information and to support patients' well-being. In addition, they suggest that research into the factors that influence the wide range of patients' experiences during such encounters is needed.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Credit author statement

Marta Vigier: Conceptualization, Methodology, Project administration, Investigation, Data Curation, Visualization, Writing – Original Draft. Katherine R. Thorson: Conceptualization, Methodology, Formal Analysis, Resources, Data Curation, Visualization, Writing – Original Draft. Elisabeth Andritsch: Resources. Andreas R. Schwerdtfeger: Supervision, Writing – Review and Editing, Resources.

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ORCID

Marta Vigier http://orcid.org/0000-0002-2307-4411
Katherine R. Thorson http://orcid.org/0000-0003-1528-1071

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