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Individual Differences in Sadness Coherence: Associations With Dispositional Affect and Age

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The current laboratory-based study examined individual differences in sadness coherence (i.e., coherence between objectively coded sad facial expressions and heart rate in response to a sad film clip) and associations with dispositional affect (i.e., positive and negative affect, extraversion, neuroticism) and age in a sample of younger and older adults. Results showed that (a) greater sadness coherence was associated with lower dispositional negative affect (i.e., greater positive to negative affect ratio; lower neuroticism) and (b) older adults had greater sadness coherence than younger adults. Findings remained stable when controlling for covariates. Results were specific to coherence characterized by an inverse association between heart rate and facial expressions of sadness (i.e., did not emerge for absolute changes in heart rate or skin conductance), specific to sad facial expressions (i.e., did not emerge for happy facial expressions), specific to stimulus (i.e., did not emerge for sadness coherence in response to a happy film clip), generalized across overall levels of emotional responding (i.e., sad facial expressions; heart rate reactivity), and remained stable when controlling for expressive suppression. These findings demonstrate that individuals who exhibit greater sadness coherence experience more favorable dispositional affect, consistent with evolutionary-functionalist models of emotion, and that sadness coherence is higher in late life, consistent with developmental accounts of heightened reactivity to loss in late life.

Keywords: sadness, response coherence, dispositional affect, age

Emotions can be defined as involving coordinated changes among different response systems, including subjective emotional experience, behavior, and physiology, and the coordination between them is often referred to as response coherence (Ekman, 1992; Levenson, 1994; Scherer, 1984). Individuals differ substantially in the degree to which different response systems cohere during emotional responding, and an emerging literature base has documented that these individual differences in response coherence are linked to real-world outcomes of adaptation (Brown et al., 2019; Lohani, Payne, & Isaacowitz, 2018; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Mauss et al., 2011; Sommerfeldt, Schaefer, Brauer, Ryff, & Davidson, 2019; Sze, Gyurak, Yuan, & Levenson, 2010).

Building on this work, the present laboratory-based study examined individual differences in response coherence (i.e., between objectively coded sad facial expressions and heart rate in response to a sad film clip) during sadness responding and links with (a) dispositional affect and (b) age in a sample of younger and older adults. We focused on sadness as an emotional response to an irrevocable loss (Lazarus, 1991) and as an emotion that plays an important part in our everyday lives (e.g., Stone, Schwartz, Broderick, & Deaton, 2010).

Focus on Individual Differences in Response Coherence

Dating back to Darwin (1872), affective scientists have been interested in how different response systems (i.e., subjective emotional experiences, behavior, physiology) cohere (e.g., Mauss et al., 2005; Sze et al., 2010) or are concordant (e.g., Hollenstein & Lanteigne, 2014) during emotional responding. Many emotion researchers may share the view that average levels of coherence across response systems are quite low during emotional responding (Barrett, 2006; cf. Levenson, 2014). Whether specific emotions

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manifest in specific patterns of behavioral or physiological changes has been debated (e.g., Levenson, 2011; McGinley & Friedman, 2017), with a recent meta-analysis showing no evidence for autonomic specificity (Siegel et al., 2018).

The present study builds on a less controversial proposition, which has received more empirical support. Regardless of how response coherence has been conceptualized and measured (e.g., using between-individual vs. within-individual approaches; see Mauss et al., 2005), studies have revealed substantial individual differences in response coherence. For example, studies have uncovered individual differences in the coherence between experience and behavior (Mauss et al., 2005; Rosenberg & Ekman, 1994), experience and physiology (Lohani et al., 2018; Mauss et al., 2011; Sommerfeldt et al., 2019; Sze et al., 2010), and behavior and physiology (Marsh, Beauchaine, & Williams, 2008). Researchers have also become interested in whether these individual differences have meaningful real-world correlates. Specifically, are individual differences in response coherence linked to dispositional affect (e.g., Brown et al., 2019), or do younger and older adults differ in their degree of response coherence (e.g., Lohani et al., 2018)?

Individual Differences in Sadness Coherence: Links With Dispositional Affect

Sadness is a negative emotion and it may thus seem surprising to expect a positive link between sadness coherence and favorable dispositional affect (e.g., experiencing high levels of positive and low levels of negative affect in daily life). Negative emotions such as sadness feel unpleasant (Adolphs, Russell, & Tranel, 1999), are often deemed undesirable (Tsai, Knutson, & Fung, 2006), and are a hallmark of low well-being and mental health when chronically activated (Diener, 2006). Yet, evolutionary-functional perspectives hold that all emotions—positive and negative—are fundamentally adaptive as they help individuals manage situational demands (e.g., Ekman, 1992; Levenson, 1994). Sadness in particular can help individuals deal with loss and aid in letting go of unattainable goals (Nesse, 2000; Wrosch & Miller, 2009), motivate them to seek help (Hackenbracht & Tamir, 2010; Levenson, 1999), and elicit sympathy and prosocial behavior from others (Frijda, 1986; Lazarus, 1991). In fact, laboratory-based studies show that older adults who respond with greater levels of sadness have a higher ratio of positive to negative dispositional affect (Haase, Seider, Shiota, & Levenson, 2012) and greater levels of social connection (Lwi, Haase, Newton, Shiota, & Levenson, 2019).

Greater response coherence could be linked to greater well-being (cf. Brown et al., 2019; Mauss et al., 2011; Sommerfeldt et al., 2019) because individuals are thought to manage situational demands most effectively when multiple response systems cohere during emotional responding (Levenson, 1994, 2003, 2014). Expressing sadness on the face in particular may help individuals communicate that they need support and sympathy (e.g., Lwi et al., 2019) in moments of physiological change (e.g., heart rate deceleration) that promote an orienting response (Stekelenburg & van Boxtel, 2002) or attend to others' suffering and compassion (Stellar, Manzo, Kraus, & Keltner, 2012; for a review, see Goetz, Keltner, & Simon-Thomas, 2010). Individuals whose response systems function such that they exhibit greater coherence may be able to manage situational demands more effectively. Over time, they may reap benefits in the form of more favorable affect (Levenson, 2014). It is also possible that greater coherence of response systems (e.g., between behavior and physiology) indexes higher levels of functioning in the peripheral or central nervous system, for example in brain regions involved in affective functioning and interoceptive signaling (Pollatos & Schandry, 2004). Higher levels of functioning in these brain regions (e.g., in the salience network) in turn have been linked to greater well-being and lower psychopathology (Uddin, 2015).

There is also empirical evidence showing that higher levels of response coherence are linked to more favorable dispositional affect. Specifically, greater coherence (between experience and facial expressions) during amusement responding has been linked to lower levels of depression and greater levels of life satisfaction (Mauss et al., 2011) and greater coherence (between experience and physiology) during overall emotional responding has been linked to higher levels of life satisfaction and lower levels of anxiety and depression (Brown et al., 2019). Another study examined response coherence during sadness and found lower levels of coherence (between facial expressions and physiology) in boys with disruptive behavior disorders compared to healthy controls (Marsh et al., 2008). Together, these findings hint toward a positive association between sadness coherence and favorable dispositional affect.

Individual Differences in Sadness Coherence: Links With Age

Emotional aging researchers have long been interested in age differences in sadness reactivity (Kunzmann & Grühn, 2005; Tsai, Levenson, & Carstensen, 2000). As individuals age, they experience loss and decline in many life domains (e.g., health, Yashin et al., 2007; social relationship partners, Wrzus, Hänel, Wagner, & Neyer, 2013). Theoretical frameworks, such as the theory of discrete emotional aging (Kunzmann, Kappes, & Wrosch, 2014) posit that, with age, individuals show elevated levels of sadness reactivity because they may be more attuned to experiences of loss, may appraise situations as irrevocable loss more readily, and may be more motivated and able to respond to loss (see also Haase et al., 2012). Previous studies support this view and show maintained or higher levels of sadness responding in older compared to younger adults in the experience of sadness (Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011), sad facial expressions (Lwi et al., 2019; Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006), and physiological activation (Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Kunzmann & Grühn, 2005) during sadness responding.

Heightened sensitivity to loss in late life may also manifest in heightened levels of response coherence during sadness responding. This idea was proposed relatively recently (Wu, Bae, Svoboda, & Haase, 2017; Lohani et al., 2018) and builds on the assumption that older adults may be able to deal with situational demands of loss particularly effectively compared to younger adults, resulting in higher sadness coherence (cf. Carstensen, Isaacowitz, & Charles, 1999). Few empirical studies have tested this proposition, but one study by Lohani and colleagues (2018) showed that older adults had greater experience-physiology coherence than younger adults when watching loss-themed film clips.

Together with other studies showing heightened level of sadness responding in late life (e.g., Kunzmann & Grühn, 2005; Seider et al., 2011), these findings support the idea that older adults may show greater coherence during sadness responding compared to young adults.

Methodological Considerations

Finally, when studying response coherence and links with adaptation and age, several methodological issues need to be considered (see Levenson, 2014).

Behavior–Physiology Coherence

Previous studies of response coherence have often focused on coherence between experience and behavior (e.g., Mauss et al., 2005; Reisenzein, Studtmann, & Horstmann, 2013) or experience and physiology (e.g., Lohani et al., 2018; Mauss et al., 2011; Sze et al., 2010) and less on the coherence between behavior and physiology (the present study focus). This may not be surprising given the important role of subjective emotional experience in emotional functioning (Barrett, Mesquita, Ochsner, & Gross, 2007). Yet, "bottom–up" evolutionary-functionalist views of emotions afford behavior and physiology a central role in the emotion activation process (e.g., Ekman, Levenson, & Friesen, 1983; Levenson, 2011, 2014) and studies have shown meaningful individual differences in the degree to which behavior and autonomic physiology cohere during emotional responding (e.g., Lohani et al., 2018; Mauss et al., 2011).

Measuring Physiology

In previous studies of response coherence, heart rate (or period) has been the most commonly analyzed physiological measure (e.g., Lohani et al., 2018; Sze et al., 2010). Heart rate or period (a) provides useful information on moment-to-moment changes in cardiac activity (Obrist, Webb, Sutterer, & Howard, 1970) during emotional responding (Cacioppo, Tassinary, & Berntson, 2016; Saul, 1990) and is thus well-suited for indexing response coherence on a second-by-second basis and (b) is a powerful visceral signal that is linked to a cortical response (i.e., heartbeat-evoked potential; Schandry, Sparrer, & Weitkunat, 1986). Previous studies of coherence have also relied on heart rate alone (e.g., Sze et al., 2010), which raises the question of whether findings will extend to other measures of autonomic physiology with skin conductance as another prominent candidate (e.g., Mauss et al., 2005).

Measuring Behavior

Previous studies of response coherence that have analyzed facial expressions to index behavior have used either electromyography, which offers unparalleled sensitivity (e.g., Lohani et al., 2018), or objective coding by trained raters, which allows for examining specific facial expressions of emotions (e.g., sad facial expressions using the Expressive Behavior Coding System; Marsh et al., 2008). When analyzing facial expressions of emotions, it is important to note that base rates can be low. For example, participants may not express sadness in response to sadness-eliciting stimuli (e.g., Seider et al., 2011), which, in fact, may drive response incoherence (see also Reisenzein, Bördgen, Holtbernd, & Matz, 2006; Reisenzein et al., 2013).

Determining Coherence Scores

Previous studies of response coherence at the within-subjects level (see Levenson, 2014) determine coherence scores by examining cross-correlations between response systems (e.g., physiology and behavior). These studies (a) use 10-s lags (e.g., Lohani et al., 2018; Mauss et al., 2005, 2011; Sze et al., 2010) based on definitions of emotions as short-lived phenomena (Levenson, 1994) with 10 s as a meaningful upper bound of lags between response systems (Lohani et al., 2018) and (b) index coherence based on the highest cross-correlation during these 10-s lags as the "most accurate index of association among responses" because it accounts for potential differences in lags across individuals (Mauss et al., 2011, p. 740). Lohani and colleagues (2018) evaluated the validity of this approach by examining average lags across response systems and concluded that "it is clearly detecting systematic response-system coherence" (p. 9).

Links With Dispositional Affect and Age

When examining links with indicators of dispositional affect and age, it is important to consider how these concepts are operationalized. To measure dispositional affect, researchers have used (a) positive and negative affect as well as their ratio (Fredrickson & Losada, 2005; Haase et al., 2012) as measured by the Positive and Negative Affect Schedule (PANAS; Watson & Clark, 1994) as important dimensions of happiness (Gruber, Mauss, & Tamir, 2011) and subjective well-being (Ozer & Benet-Martínez, 2006) and (b) extraversion and neuroticism as measured by the Big Five Inventory (BFI; John & Srivastava, 1999) as important affect-relevant (Costa & McCrae, 1980; Larsen & Ketelaar, 1991) and broadly adaptive (Soto, 2019) personality traits. To measure age differences, researchers often rely on comparisons of younger and older adults (e.g., Lohani et al., 2018).

The Present Study

The present laboratory-based study examined coherence (i.e., between facial expressions and autonomic physiology) during sadness responding and its links with dispositional affect and age in a community sample of younger (aged 20–35) and older (aged 55–70) adults. Drawing from prior research (e.g., Brown et al., 2019; Lohani et al., 2018), we hypothesized that greater levels of sadness coherence would correlate with greater positive than negative dispositional affect and that older adults would show greater levels of sadness coherence than younger adults.

The present study sought to follow best practices in response coherence research (Levenson, 2014). First, as recommended and similar to previous studies (e.g., Mauss et al., 2005), we used a within-subjects design to measure coherence (i.e., by assessing emotional responses continuously, taking into account 10-s time lags, and using the maximum cross-correlation in this time window to account for individual differences in response lags). Second, as recommended (Levenson, 2014) and similar to previous studies (Marsh et al., 2008), we examined 30-s windows of peak emotional responding focusing on a sad film clip and (to determine specificity) a happy film clip (Johnson et al., 2017). Third, as in prior coherence studies (e.g., Lohani et al., 2018; Mauss et al., 2005; Sze et al., 2010), we focused on coherence with heart rate and (to determine specificity) coherence with skin conductance level (SCL) as a slower-acting physiological response system (Dawson, Schell, & Filion, 1990). Sad and (to determine specificity) happy facial expressions were objectively coded by trained raters during using the Emotion Expressive Behavior Coding System (Gross, 1996). Fourth, we studied multiple aspects of dispositional affect, including positive and negative affect as measured by the Positive and Negative Affect Schedule (Watson & Clark, 1994) and neuroticism and extraversion as measured by the BFI (John & Srivastava, 1999). Fifth, the study drew from a community sample of younger (age 20–35) and older (age 55–70) adults. Finally, we examined the robustness of findings when controlling for covariates (i.e., gender; age [in all dispositional affect analyses], and expressive suppression; cf. Brown et al., 2019).

Method

Participants

The sample consisted of 104 younger (age 20–35) and older (age 55–70) adults from the Chicagoland area. Participants were recruited through flyers (e.g., posted in shops, community centers, and online) and were screened via phone or e-mail to exclude participants who (a) had diabetes or another medical condition that would prevent them from sitting comfortably in a chair for 2 hr, (b) were allergic to the gel used for the physiological sensors, or (c) fell outside the specified age ranges. Participants were paid $30 for their participation in the study. All study procedures were approved by the Institutional Review Board at Northwestern University.

For the present analyses, data were not usable for 14 participants due to (a) stimulus presentation, video recording, or psychophysiology equipment failures during the laboratory assessment ($n = 13$) and (b) participants not consenting to video recording ($n = 1$). Thus, the final sample consisted of 90 participants (46 females), including 47 younger adults (20–35 years; $M = 25.96$, $SD = 4.92$) and 41 older adults (55–70 years; $M = 61.78$, $SD = 6.35$). Although recruitment focused on clearly defined age ranges, two participants fell outside these ranges (i.e., they were 38 and 49 years old). We decided to include these participants in all analyses with continuous variables (e.g., regression analyses) but not in analyses comparing older adults with younger adults. Findings remained stable regardless of whether these two participants were included.

Our sample of 90 participants allowed for detecting medium-sized (cf. Cohen, 1992) effects ($f^2 = .09$) at an alpha level of .05 and power at .80 for two-tailed tests in regression-type analyses. The sample was 47% White, 23% Black or African American, 12% Latino or Hispanic American, 12% Asian, and 6% mixed ethnicity or other. In terms of socioeconomic status, the median annual household income corresponded to approximately $20,000–$35,000 and the mean education level translated to the completion of a 2-year college degree.

Procedure

The 2-hr laboratory session consisted of two parts: (a) emotion and (b) questionnaire assessments. Upon arrival at the Northwestern Life-Span Development Lab, participants reviewed and signed consent forms for participation and video recording. The experimenter then attached physiological sensors while participants were seated in a comfortable chair that faced a TV monitor positioned such that an unobtrusive camera recorded their facial expressions.

At the beginning of the emotion assessment, participants reported on their subjective emotional experiences "right now" using an emotion checklist. Participants then completed six trials in which they viewed film clips. Within each trial, participants watched (a) an "X" on the screen for 60 s with the instruction to clear their minds of any thoughts or feelings, (b) on-screen instructions to "watch the film clip" for 5 s, (c) a short film clip for approximately 2–3 min, and (d) another "X" on the screen for 20 s. After each film clip, participants reported on their subjective emotional experiences while they were watching the film clip.

The present analyses focused on the sad film clip, presented in Trial 5, and (to determine specificity), the happy film clip, presented in Trial 1, respectively. The remaining trials presented film clips designed to elicit achievement (Trial 2), affiliation (Trial 3), and power (Trial 4) motivation and a neutral state (Trial 6). The sad film clip was a 3-min 21-s excerpt from the movie *21 Grams* (Iñárritu & Salerno, 2003), where a mother discovers that her family has been killed in a car accident. The happy film clip was a 2-min 34-s montage showing Sarah Hughes winning the Olympic gold medal and celebrating. Both film clips have been used successfully in prior studies to elicit sadness (Seider et al., 2011; Shiota & Levenson, 2009) and happiness (e.g., Johnson et al., 2017), respectively. After the emotion assessment, participants completed a questionnaire that included the dispositional affect scales. Participants were then debriefed and compensated.

Measures

Subjective emotional experience. Participants reported how strongly they felt 11 different emotions (amusement, anger, compassion, contentment, disgust, enthusiasm, excitement, fear, joy, sadness, and surprise) on a scale of 1 (*not at all*) to 9 (*strongest ever felt*) at baseline and after each film clip. For the present study, we focused on sadness and enthusiasm experiences at baseline and after the sad and happy film clip, respectively.

Facial expressions. Participants' facial expressions were recorded using a remotely controlled camera as they watched the film clips. Trained raters watched the film clips without sound and coded eight different emotions (anger, contempt, disgust, fear, happiness, interest, sadness, surprise) on a second-by-second basis on an intensity scale ranging from 0 to 3 using a modified version of the Emotion Expressive Behavior Coding System (Gross, 1996). As in prior studies (e.g., Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012; Johnson et al., 2017), codes were obtained for the 30 s of peak emotional responding for each film clip (i.e., sad film clip: doctor informs the protagonist about her family's deaths and she cries; happy film clip: figure skater learns that she won the gold medal). Two trained raters coded each participant video with 60% overlap. Reliability analyses for the sadness and happiness behavior codes were conducted following Côté, Gyurak, and Levenson (2010). Average agreement between coders was 77% (sadness: 67%; happiness: 87%). Averages of the raters' codes were used for the present analyses.

The present study focused on sad facial expressions with ratings ranging from 0 (*no sadness*) to 1 (*slight sadness*; e.g., inner eyebrow turning up slightly or mouth turning down) to 2 (*moderate sadness*; e.g., tears building up in the eyes, inner eyebrow turning up clearly, or increased blinking) to 3 (*strong sadness*; e.g., many of the previous signs together or visible crying). To determine specificity, we also examined happy facial expressions with ratings ranging from 0 (*no happiness*) to 1 (*slight happiness*; e.g., slight smile without teeth showing) to 2 (*moderate happiness*; e.g., clear smile with teeth showing, cheeks raise and wrinkles form around the eyes) to 3 (*strong happiness*; e.g., smiles as broadly as possible or laughs).

Autonomic physiology. Continuous physiological recordings of major organ systems involved in emotional responding (cardiac, vascular, respiratory, and electrodermal) were obtained using standard procedures (Stern, Ray, & Quigley, 2001) and MindWare Technologies Ltd. equipment (MindWare Technologies, Inc., Gahanna, OH). Electrocardiogram (heart rate) and electrodermal (SCL) activities were examined. Heart rate was measured with a three-lead configuration and calculated based on the time interval between two successive *R* peaks. To calculate average heart rate, *R*-wave peak detection software was used to detect probable heart periods (Berntson, Quigley, & Lozano, 2007).

In addition, each electrocardiogram signal was screened for artifacts by members of the research team who were blind to participants' demographics and hypotheses. Skin conductance was measured by passing a constant voltage between two electrodes attached to the palm of the nondominant hand and calculated based on tonic SCL. Average levels of heart rate and skin conductance were calculated before and during each film clip. Heart rate and heart rate coherence were available for all 90 participants. Skin conductance and skin conductance coherence data were available for 84 participants (among those, $n = 52$ [62%], $n = 28$ younger adults, 23 older adults exhibited changes in SCL >0.01 μS, cf. Boucsein et al., 2012).

Dispositional affect. Dispositional affect was measured drawing from two established measures, (a) the PANAS (Watson & Clark, 1994) and (b) the BFI (John & Srivastava, 1999). On the PANAS, participants indicated how much they felt 10 positive affective states (e.g., excited, $\alpha = .85$) and 10 negative affective states (e.g., distressed, $\alpha = .89$) during the previous month on a scale of 1 (*slightly or not at all*) to 5 (*a lot*). Our primary analyses focused on the ratio of positive to negative affect, similar to other work (Fredrickson & Losada, 2005; Haase et al., 2012), but we also analyzed positive and negative affect separately in follow-up analyses. On the BFI, participants indicated how much they personally resembled 44 traits with eight items measuring neuroticism (e.g., depressed, blue; $\alpha = .83$) and 8 items measuring extraversion (e.g., full of energy, generates a lot of enthusiasm; $\alpha = .84$) on a scale of 1 (*disagree strongly*) to 5 (*agree strongly*).

Covariates. We included gender as a covariate (0 = male; 1 = female) in our primary analyses, and age in all non-age-focused analyses. In follow-up analyses, we controlled for expressive suppression (Suppression subscale of the Emotion Regulation Questionnaire, Gross & John, 2003, four items, e.g., "I control my emotions by not expressing them," $\alpha = .76$).

Data Analyses

Manipulation check. The film clips elicited the intended emotions, as participants experienced greater sadness after the sad film clip, $t(83) = 16.23$, $p < .001$, and greater excitement after the happy film clip, $t(85) = 7.78$, $p < .001$, compared to baseline levels of the respective emotion.

Calculating coherence scores. Sadness can manifest itself in changes in emotional experiences, facial expressions, and physiology. The present study examined coherence between facial expressions (with a focus on sad facial expressions) and changes in physiology (with a focus on changes in heart rate). In view of recent meta-analytic findings documenting a lack of autonomic specificity in emotional responding (Siegel et al., 2018) and considering the different psychological processes (e.g., orienting response, Stekelenburg & van Boxtel, 2002; compassion, Goetz et al., 2010) that a change in heart rate can index (akin to a one-to-many association, see Cacioppo et al., 2016), we took a data-driven approach to determine coherence scores.

First, we examined heart rate changes in response to the sad film clip in the present study and found that, on average, participants' heart rate decreased in response to the sad film clip compared to the prefilm baseline, $t(89) = 2.14$, $p = .035$, consistent with some prior studies showing greater heart rate deceleration in sadness reactivity (e.g., Kreibig, 2010; Mauss et al., 2005). Thus, for our primary analyses, we operationalized sadness coherence using a relative score (i.e., an inverse association between heart rate and sad facial expressions). Second, in follow-up analyses, we operationalized sadness coherence using an absolute score (i.e., indexed by sad facial expressions accompanied by heart rate acceleration or deceleration, and using the absolute value of the relative coherence scores with values ranging from 0 to 1, see Lohani et al., 2018) and examined if findings remained stable when analyzing this absolute coherence score.

To calculate coherence scores between sad facial expressions and heart rate, data were matched on a second-by-second basis, cross-correlations were calculated using 10-s time lags, and the correlation that was the greatest in magnitude was retained for further analysis, following established procedures utilized in previous coherence research (Lohani et al., 2018; Mauss et al., 2005; Sze et al., 2010). Converging with Lohani and colleagues (2018), the modal lag for the maximum coherence scores was 0 ($M = .08$, $SD = 4.37$). Correlations were multiplied by -1, such that greater sad facial expressions accompanied by greater heart rate deceleration indicated greater sadness coherence.

There were 39 participants (24 younger adults and 15 older adults) who did not exhibit any sad facial behavior or did not change the intensity of their sad facial expressions throughout the coded segment of the film clip. Previous research on sadness reactivity has shown that it is quite common for participants to not exhibit sad facial expressions to sad film clips (e.g., Seider et al., 2011). Because their facial expressions remained constant, cross-correlations were not available for these participants, resulting in coherence scores of 0 (arguably reflecting a real lack of coherence, see also Reisenzein et al., 2006). We retained these participants in the analyses. When we repeated the analyses excluding these participants, all findings remained stable.

Data analysis plan. For preliminary analyses, we examined descriptive statistics and intercorrelations between key variables.

We also conducted linear regressions to determine if sadness coherence was associated with overall levels with sad facial expressions (i.e., frequency and intensity) and heart rate reactivity (i.e., baseline-to-film clip changes in heart rate).

For the primary analyses, we conducted multiple regression analyses to assess whether (a) sadness coherence predicted dispositional affect and (b) age predicted sadness coherence. Additionally, we examined if findings remained stable when controlling for gender and age (for affect analyses), and when excluding participants with coherence scores of 0.

In follow-up analyses, we examined whether findings (a) were specific to sadness coherence characterized by an inverse association between heart rate and sad facial expressions, (b) were specific to sadness coherence during the sad film clip, (c) generalized across overall levels of emotional responding, and (d) remained stable when controlling for expressive suppression. First, we conducted linear regression analyses to examine (a) if absolute sadness coherence (i.e., with values ranging from 0 to 1) predicted dispositional affect and (b) if sadness coherence between facial expressions and skin conductance predicted dispositional affect. Second, we conducted linear regression analyses to assess whether (a) sadness coherence during the happy film clip, (b) happiness coherence during the sad film clip, or (c) happiness coherence during the happy film clip predicted dispositional affect. Third, we conducted moderated regression analyses to assess if the relationships between sadness coherence, dispositional affect, and age were moderated by facial expressions or heart rate reactivity during the sad film clip. Finally, we tested if the relationships between sadness coherence, dispositional affect, and age held when controlling for expressive suppression.

Results

Preliminary Analyses

Table 1 shows descriptive statistics and intercorrelations between key variables. Preliminary analyses showed that sadness coherence was not associated with overall levels of sad facial expressions or heart rate reactivity (i.e., baseline-to-film clip changes) in response to the sad film clip. Specifically, sadness coherence was not associated with sad facial expressions in any form, whether it was how frequent participants displayed sadness, $b = 0.04$, $SE_b = 0.30$, $\beta = 0.01$, $p = .89$, how intense their sad expressions were, $b = 0.00$, $SE_b = 0.28$, $\beta = 0.00$, $p > .99$, or the combined mean *z* score of both frequency and intensity, $b = 0.02$, $SE_b = 0.27$, $\beta = 0.01$, $p = .94$. Moreover, sadness coherence was not associated with heart rate reactivity in response to the sad film clip, $b = 0.60$, $SE_b = 0.95$, $\beta = 0.07$, $p = .53$. On the other hand, greater sadness coherence was marginally associated with the subjective experience of sadness after the sad film clip, $b = 0.04$, $SE_b = 0.02$, $\beta = 0.19$, $p = .082$, and significantly associated with greater increases in sadness experience from baseline to film clip, $b = 0.04$, $SE_b = 0.02$, $\beta = 0.26$, $p = .016$.

Sadness Coherence and Dispositional Affect

Regression analyses showed that greater sadness coherence was associated with a greater positive to negative affect ratio, $b = 0.59$, $SE_b = 0.25$, $\beta = 0.24$, $p = .021$, 95% confidence interval [CI: .09, 1.09], which held after controlling for age and gender, $b = 0.55$, $SE_b = 0.28$, $\beta = 0.22$, $p = .050$, 95% CI [.00, 1.09].[1,2] Moreover, greater sadness coherence was associated with lower neuroticism, $b = -0.59$, $SE_b = 0.23$, $\beta = -0.27$, $p = .010$, 95% CI [−1.04, −.15], which also held after controlling for age and gender, $b = -0.55$, $SE_b = 0.24$, $\beta = -0.24$, $p = .027$, 95% CI [−1.03, −.06]. Sadness coherence was not associated with extraversion, $b = 0.18$, $SE_b = 0.23$, $\beta = 0.08$, $p = .45$, 95% CI [–.29, .64]. When excluding participants with coherence scores of 0, all findings remained stable (positive to negative affect ratio, $b = 0.60$, $SE_b = 0.28$, $\beta = 0.30$, $p = .037$, 95% CI [.04, 1.16], controlling for covariates: $b = 0.65$, $SE_b = 0.32$, $\beta = 0.32$, $p = .048$, 95% CI [.01, 1.30]; neuroticism, $b = -0.59$, $SE_b = 0.21$, $\beta = -0.37$, $p = .007$, 95% CI [−1.01, −.17], controlling for covariates: $b = -0.61$, $SE_b = 0.24$, $\beta = -0.38$, $p = .014$, 95% CI [−1.09, −.13]). Figure 1 shows associations between sadness coherence and aspects of dispositional affect.[3,4]

Sadness Coherence and Age

Regression analyses showed that older age was associated with greater sadness coherence, $b = 0.01$, $SE_b = 0.00$, $\beta = 0.23$, $p = .028$, 95% CI [.00, .01], which held after controlling for gender, $b = 0.01$, $SE_b = 0.00$, $\beta = 0.26$, $p = .017$, 95% CI [.00, .01]. Findings were stable when we excluded participants with coherence scores of 0, $b = 0.01$, $SE_b = 0.00$, $\beta = 0.32$, $p = .024$, 95% CI [.00, .02], and when controlled for gender, $b = 0.01$, $SE_b = 0.00$, $\beta = 0.36$, $p = .013$, 95% CI [.00, .02]. Figure 2 shows associations between age and sadness coherence.[5]

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[1] We focused on the positive to negative affect ratio as an important marker of human flourishing (Fredrickson & Losada, 2005), which allowed us to examine both positive and negative affect in relation to each other, obtain a more robust estimate with more items measuring the construct of dispositional affect, and reduce the number of statistical tests.

[2] To probe whether findings for positive to negative affect ratio were driven by lower negative or higher positive affect, we analyzed whether sadness coherence predicted positive or negative affect separately and when controlling for the other. Results showed that sadness coherence negatively predicted negative affect alone, $b = -0.43$, $SE_b = 0.22$, $p = .052$, and when controlling for positive affect, $b = -0.43$, $SE_b = 0.21$, $\beta = -0.21$, $p = .039$. However, sadness coherence did not predict positive affect alone, $b = -0.01$, $SE_b = 0.19$, $p = .95$, and when controlling for negative affect, $b = -0.14$, $SE_b = 0.19$, $\beta = -0.08$, $p = .46$.

[3] There were no outliers for sadness coherence or neuroticism. For the positive to negative affect ratio, there was one participant who may be marked as an outlier (>1.5 *SD*, but <3 *SD* from the mean). When selecting for participants without a coherence score of 0, this participant was no longer an outlier. Regardless, when excluding this possible outlier, sadness coherence still significantly predicted a greater positive to negative affect ratio, $b = 0.58$, $SE_b = 0.25$, $\beta = 0.24$, $p = .026$.

[4] Age did not moderate associations between sadness coherence and the positive to negative affect ratio, $b = -0.03$, $SE_b = 0.10$, $\beta = -0.03$, $p = .79$, neuroticism, $b = 0.03$, $SE_b = 0.09$, $\beta = 0.04$, $p = .71$, or extraversion, $b = -0.11$, $SE_b = 0.09$, $\beta = -0.13$, $p = .24$.

[5] When analyzing age differences in sadness coherence using age group as a dichotomous variable, older adults had greater sadness coherence than younger adults, $F(1, 88) = 5.24$, $p = .024$, $\eta_p^2 = .06$.

Table 1
Descriptive Statistics and Intercorrelations Between Key Study Variables

Variable	*M* (*SD*)	1	2	3	4	5	6
1. Sadness coherence	−0.01 (0.36)	—					
2. PNA ratio	1.92 (0.87)	.24*	—				
3. Neuroticism	2.81 (0.80)	−.27**	−.73**	—			
4. Extraversion	3.43 (0.80)	.08	.19†	−.23*	—		
5. Age	42.67 (18.63)	.23*	.08	−.11	−.02	—	
6. Gender	0.51 (0.50)	−.03	−.11	.21*	−.04	−.03	—
7. Expressive suppression	3.26 (1.31)	−.20†	−.16	.11	−.54**	−.12	−.13

Note. PNA = positive to negative affect. Gender is coded 0 = male, 1 = female.
† $p < .10$. * $p < .05$. ** $p \leq .01$.

Follow-Up Analyses

Are findings specific to sadness coherence indexed by an inverse association between heart rate and sad facial expressions? To determine whether findings were specific to sadness coherence indexed by this inverse association, we analyzed (a) absolute sadness coherence (i.e., absolute value of sadness coherence with scores ranging from 0 to 1) and (b) coherence between sad facial expressions and skin conductance in response to the sad film clip. Findings were specific to sadness coherence indexed by an inverse association between heart rate and sad facial expressions. Specifically, absolute sadness coherence was not significantly associated with the positive to negative affect ratio, $b = 0.48$, $SE_b = 0.37$, $\beta = 0.14$, $p = .19$; neuroticism, $b = 0.15$, $SE_b = 0.34$, $\beta = 0.05$, $p = .65$; extraversion, $b = 0.54$, $SE_b = 0.33$, $\beta = 0.17$, $p = .11$; or age, $b = 0.00$, $SE_b = 0.00$, $\beta = 0.18$, $p = .09$. Second, coherence between sad facial expressions and skin conductance (with greater coherence indicated by greater sad facial expressions and lowered skin conductance) was not significantly associated with the positive to negative affect ratio, $b = 0.31$, $SE_b = 0.25$, $\beta = 0.14$, $p = .21$; neuroticism, $b = -0.14$, $SE_b = 0.21$, $\beta = -0.08$, $p = .50$; extraversion, $b = 0.16$, $SE_b = 0.23$, $\beta = 0.08$, $p = .48$; or age, $b = 0.00$, $SE_b = 0.00$, $\beta = -0.03$, $p = .79$. Absolute sadness coherence for skin conductance was positively associated with absolute coherence for heart rate, $b = 0.73$, $SE_b = 0.06$, $\beta = 0.81$, $p < .001$, but was not significantly associated with the positive to negative affect ratio, $b = 0.51$, $SE_b = 0.34$, $\beta = 0.16$, $p = .14$; neuroticism, $b = -0.01$, $SE_b = 0.29$, $\beta = -0.01$, $p = .97$; extraversion, $b = 0.50$, $SE_b = 0.31$, $\beta = 0.17$, $p = .12$; or age, $b = 0.00$, $SE_b = 0.00$, $\beta = 0.20$, $p = .08$.

Are findings specific to sadness coherence during the sad film clip? To determine whether findings were specific to the sad film clip, we analyzed (a) sadness coherence during the happy film clip and (b) happiness coherence during the sad and happy film clips (all coherence indices between facial expressions and heart rate). Findings were specific to sadness coherence during the sad film clip. First, sadness coherence during the happy film clip was not associated with dispositional affect or age ($ps \geq .27$). Second, happiness coherence (greater coherence indicated by greater happy facial expressions and increased heart rate) during the sad film clip was not associated with dispositional affect or age ($ps \geq .13$). Moreover, happiness coherence during the happy film clip was not associated with dispositional affect or age ($ps \geq .34$).

Do findings generalize across overall levels of emotional responding? To determine whether findings generalized across overall levels of emotional responding, we analyzed whether (a) sad facial expressions (z-scored mean of frequency and intensity) or (b) heart rate reactivity (i.e., baseline-to-film clip differences) moderated the associations between sadness coherence and dispositional affect or age and sadness coherence. Findings generalized across overall levels of emotional responding in terms of sad facial expressions and heart rate reactivity. Specifically, first, sad facial expressions did not moderate associations between sadness coherence and dispositional affect nor between age and sadness coherence ($ps \geq .26$). Additionally, heart rate reactivity did not moderate associations between sadness coherence and dispositional affect, nor between age and sadness coherence ($ps \geq .37$).[6]

Do findings hold when controlling for expressive suppression? To rule out the possibility that expressive suppression would confound associations with sadness coherence, we controlled for expressive suppression. Findings remained stable when controlling for expressive suppression, as sadness coherence still significantly predicted a greater positive to negative affect ratio, $b = 0.53$, $SE_b = 0.07$, $\beta = 0.21$, $p = .042$, and lower neuroticism, $b = -0.57$, $SE_b = 0.23$, $\beta = -0.26$, $p = .015$. Additionally, age significantly predicted greater sadness coherence when controlling for suppression, $b = 0.004$, $SE_b = 0.00$, $\beta = 0.21$, $p = .045$.

Discussion

The present laboratory-based study of younger and older adults showed that greater behavior-physiology coherence during sadness responding was (a) associated with more favorable dispositional affect and (b) higher in late life. Specifically, individuals who exhibited greater coherence during sadness responding (i.e., their heart rate decelerated as they showed greater sad facial expressions

[6] When controlling for sad facial expressions (z-scored mean of intensity and frequency) and heart rate reactivity, sadness coherence continued to predict dispositional affect (positive to negative affect ratio: $b = 0.62$, $SE_b = 0.25$, $\beta = 0.26$, $p = .015$, neuroticism: $b = -0.61$, $SE_b = 0.23$, $\beta = -0.28$, $p = .009$). Furthermore, age continued to predict greater sadness coherence when controlling for sad facial expressions and heart rate reactivity, $b = 0.01$, $SE_b = 0.00$, $\beta = 0.24$, $p = .030$.

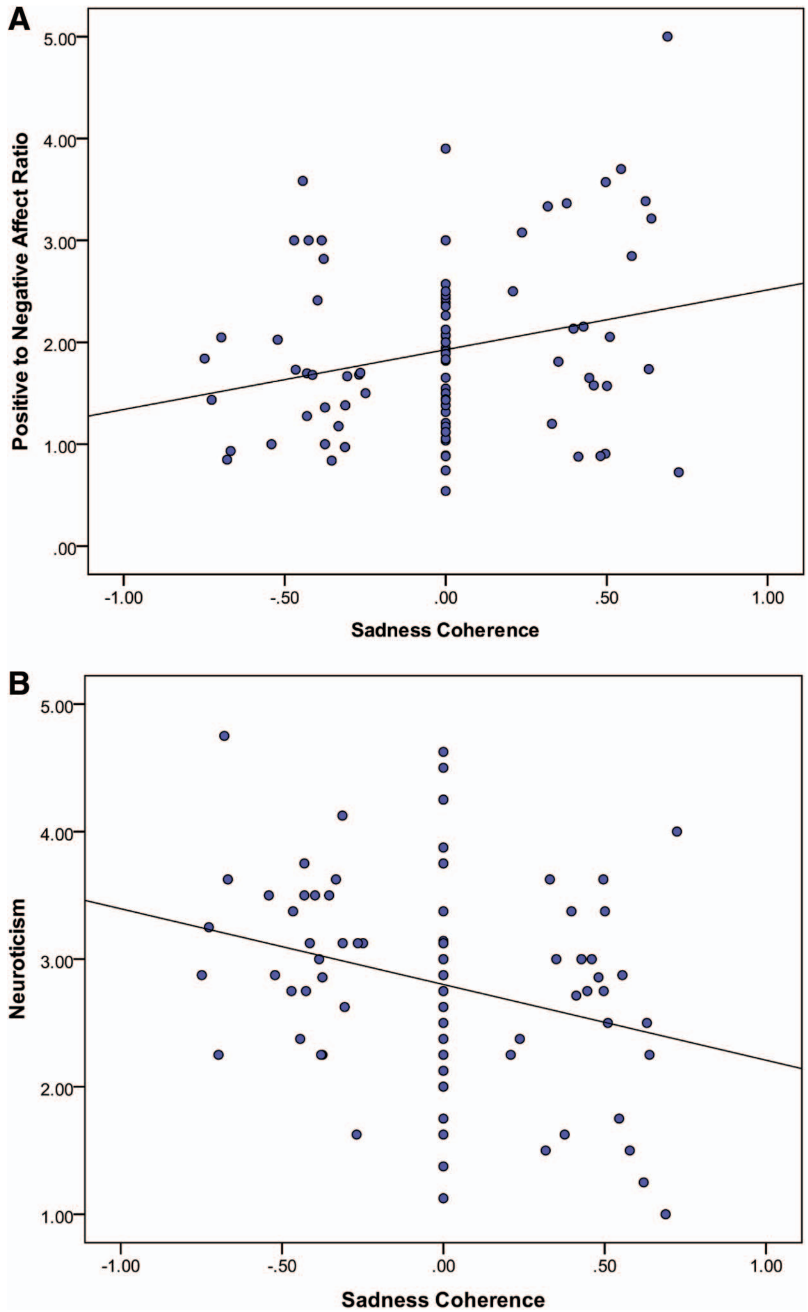

Figure 1. Associations between sadness coherence and (A) positive-to-negative affect ratio and (B) neuroticism. See the online article for the color version of this figure.

in response to a sad film clip) showed greater dispositional positive affect (e.g., excitement) relative to negative affect (e.g., distress) and were less neurotic (e.g., tense, blue, depressed) in their daily lives. Moreover, older adults exhibited greater coherence during sadness responding compared to younger adults. Findings remained stable when controlling for gender and age (when analyzing affect). Moreover, findings were specific to an inverse association between heart rate and facial expressions (i.e., did not emerge for absolute changes in heart rate or skin conductance); sad facial expressions (i.e., did not emerge for happy facial expressions); and stimulus (i.e., did not emerge for sadness coherence in response to a happy film clip). Moreover, findings generalized across overall levels of emotional responding (i.e., sad facial expressions; heart rate reactivity) and remained stable when controlling for expressive suppression.

Sadness Coherence and Dispositional Affect

The present findings show that greater coherence during sadness responding predicted more favorable dispositional affect, expand-

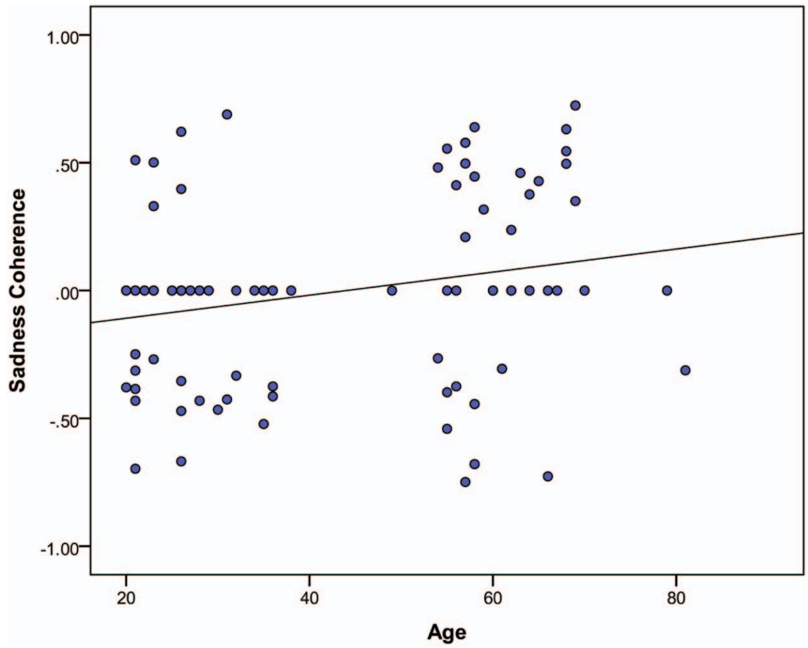

Figure 2. Association between sadness coherence and age. See the online article for the color version of this figure.

ing upon previous work by Mauss and colleagues (2011)[7] and Brown and colleagues (2019) who demonstrated greater well-being with greater coherence during amusement responding and overall emotional responding, respectively.

Evolutionary-functionalist accounts of emotion have long proposed that coherence between emotional response systems should be adaptive (Levenson, 2014). The present findings emphasize that response coherence may be beneficial for not only positive but also negative emotions, such as sadness (Ekman, 1992; Levenson, 1994; see also Haase et al., 2012), as individuals whose response systems cohere during emotional responding may be able to manage situational demands most effectively (e.g., Levenson, 2014). Our findings raise the possibility that individuals whose heart rates slow down (which may index an orienting response and heightened compassion and empathy; Goetz et al., 2010; Stekelenburg & van Boxtel, 2002; Stellar et al., 2012) while they show sad facial expressions (which may elicit support and sympathy from others, Lwi et al., 2019) during sadness responding may be able to most effectively deal with loss, leading to greater well-being (e.g., Wrosch, Scheier, & Miller, 2013). Response coherence could also serve important social functions (with invisible physiological changes accompanied by visible behavioral changes) and foster trust and prosociality in others (cf. Feinberg, Willer, & Keltner, 2012). It is also possible that expressing sadness is soothing or calming (cf. Gračanin, Bylsma, & Vingerhoets, 2014) and thus leads to decreases in heart rate (reflected in greater response coherence), which ultimately benefits well-being.[8] Clearly, future research can follow up on these speculations.

Sadness Coherence Across the Life Span

The present findings showed greater behavior-physiology coherence during sadness responding among older compared to younger adults and thus expand upon previous work by Lohani and colleagues (2018), who showed similar age-related differences in experience-behavior and experience-physiology coherence during sadness responding.

A substantial body of research has shown that, as individuals age and increasingly experience loss, they show preserved or even higher levels of sadness reactivity at the level of individual response systems (e.g., Scheibe & Carstensen, 2010; Seider et al., 2011). Converging with Lohani and colleagues (2018), the present study shows that these age-related differences extend beyond individual response systems to include greater sadness coherence in late life. Older adults may achieve higher levels of coherence because they tend to engage less in expressive suppression (John & Gross, 2004), an emotion regulation strategy that could disrupt sadness coherence. However, our findings do not support this explanation as neither frequency nor intensity of sad facial behavior were associated with sadness coherence and findings remained stable when controlling for these variables or expressive suppression. We speculate that as older adults become more attuned to and willing to engage with loss, their response systems also become

[7] Previous research found that greater coherence (i.e., between experience and facial expressions) during amusement responding was linked to lower levels of depression and greater levels of life satisfaction (Mauss et al., 2011), but it is important to note several differences to the present study. Specifically, we analyzed (a) coherence between facial expressions and physiology (not experience), (b) coherence in response to a happy film clip designed to elicit excitement (not amusement), and (c) associations with positive to negative affect ratio and neuroticism (not depression and life satisfaction). Clearly, more research is needed to examine response coherence for different positive emotions and associations with well-being.

[8] We thank an anonymous reviewer for this suggestion.

more coordinated when responding to loss (Kunzmann et al., 2014).

Greater response coherence in late life could also be supported at a neural level. There is emerging evidence that some aspects of neural functioning are relatively spared from age-related decline. In particular, Touroutoglou, Zhang, Andreano, Dickerson, and Barrett (2018) recently demonstrated higher levels of connectivity in a subnetwork of the salience network in older adults, raising the possibility that older adults may be at an advantage at detecting relevant stimuli and coordinating neural responses, eventually resulting in greater response coherence.

Specificity, Generalizability, and Robustness

The present study carefully tested specificity of the findings to enhance robustness and replicability. First, findings were specific to sadness coherence characterized by an inverse association between heart rate and facial expressions and did not emerge when analyzing absolute sadness coherence scores (i.e., changes in heart rate regardless of direction). While patterns of autonomic responding do not seem to exhibit much emotion specificity (Siegel et al., 2018), there is arguably more evidence to support the view that physiological processes may indicate multiple psychological processes, akin to a one-to-many association (Cacioppo et al., 2016). Heart rate deceleration in particular has been linked to an orienting response (Stekelenburg & van Boxtel, 2002) as well as heightened empathy and attending to others' suffering (Krebs, 1975; Stellar et al., 2012). We interpret that the present findings emerged specifically for individuals whose emotion systems exhibit changes in heart rate that have also been found in orienting and empathy responding while showing sad facial expressions.

Moreover, findings were specific to heart rate (measured on a second-by-second basis and akin to the inverse of interbeat interval), which has often been the measure of choice in previous coherence studies (e.g., Lohani et al., 2018; Sze et al., 2010) because of its sensitivity to index short-term physiological changes (e.g., Cacioppo et al., 2016). Findings did not emerge for skin conductance. To detect meaningful associations with skin conductance, longer coding or analysis windows may be needed (cf. Kettunen, Ravaja, Näätänen, Keskivaara, & Keltikangas-Järvinen, 1998). It is also possible that heart rate may also provide a clearer visceral and neural signal (heartbeat-evoked potentials and their neural origins are well-documented, Schandry et al., 1986), thus, serving as a physiological anchor for response coordination, or that sadness coherence effects are not driven by the sympathetic nervous system. Clearly, more research is needed to further examine this question.

Furthermore, findings were specific to sad facial expressions and not happy facial expressions in response to a sad film clip. The specificity of facial expressions has been hotly debated (cf. Barrett, 2011; Levenson, 2011). While the present findings cannot settle this debate, they contribute a data point to emphasize the usefulness of differentiating between different emotions (e.g., Haase, Holley, Bloch, Verstaen, & Levenson, 2016). Findings were also specific to the sad film clip and did not emerge for sadness coherence in response to a happy film clip. This finding emphasizes the importance of context in the study of emotion (e.g., Kunzmann & Isaacowitz, 2017) and the importance of emotion-stimulus match in particular. In fact, an emerging body of evidence suggests that responding to a happy film clip with negative emotions may be linked to clinical and neurological dysfunction (Chen et al., 2017; Johnson et al., 2017).

Finally, the present findings were generalizable (i.e., not moderated by overall levels of facial expressions or heart rate reactivity) and were not driven by one measure of emotion (i.e., remained stable when controlling for overall levels of sad facial expressions and heart rate reactivity). Our findings also remained stable when controlling for expressive suppression (which has been found to be negatively associated with coherence, Brown et al., 2019), suggesting that coherence may be associated with adaptive functioning above and beyond individual differences in expressive suppression.

Limitations and Strengths

The present laboratory-based study had a number of strengths, as it examined (a) coherence between objectively coded behavior and physiology on a second-by-second basis, (b) different aspects of dispositional affect, and (c) a community sample of younger and older adults. However, the study also had limitations.

First, our sample size may seem small to researchers who conduct large-scale studies. However, it is consistent with other response coherence studies (e.g., Brown et al., 2019; Mauss et al., 2005; Marsh et al., 2008) and allowed for detecting medium (and minimally practically significant; Ferguson, 2009) effect sizes.

Second, our study mirrored previous studies of response coherence by (a) focusing on heart rate as the measure of choice (e.g., Sze et al., 2010). Because the heart is innervated by the sympathetic and parasympathetic branches of the autonomic nervous system, future studies should determine if effects were driven by sympathetic or parasympathetic changes (though our findings did not generalize to skin conductance, which is tied to the sympathetic nervous system). We also (b) used 30-s windows of peak emotional responding, similar to previous studies (e.g., Gyurak et al., 2012; Johnson et al., 2017). Research has shown that 30-s analysis windows are sufficient to establish age differences in response coherence, irrespective of the film clip window chosen (Lohani et al., 2018). However, we also note that given a lag of 10 s, this may also mean that some cross-correlations may be drawn from as few as 20 data points. Thus, future studies should systematically vary the length of the coding window to examine how thin the slice of behavior can be to yield meaningful information (cf. Ambady & Rosenthal, 1992).

Third, we did not assess whether participants were familiar with the film clips or took medications. As familiarity may amplify (Gabert-Quillen, Bartolini, Abravanel, & Sanislow, 2015; Gilman et al., 2017) and medications may alter emotional reactivity, future coherence studies may benefit from controlling for familiarity and medications.

Finally, this is a cross-sectional, correlational study. Future work should examine whether coherence is more of a trait or a state characteristic, whether coherence predicts dispositional affect longitudinally or vice versa and whether age differences in sadness coherence reflect developmental changes or cohort effects.

Future Directions

Converging with other work (Lohani et al., 2018; Mauss et al., 2011; Sze et al., 2010), the present findings highlight the usefulness of examining response coherence from an individual-difference perspective. In particular, the present study is the first to examine individual differences in behavior-physiology coherence and associations with dispositional affect and age. We note that average levels of behavior-physiology coherence in sadness responding in the present study were close to 0, similar to the only other study we are aware of that examined coherence between sad facial behavior and physiology (Mauss et al., 2005). At the same time, those individuals who reported greater increases in the intensity of their sadness experience as they watched the film clip also exhibited greater behavior-physiology coherence, converging with theoretical accounts (Mauss et al., 2005; Rosenberg & Ekman, 1994) and some prior empirical work (Brown et al., 2019). It is possible that response coherence is best studied when emotion intensity is sufficiently high (cf. Levenson, 2014), which is arguably not always feasible in lab settings.

A large body of work has examined individual differences in other aspects of emotional functioning (e.g., reactivity, regulation), sources of these individual differences (e.g., genetic factors, attachment), and their consequences (e.g., well-being, mental health, physical health). There is great potential to extend this approach of studying individual differences in response coherence. Future research may examine individual differences in response coherence for other emotions (e.g., disgust); associations with other indicators of adaptation (e.g., low-arousal positive and negative affect, cf. Pressman & Cross, 2018; mental and physical health; social connectedness); and other developmental differences (e.g., childhood, adolescence, midlife, and very old age; using longitudinal designs). It will also be critical to investigate mechanisms linking response coherence and adaptation as well as the social, motivational and neural mechanisms underlying higher levels of sadness coherence in late life.

Conclusion

The present study shows that greater coherence between behavior (e.g., sad facial expressions) and physiology (e.g., heart rate) during sadness responding was linked with lower negative dispositional affect. This finding is consistent with evolutionary-functionalist accounts of emotion that view response coherence as fundamentally adaptive, including response coherence for negative emotions such as sadness (Levenson, 1994, 2003). Moreover, the present study shows that older adults have higher levels of coherence during sadness responding, converging with developmental accounts of heightened reactivity to loss in late life (e.g., Kunzmann & Grühn, 2005; Seider et al., 2011).

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