Biological Psychology 138 (2018) 91–95

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Physiological linkage to an interaction partner is negatively associated with stability in sympathetic nervous system responding

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ARTICLE INFO

Keywords:
Physiological linkage
Physiological stability
Dyadic interaction
Social psychophysiology
Within-person variability

ABSTRACT

Recent work has demonstrated that people can be influenced by the physiological states of their interaction partners, showing *physiological linkage* to them from one moment to the next. In a study of unacquainted dyads who interacted for 30 min ($n_{dyads} = 47$), we examine the novel question: Are people who show physiological linkage to their partners in sympathetic nervous system responding also less stable in their own responses? Understanding this relationship has important implications for how social relationships impact affective functioning and health. Results using multilevel modeling demonstrated that the within-person correlation between linkage and stability was negative—the more dyad members were physiologically influenced by their interaction partners, the less stable they were in their own physiological responding. This work shows that physiological linkage can come at a cost to people's own stability, meaning our physiological states are more vulnerable to social influence than previously thought.

1. Introduction

Psychologists have long been interested inthe idea that people who interact with one another can experience similar peripheral physiological responses as the result of a psychosocial process between them (for reviews, see Timmons, Margolin, & Saxbe, 2015; Palumbo et al., 2016). For example, babies of mothers who have been stressed show similar heart rates to them during play time (Waters, West, & Mendes, 2014; Waters, West, Karnilowicz, & Mendes, 2017). Within negotiations between new acquaintances, higher-status partners influence the physiology of their lower-status partners (Kraus & Mendes, 2014). Many terms have been used to refer to the interdependence of physiological responses between two people, including coregulation, coupling, covariation, synchrony, and linkage (Chatel-Goldman, Congedo, Jutten, & Schwartz, 2014; Helm, Sbarra, & Ferrer, 2014; Levenson & Gottman, 1983; Papp, Pendry, & Adam, 2009; Waters et al., 2014). In this paper, we use the term *physiological linkage* as an umbrella term capturing all of these conceptualizations, and we measure linkage as the extent to which a partner's physiological response at one moment predicts one's own physiological response the following moment.

Scholars have theorized that physiological linkage occurs when people are attentive to their interaction partners: the physiological response of one dyad member is associated with signals that the other dyad member notices; the second dyad member "picks up" on these cues and then experiences a similar physiological state (Thorson, West and Mendes, 2018). Thus, psychological processes that are associated with reading another person's psychological states are necessary for linkage to occur: one partner must be *perceptive* of the other person's psychological state and the other must be *expressive* of his or her psychological state.

Historically, researchers have focused on studying physiological linkage within close relationship pairs—for example, within romantic couples or between parents and their children (e.g., Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011; Levenson & Gottman, 1983; Timmons et al., 2015)—potentially because close relationship partners may be both more perceptive of each other's psychological states and more expressive of their psychological states when with each other (Gross & John, 2003; Thomas & Fletcher, 2003). However, recent research has also examined these questions in the context of new relationships in which partners have a strong motivation to attend to the psychological states of their partners. For example, in cross-race interactions, people are highly attentive to partners who express anxiety, and thus, they show physiological linkage to those partners (West, Koslov, Page-Gould, Major, & Mendes, 2017). Consistent with research that low-status people attend upward to high-status ones, among new acquaintances who are negotiating with each other, low-status perceivers show physiological linkage to their higher-status partners (Kraus & Mendes, 2014). Therefore, although the bulk of research on

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https://doi.org/10.1016/j.biopsycho.2018.08.004
Received 27 February 2018; Received in revised form 27 July 2018; Accepted 3 August 2018
Available online 16 August 2018

physiological linkage has focused on close relationship pairs, when new acquaintances have sufficient reason to attend to one another, physiological linkage can occur between them as well.

Another process that has long been of interest to scholars is physiological stability—the extent to which people are stable in their own physiology from one time point to the next. Clinical and personality psychologists have demonstrated that stability in physiology and affect is an important predictor of psychological and physical outcomes, including daily well-being and general physical health (Hardy & Segerstrom, 2017; Howell, Ksendzova, Nestingen, Yerahian, & Iyer, 2017), while a lack of stability is associated with psychological distress, depression, and mania (Gruber, Kogan, Quoidback, & Mauss, 2013; Gruber, Mennin, Fields, Purcell, & Murray, 2015; Hardy & Segerstrom, 2017).

That being said, too much stability—that is, an inability to respond flexibly to environmental changes—can also come at a cost to people's social functioning and health (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Muhtadie, Koslov, Akinola, & Mendes, 2015; Phillips, 2011; Schwedtfeger & Rosenkaimer, 2011). For example, when people are dealing with extreme emotional events, experiencing strong affective and physiological reactivity can be more socially adaptive than remaining stable and experiencing little change at all (Nadler & Liviatan, 2006; Ouellet-Morin et al., 2011). Thus, across contexts, it is clear that understanding the factors that contribute to different levels of stability has important implications for people's daily social functioning and overall health.

One unanswered question regarding the processes of both physiological linkage and stability is whether these two processes are related to each other within individuals. Recent methodological and statistical advances in the study of physiological linkage often incorporate stability parameters (e.g., the stability and influence model; Thorson, West and Mendes, 2018), but for social scientists interested in the dyadic process of physiological linkage, the interest is typically in demonstrating physiological linkage above and beyond stability (e.g., Bernard, Kashy, Levendosky, Bogat, & Lonstein, 2017), with less attention paid to factors that affect stability.

Here, we propose that physiological linkage may come at a cost to stability in people's own physiological responses, such that the more people are influenced by others, the less stable they are in their own responding. Stability in both physiological and subjective experiences is thought to be linked to less influence from other people and environmental stimuli (Brose, Scheive, & Schmiedek, 2013; Larsen & Ketelaar, 1991; McEwen & Wingfield, 2003; Popp, Laursen, Kerr, Stattin, & Burk, 2008). Moreover, the relationship between how stable someone is and how much they are physiologically influenced by a partner has important implications for social relationships, affective functioning, and health. For a doctor who is physiologically influenced by interacting with a stressed patient, the disruption of physiological stability might be associated with worse health outcomes over time (Hardy & Segerstrom, 2017). For a spouse whose anxiety is down-regulated through his spouse physiologically influencing him, a lack of stability might be associated with less anxiety over time (Butler, 2011; Sbarra & Hazan, 2008). For people who have trouble adapting or responding to changes in their environments (e.g., children who have experienced maltreatment; Ouellet-Morin et al., 2011), being physiologically influenced by others might help improve their physiological and affective flexibility to important stimuli in their environments.

We propose that even among new acquaintances, interdependence between stability and linkage may emerge, as physiological linkage can occur between new acquaintances within moments of interacting (e.g., Guastello, Pincus, & Gunderson, 2006; Kraus & Mendes, 2014; West et al., 2017). This finding would have important implications for how physiological states can be influenced even by casual social acquaintances—from our neighbors to our doctors—in ways that social scientists have not yet considered.

1.1. Current research

We test the relationship between physiological linkage and physiological stability in sympathetic nervous system (SNS) responding on a moment-to-moment basis throughout a dyadic interaction between two new acquaintances, and we measure physiological linkage as the extent to which a partner's SNS response at one moment predicts one's own SNS response the following moment. We measure SNS activity via pre-ejection period (PEP; Schachinger, Weinbacher, Kiss, Ritz, & Langewitz, 2001) because it is associated with momentary changes in the intensity of affective states and is responsive to changes in a short time frame (Mendes, 2016).

We apply a *stability and influence model*—a version of the Actor-Partner Interdependence Model (Kashy & Kenny, 2000; Kenny, Kashy, & Cook, 2006)—in which participants' physiology at one time point is treated as a function of their own physiology at the prior time point (the stability effect) and their partner's physiology at that prior time point (the linkage effect). The model outlined by Thorson, West and Mendes, (2018) allows for the estimation of stability and linkage as random effects, which captures the variance in these effects across participants. Critical to the present research is the within-person covariance between the stability and linkage random effects, which tests whether, within individuals, being physiologically influenced by one's partner is associated with being more or less stable in one's own physiological responding over time.

Because physiological linkage is most likely to be present when dyad members are motivated to attend to one another and have access to rich behavioral cues from one another (see work by Kraus & Mendes, 2014; Marci & Orr, 2006; Reed, Randall, Post, & Butler, 2013; Thorson, West and Mendes, 2018; West et al., 2017), we investigate this relationship within dyad members who are working face-to-face with each other to solve math problems. We selected this context because it is one in which people should be motivated to attend to their partners because partners can be an important source of information in helping to solve problems. Furthermore, this type of situation allows partners to be expressive about their psychological states via multiple channels: for example, people can verbally express frustration, they can fidget with their hands to show anxiety, or they can sit upright to display engagement. We anticipate that results obtained in this context would generalize to other collaborative and cooperative learning environments in which people can receive help from another partner, and, more broadly, to situations in which people are motivated to attend to their partners and can perceive behavioral and sensory cues regarding the psychological states of those partners.

2. Methods

Additional methodological and analytic details are provided in the Supplemental Materials (SM); measures, data, and syntax are available at https://osf.io/6s87a/.

2.1. Participants

Participants were 94 college students (64 females, 30 males; 46 participants identified as Asian, 32 as White, 6 as Hispanic, 4 as multiracial, 3 as Black, 2 as "other," and 1 as "unknown;" M_{age} = 20.15, SD_{age} = 1.54); pre-screening criteria are outlined in the SM. Seventeen of the dyads were same-gender, and thirty were cross-gender. This study received research ethics committee approval, and informed consent was obtained from all participants.

2.2. Procedure

Participants arrived separately and recorded a five-minute physiological baseline in separate rooms. These data are part of a larger project designed to look at stress during math tasks; as part of this project, participants completed a low-arousal control manipulation (reported in Thorson, Forbes, Magerman, West, 2018). After this, dyad members were moved to the same room, introduced to one another, and solved 27 math problems together for approximately 30 min.

2.3. Measures

We employed electrocardiography (ECG) and impedance cardiography (ICG) to obtain measurements of PEP—the amount of time during a cardiac cycle between the left ventricle of the heart contracting and the aortic valve opening. We recorded ICG and ECG responses using an integrated system (Biopac MP150, Biopac Systems, Goleta, CA) with amplifiers for ECG (ECG100C) and ICG (NICO100C). We used band electrodes in a standard tetrapolar configuration for the recording of ICG responses, and two snap electrodes in a modified Lead II configuration (near the right clavicle, below the ribcage on the left side of the torso) for the recording of ECG responses Sherwood et al. 1990. A 400 μA current was passed through the outer band electrodes, and Z0 and its first derivative, $\Delta z/\Delta t$, were recorded from the inner bands. After the study, physiological data were analyzed in 30-second intervals using Mindware's impedance cardiography software (IMP 3.0.25, Mindware Technologies, Gahanna, OH), and PEP measurements were calculated as the amount of time between the Q point on the ECG wave (when the left ventricle contracts) and the B point on the $\Delta z/\Delta t$ wave (when the aortic valve opens). We visually inspected all intervals and manually selected the Q and B points when they were incorrectly identified by the software. We selected the B point as the notch at the beginning of the longest upstroke before the Z point (Lozano et al., 2007). We computed reactivity scores by subtracting baseline PEP responses (the last 30-second interval of baseline) from PEP responses in 30-second intervals throughout the dyadic task (see Waters et al., 2017, & West et al., 2017, for similar procedures).

2.4. Analytic strategy

We conducted a two-level crossed model that estimated the fixed effects of stability and linkage (see https://osf.io/6s87a/ for syntax and Thorson, West and Mendes, 2018). We treated all dyads as indistinguishable; the random effects were constrained to be the same across both dyad members (see Kenny et al., 2006).

3. Results

We first examined whether there was variance in the stability and linkage effects. There was significant variance in the stability effect, variance = 0.04, SE = 0.01, Z = 4.12, $p < 0.001$, and in the linkage effect, variance = 0.01, SE = 0.005, Z = 2.37, p = 0.018. Because there was significant variance in both effects, we next examined the primary effect of interest: the within-person covariance between the stability and linkage effects. This effect was significant and negative, covariance = -0.01, SE = 0.01, Z = -2.99, p = .003, meaning that the more influenced people were by their partners (i.e., the more they experienced physiological linkage to their partners), the less stable they were in their own physiological responding. Including a covariate that represented whether dyads were same-gender or cross-gender in the model as a fixed effect did not alter the significance or direction of these effects. All estimates from the model are listed in the SM. Finally, we tested for differences in the fixed effects of stability and linkage as a function of dyad type and did not find any ($ps > .42$).

4. Discussion

In a study of dyad members working together, we found that people who were more physiologically influenced by their partners were less stable over time in their own SNS responding. Importantly, we found this effect in stranger dyads who had no prior relationship with one another, suggesting that the stability of physiology can be affected by anyone we meet in our daily lives, and is, therefore, more susceptible to social influence than previously realized.

This research adds to a growing body of work connecting physiological linkage with other aspects of physiology—in particular, measures of ANS (autonomic nervous system) and HPA (hypothalamic-pituitary-adrenal) axis reactivity. For example, Saxbe and colleagues found that greater linkage of HPA reactivity between spouses was associated with greater HPA reactivity to a conflict discussion (Saxbe et al., 2014). Similarly, babies reunited with mothers who had undergone a stressful evaluation showed both greater covariation of SNS responses with their mothers, as well as greater SNS reactivity (Waters et al., 2014). In addition, recent research has examined how linkage of SNS responses is associated with HPA reactivity in one's partner. This work has shown, for example, that African Americans are more strongly linked to European American partners who exhibit greater HPA reactivity while interacting with them (West et al., 2017). In sum, these findings indicate that physiological linkage seems to occur at times when one or both partners are experiencing heightened physiological reactivity. Our work aligns with these findings by showing that physiological linkage also occurs when people experience less physiological stability.

4.1. Limitations and future directions

We examined the association between physiological linkage and stability when dyad members were working face-to-face together to solve problems. We argue that this setting is ideal for detecting physiological linkage because people are motivated to attend to one another and have access to cues indicating each other's psychological states. However, whether the negative relationship we detected between physiological linkage and stability extends to other contexts is an open question. It is possible that the relationship between physiological linkage and stability is inherently negative: in order to be physiologically influenced by someone at all, some stability must be sacrificed (even if people remain physiologically stable overall). On the other hand, it is also possible that certain settings or relationships produce a positive association between stability and linkage: for example, perhaps among close relationship pairs, when one partner regulates another's emotional state, the person being regulated is physiologically influenced by the regulator, resulting in greater physiological stability (e.g., this might occur in "coregulation"; Butler, 2011; Butler & Randall, 2012; Sbarra & Hazan, 2008).

Ideal contexts for investigating the relationship between linkage and stability are ones that create physiological reactivity and variability in that reactivity across participants; without that variability, it may be difficult to detect physiological linkage at all (Thorson, West, & Mendes 2018). In addition, ideal contexts would also create variability in both stability and linkage because, statistically, estimating the covariation parameter between stability and linkage requires variance in both of those processes. Future research is needed to test the boundary conditions of the negative relationship between stability and linkage that we observed here and examine potential variables that might affect the direction of this association, including the type of relationship between partners, the cause of linkage (e.g., emotional coregulation, stress contagion, or physical mimicry), and the direction of linkage (positive or negative; "in-phase" or "anti-phase"; Palumbo et al., 2016; Reed et al., 2013).

In the current work, we examined the association between physiological linkage and stability in stranger dyads, but future work should consider whether this association holds within close relationship pairs. Across close and non-close relationship pairs, we have theorized that physiological linkage is most likely to be present when dyad members are motivated to attend to one another and have access to cues that indicate each other's psychological states (T; Thorson, West and Mendes, 2018). Because close relationship partners may be both more perceptive of each other's psychological states and more expressive of their psychological states when with each other (Gross & John, 2003; Thomas & Fletcher, 2003), physiological linkage may be stronger between close relationship partners and people with existing relationships than between unacquainted people (Sbarra & Hazan, 2008). If this is the case, then close relationship partners might experience even less stability when they are linked to their partners. In contrast, there may be occasions when close relationship partners are less attentive to each other than new acquaintances who are trying to learn about each other and make a good impression in front of one another (Kenny & Acitelli, 2001; Kenny & DePaulo, 1993). If this is the case, then linkage might be lower between close relationship partners, meaning that there is less of an impact on stability. Future research across samples is needed to test these predictions and to examine whether the relationship between stability and linkage changes over time. Optimal studies for examining these questions might consider how the relationship between stability and linkage shifts across time for different kinds of relationships as they progress in order to understand whether changes reflect differences due to relationship kind or relationship length.

Relevant to the current work is the question of whether physiological linkage functions more like a trait or as a situational/relational process. To our knowledge, linkage of SNS responding has primarily been studied as a function of the situation: researchers have observed that people are more strongly or weakly linked depending on the context or the type of relationship between two individuals (Helm et al., 2014; Marci & Orr, 2006; Reed et al., 2013). We are not aware of any studies that have examined physiological linkage of SNS responding within repeated interactions to see whether the same people are more or less susceptible to others across contexts. However, there is work suggesting that trait-level empathy is associated with experiencing physiological linkage to partners (Chatel-Goldman et al., 2014; Guastello et al., 2006; Marci, Ham, Moran, & Orr, 2007). Furthermore, it seems reasonable to expect individual differences in linkage, given that some people are more or less perceptive of others' emotional states (Ickes, Stinson, Bissonnette, & Garcia, 1990; Thomas & Fletcher, 2003), a process which is theorized to be a critical component of physiological linkage (Levenson & Ruef, 1992; Thorson, West and Mendes, 2018). Thus, we anticipate that linkage is a function of both situational and trait-level influences, and future work might examine their interactive effects simultaneously.

Whether and when physiological linkage operates more like a trait or a situational process is relevant to the type of relationship that exists between linkage and stability. For example, if some situations elicit more linkage, do they also cause decreases in stability? If certain people experience more linkage across contexts, are they also consistently less stable? Because the current work reveals a correlational association between physiological linkage and stability, future work might consider how to establish causal claims about the nature of the association. Longitudinal studies that capture people's physiological stability both in the absence and the presence of other partners who can influence them might address this question.

It is possible that the processes underlying physiological linkage were different for same-gender versus cross-gender dyads, particularly given the task that participants completed. We did test for differences in linkage as a function of dyad type and did not find any, but it is possible that this test was underpowered. In same-gender dyads, linkage might reflect greater attempts to affiliate with and get to know one's partner in order to form friendships. In cross-gender dyads, linkage might reflect attention to one's partner in order to succeed on the math task and appear intelligent (Inzlicht & Ben-Zeev, 2003). Such differences in the psychological processes underlying physiological linkage could affect the association between linkage and stability, and future work might continue to examine whether dyadic gender composition affects linkage and stability in different social contexts and whether this influences the relationship between linkage and stability.

4.2. Implications

When considering translational implications of these results, it is important to recognize that neither stability nor linkage should be considered a "good" or healthy process universally (as described in work on both physiology and affect: Genet, Malooly, & Siemer, 2012; Timmons, et al., 2015). That being said, if there are specific instances in which people's physiological stability is of concern (e.g., it may be too low among people with bipolar disorder and too high among people with depression; Bylsma, Morris, & Rottenberg, 2008; Frank, 2005), these results suggest that considering people's interactions with others might be worthwhile. To the extent that certain relationship partners or situations have an impact on people's physiology over time, their physiological stability may also be affected in beneficial ways as well.

Consideration of social contexts can help determine whether the relationship between physiological stability and linkage is helpful or harmful. For example, when two people are negotiating with one another and perspective-taking is required to reach a final outcome that is favorable for both parties, linkage that is coupled with less stability might be positive in that it reflects both partners responding to the fluxes and flows in each other's affective states over time. In contrast, in highly stressful contexts where calm is required to effectively execute tasks (e.g., for a physician in the emergency department of a hospital), linkage that is coupled with less stability may not be adaptive. In general, we recommend the consideration of multiple streams of information over time (e.g., mean reactivity levels, observed behaviors, and subjective reports) before making valenced judgments on the relationship between stability and linkage and, subsequently, recommending translational applications for particular contexts.

4.3. Conclusion

We tested the relationship between physiological linkage and physiological stability in sympathetic nervous system responding on a moment-to-moment basis throughout a dyadic interaction between new acquaintances and found that the within-person correlation between stability and influence was negative—the more dyad members were physiologically influenced by their interaction partners, the less stable they were in their own physiological responding. These findings are the first to our knowledge to demonstrate that even among new acquaintances, being physiologically influenced might come at a cost to physiological stability. Future work might consider whether these results extend to other contexts and types of relationships to better understand how and when physiological stability is susceptible to influence from others.

Author note

The authors would like to thank the research assistants from the West Interpersonal Perception Lab for their dedication to this research. Syntax and data for all analyses can be found at https://osf.io/6s87a/. Some of the data in this manuscript are reported in Thorson, Forbes, et al., 2018 (available upon request); however, none of these findings are related to the association between physiological linkage and physiological stability. The authors have no competing interests to declare. This work was supported by the National Science Foundation [DRL1535414].

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.biopsycho.2018.08.004.

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