Respiratory Sinus Arrhythmia Predicts Early Trajectories Of Acculturation Among New International Students

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ABSTRACT

Respiratory sinus arrhythmia (RSA) is a marker of parasympathetic activity hypothesized to index a neurophysiological system supporting social engagement behaviours. Following migration, people must navigate and adapt to a new sociocultural environment. Whether RSA impacts this psychological acculturation process is unknown. This longitudinal study investigated whether resting RSA on arrival in the receiving country was related to changes in cultural orientations toward both mainstream and heritage cultural groups during the first five months following migration. Sixty new international students provided information on their cultural orientations toward the mainstream and heritage cultural groups shortly after arrival in the new country and two and five months after the first assessment. Results indicated that both heritage and mainstream orientations increased linearly over time. Furthermore, greater resting RSA at baseline was prospectively associated with larger increases in positive orientation toward the mainstream culture but not the heritage culture, over and above individual differences in extraversion, depression, and anxiety. These data provide longitudinal evidence that higher RSA promotes an approach-oriented stance toward a novel cultural environment.

Keywords: Respiratory sinus arrhythmia; acculturation; acculturation orientations; autonomic nervous system; social functioning; longitudinal; international students; migration

Introduction

In recent years, the biological underpinnings of the cultural shaping of social psychological processes have started to be uncovered. Scholars have argued that culture, mind, and brain are mutually constituted (Ambady, 2011; Kitayama & Park, 2010; Ryder, Ban, & Chentsova-Dutton, 2011). From studies supporting the role of the serotonin transporter gene in the emergence of cultural variations in individualism and collectivism (Chiao & Blizinsky, 2010) to evidence of cultural differences in neural representations of the self (Zhu, Zhang, Fan, &

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Han, 2007), researchers have shown that biological factors can contribute substantially to our understanding of the social psychology of culture. However, despite the fact that a sizable proportion of the human population lives in a cultural environment different from the one in which they have been initially socialized, research on how these biological factors are implicated in intra-individual processes of cultural change and adaptation is strikingly absent. Indeed, the biological processes implicated in how people learn to engage in their new social environment and negotiate their multiple cultural traditions are largely unknown (Hong & Khei, 2014). As a contribution toward addressing this gap, the current study investigates the role of respiratory sinus arrhythmia (RSA), a neurophysiological marker of social engagement capacities, in prospectively predicting early trajectories of change in recently arrived migrants' orientation toward the receiving cultural group.

Becoming Multicultural: A Social Phenomenon

As a result of living in a new cultural environment, migrants typically experience substantial psychological changes that lead to an extensive reconfiguration of their lives (Cresswell, 2009). Upon settlement, migrants need to acquire a suite of new cultural skills, ranging from learning a new language to understanding new norms and values (Masgoret & Ward, 2006). Over time, they develop multicultural competence, which refers to the flexible use of their cultural knowledge in response to the changing cultural demands of the local context (Chiu & Hong, 2013). In parallel, migrants need to recreate a social architecture by integrating social networks and forming new social identities or renegotiating existing ones. In doing so, they reorganize their self-concept to accommodate multiple cultural influences (Amiot, de la Sablonnière, Terry, & Smith, 2007; No, Wan, Chao, Rosner, & Hong, 2010).

Scholars have argued that these changes in multicultural competence and multicultural identities, hereafter referred to as “acculturation”, result from a complex process of re-socialization evolving out of repeated interactions with members of the new and heritage communities (Chiu & Hong, 2013; No et al., 2010; Tardif-Williams & Fisher, 2009). In this view, acculturation is inherently a social phenomenon that hinges on social engagement with the new cultural context. Thus, individual differences in migrants' social engagement capacity could substantially influence the acculturation process.

Acculturation Orientations: Temporal dynamics and Antecedents

Cultural orientations are central constructs in acculturation research (Sam & Berry, 2010) that are associated with both psychological and sociocultural adjustment among migrants (Nguyen & Benet-Martìnez, 2013; Ward & Kennedy, 1999). In the prevailing bidimensional acculturation framework (Berry, 2005; Ryder, Alden, & Paulhus, 2000), they reflect “the extent to which acculturating individuals *are involved* with the host or mainstream culture” (mainstream orientation; Nguyen & Benet-Martinez, 2013, p.123, our emphasis) and “with their ethnic or nondominant culture” (heritage orientation; Nguyen & Benet-Martinez, 2013, p.123). Mainstream and heritage cultural orientations are thought to constitute two independent dimensions of cultural involvement (Ryder, et al., 2000). While some researchers examine these cultural orientations directly, some focus rather on acculturation strategies (integration, assimilation, separation, and marginalization; Berry, 2005), the fourfold typology resulting from crossing the mainstream and heritage orientations.

In either case, the exact meaning of “are involved” in the above definition is unclear. Conceptualizations of cultural orientations abound, including attitudes toward cultural contact or attitudes toward cultural adoption (e.g., Snauwaert, Soenens, Vanbeselaere & Boen, 2003), “wish to have contact and to participate in the larger society” (Berry & Sabatier, 2011, p. 659), or identity, behaviours, and values (Nguyen & Benet-Martinez, 2013). Thus, collectively these conceptualizations include a hodgepodge of attitudes, motivations, identifications, behaviours, and values. To complicate matters further, terms and conceptualizations are often used interchangeably (Snauwaer, Soenens, Vanbeselaere & Boen, 2003).

Regardless of this conceptual heterogeneity, in the case of recent migrants entering a new cultural context,

the mainstream orientation reflects to a large extent a person's stance toward initiating and establishing engagement in the receiving cultural group, with positive orientations indexing openness toward cultural involvement. Indeed, newly arrived migrants are, at least to some extent, compelled to have contact with the new culture, while at the same time having less access to their heritage culture. The mainstream orientation reflects individual differences in migrants' dispositions toward this situation. The heritage orientation reflects involvement in the heritage cultural tradition, but, in contrast to the mainstream orientation, it represents a more stable pattern of cultural involvement as it results from years of socialization and experience with the heritage cultural tradition. These orientations are thought to be underlain by a suite of behavioural, cognitive, and affective mechanisms facilitating an approach-oriented stance toward a given culture. Cultural orientations are closely related to the process of cultural learning and multicultural identity construction (Sam & Berry, 2010).

Despite the importance of cultural orientations in both theoretical and empirical accounts of acculturation, surprisingly little is known about their antecedents or about how they change over time. Scholars emphasize that the acculturation process is inherently longitudinal and unfolds over time (e.g., Berry, 1997; Sam & Berry, 2010), yet most acculturation studies are limited by cross-sectional designs (Ryder & Dere, 2010). In short, there is a dearth of research on temporal dynamics. The few longitudinal studies published to date suggest that cultural orientations towards both the mainstream and heritage cultures can change over time (e.g., Brown et al., 2013; Kiang, Witkow, & Champagne, 2013; Rogers-Sirin & Gupta, 2012; Schwartz et al., 2013; Updegraff, Umaña-Taylor, McHale, Wheeler, & Perez-Brena, 2012). For example, international students in the US reported higher identification with the mainstream cultural group three and a half months after migration (Cemalcilar & Falbo, 2008). Similarly, Brown and colleagues (Brown et al., 2013) found that over a one-year period, desire for cultural maintenance and for intergroup contact both increased among ethnic minority children. Likewise, in a sample of adolescent diaspora immigrants to Germany, attitudes toward contact with native Germans became more positive over a 4-year period (Stoessel, Titzmann, and Silbereisen, 2012). Such studies help us better understand the temporal dynamics of cultural orientations, in spite of the variety of conceptualizations used. However, the reliance on youth and emerging adult samples means that the co-occurrence of developmental transitions and cultural adaptation processes confounds their respective contribution to the changes observed.

When it comes to the antecedents of cultural orientations, even cross-sectional studies are relatively rare. A few studies suggest that the sociopolitical context (Bourhis, Moïse, Perreault, & Senécal, 1997; Bourhis, Montaruli, El-Geledi, Harvey, & Barrette, 2010), demographic characteristics (Allen, Vaage, & Hauff, 2006), and personality factors such as need for cognitive closure (Kosic, 2004, 2006) influence cultural orientations. Longitudinal studies starting ideally right before migration or very shortly after would allow for the identification of initial predictors of acculturation trajectories, which, in turn, would facilitate the identification of individuals who are more likely to experience psychosocial adjustment difficulties (Nguyen and Benet-Martínez, 2013). Unfortunately, very few longitudinal studies capture the initial stages of acculturation and the predictors of cultural orientations dynamics. In a notable exception, Jasinskaja-Lahti, Mähönen, & Ketokivi (2012) employed a pre- and post-migration paradigm to show that pre-migration attitudes influenced changes in national identification and attitudes toward the new mainstream cultural group over time. Nonetheless, as Sam and Berry (2010) point out in a review of acculturation research in general, little is known about "what predicts individuals to want to ... adopt different types of acculturation strategies" (2010, p. 479) – and underlying cultural orientations.

In line with the present conceptualization of acculturation as hinging on social participation, individual characteristics related to social functioning are a promising direction to explore in order to identify antecedents of the acculturation process. Individual differences in social engagement capacities might influence migrants' ability to easily interact with members of a new mainstream cultural group, and therefore, their openness toward cultural involvement (see e.g., Yu, 2013 on the role of communication ability and motivation for intercultural contact in the acculturation process). Given that the mainstream cultural orientation reflects migrants' openness toward cultural involvement, we propose that individual differences in social engagement capacities are likely to

influence the trajectories of migrants' mainstream cultural orientation.

Within a cultural neuroscience framework, we consider the role of respiratory sinus arrhythmia (RSA), a physiological marker of social engagement capacity (Porges, 2007), as a predictor of migrants' changes in mainstream cultural orientation over time. As such, our approach differs from that of most work investigating interrelations between cultural and biological processes; to date, cultural neuroscience studies have typically examined how "culture shapes biology" (Azar, 2010, p.44) and showed, using neuroimaging methods, that a range of tasks elicit different patterns of brain activation as a function of participants' cultural background (e.g., Ambady & Bharucha, 2009 for a review). In contrast, the present study focuses on stable biological individual differences (RSA) as a predictor of fluctuations in culturally-relevant processes (mainstream cultural orientation during early stages of migration).

Respiratory Sinus Arrhythmia and Social Engagement

At rest, cardiac activity is mostly regulated by the autonomic nervous system. The combined action of the sympathetic and parasympathetic branches of the autonomic nervous system results in fluctuations in time intervals between heartbeats. While the slow-acting effect of sympathetic activation leads to heart rate acceleration, parasympathetic output through the vagal nerve provides tonic and fast-acting inhibitory influences on cardiac activity that can be quickly removed in responses to challenges (Berntson et al., 1997). RSA represents oscillations in inter-beat intervals associated with the respiration cycle. These oscillations are specifically regulated by vagal-dependent parasympathetic output from brain stem nuclei to the sinoastrial node of the heart (Berntson et al., 1997; Thayer & Lane, 2009).

Porges' (2007) Polyvagal Theory posits that the mammalian autonomic nervous system evolved to support social engagement. This phylogenetic theory proposes that throughout vertebrate evolution, structural and functional connections between brain stem nuclei involved in the neural control of cardiac activity, striated muscles of the face, and smooth muscles of viscera emerged, facilitating the deployment of different behavioural responses to threat. In more evolved mammals, the brain stem nuclei regulating heart rate activity became connected to the soft palate, pharynx, larynx, and eyelid, middle ear, and other facial muscles involved in emotional expression and social communication behaviours. Furthermore, vagal-dependent modulation of cardiac activity allowed rapid shifts in energy mobilization that promoted the development of social engagement responses to stress instead of the metabolically costly fight or flight response. This enabled the coordination of physiological and behavioural states supporting social engagement responses. In this framework, RSA is conceptualized as an index of this neurophysiological system supporting social engagement behaviour in humans (Porges, 2007).

A number of empirical studies provide support for the hypothesis that RSA represents an index of individual differences in social engagement capacities. For instance, lower resting RSA was associated with lower levels of prosocial behaviour in children (Beauchaine et al., 2013). In adults, higher resting RSA was related to emotion recognition (Quintana et al., 2012), greater perception of social support (Maunder et al. 2012), lower rejection sensitivity (Gyurak & Ayduk, 2008), increased positive emotions and social connectedness during social interactions (Kok & Frederickson, 2010), and a tendency to employ more socially-oriented coping and emotion regulation strategies when distressed (Geisler, Kubiak, Siewert, & Weber, 2013). In addition, married and more socially integrated individuals had higher levels of resting RSA than unmarried or less socially integrated individuals (Hemingway et al., 2005; Horsten et al., 1999; Randall, Bhattacharyya, & Steptoe, 2009). Among cohabiting couples, greater resting RSA was also associated with better marital quality and more positive daily interactions (Diamond et al., 2011; Smith et al., 2011). Collectively, these data indicate that resting RSA can be conceptualized as a biological marker of individual differences in social engagement capacities and constitutes an important predictor of future psychosocial outcomes.

Furthermore, RSA is remarkably stable over time, both over short and long time periods. Indeed, the

correlation between individuals' resting RSA measurement taken five years apart was r = .74 (Bornstein & Suess, 2000). Similarly, on a shorter time frame, correlations among resting RSA values taken a few days apart ranged between r = .73 and r = .92 (Hatch, Borcherding, & Norris, 1990). Although resting RSA can fluctuate to some extent in response to life events and stressors such as migration (Gouin, Zhou, & Fitzpatrick, 2015), these results show that it remains a relatively stable physiological characteristic.

Given this conceptualization of RSA as a trait-like marker of individual differences in social engagement capacities, resting RSA might predict one's capacity and motivation to navigate a new social and cultural environment. As such, resting RSA might influence the early acculturation process of recently migrated individuals by predicting change over time in their cultural orientation toward the mainstream group specifically. Indeed, newly arrived migrants' mainstream orientation reflects their openness toward involvement with the new culture and can change over time (e.g., Brown et al., 2013; Kiang, Witkow, & Champagne, 2013; Rogers-Sirin & Gupta, 2012; Schwartz et al., 2013; Updegraff, Umaña-Taylor, McHale, Wheeler, & Perez-Brena, 2012). Upon settlement in the new society, migrants are compelled to have contact with the new culture, and changes in the mainstream orientation are likely to be tied to their pattern of social engagement. We propose that higher RSA may promote this change process among recent migrants.

By contrast, the heritage orientation reflects an established pattern of cultural involvement, formed against the backdrop of a migrant's extensive knowledge of the cultural tradition in which s/he was socialized. One's positioning in relation to one's heritage cultural tradition results from years of experience and engagement in that tradition and is therefore likely to represent a more stable disposition than the mainstream orientation. Thus, a recent migrant's involvement in the heritage culture is likely to reflect the coalesced influence of social class, family histories, idiosyncratic experiences, personal values, etc., more than the influence of social engagement capacities. As such, examining the association between initial RSA and the heritage orientation provides a form of "control condition" that allows us to test the specificity of the role of RSA in predicting changes in cultural orientation to the new mainstream group among new migrants who are suddenly immersed in a new cultural environment while having more restricted access to their heritage culture. In that context, to the extent that they happen, changes in the heritage orientation may be tied to changes in social identities more than to social engagement (Ethier & Deaux, 1994). As a matter of fact, results on longitudinal changes in heritage orientation have been mixed: some studies documented increases over time (e.g., Brown et al., 2013), other studies reported no changes (e.g., Cemalcilar & Falbo, 2008), and still other studies documented decreases over time (e.g., Updegraff et al., 2012).

Present Study

The goal of the current longitudinal study was to prospectively investigate the associations between initial resting RSA and changes in cultural orientations over the first five months in the host country among recently arrived migrants. The present study focused on resting RSA shortly after arrival as a trait-like marker of individual differences in social engagement capacities upon arrival in the host country. In order to examine the unique predictive power of this physiological index we evaluated its association with cultural orientations in relation to extraversion, a stable self-reported individual difference in sociability. Further, given the documented associations of anxiety and depression with both RSA (Chalmers, Quintana, Abbott, & Kemp, 2014) and cultural orientations (Nguyen & Benet-Martinez, 2013), individual differences in psychological distress were controlled to evaluate the unique association between RSA and changes in cultural orientations. Based on past longitudinal work demonstrating increases over time in migrants' mainstream cultural orientation (and related constructs; Brown et al., 2013; Cemalcilar & Falbo, 2008; Stoessel, Titzmann, and Silbereisen, 2012), we expected that participants' mainstream cultural orientation would become more positive over the duration of the study. In contrast, and in line with past research's mixed results on longitudinal changes in the heritage orientation (Brown et al., 2013; Cemalcila & Falbo, 2008; Updegraff et al., 2012), we formed no expectation regarding participants' changes over time in their heritage cultural orientation.

Importantly, we hypothesized that greater resting RSA shortly after arrival would predict[1] greater increases in mainstream cultural orientation, but not in heritage cultural orientation, while adjusting for trait levels of extraversion, for initial depression and anxiety levels, as well as for age, sex, and body mass index (BMI), which has been shown to be related to RSA (Koenig et al., 2014). Given that RSA fluctuates in response to stress to some extent (Gouin, Zhou, & Fitzpatrick, 2015), we also controlled for changes in RSA over time (difference between RSA at Times 3 and 1). The current study thus aims to address two gaps in the acculturation literature by examining changes in cultural orientations longitudinally, and by evaluating the role of a theoretically-relevant physiological index of social engagement capacities as an antecedent of change in cultural orientations over time.

Methods

Participants

The present study is part of a larger research project on international students' social integration. This research was conducted in an English-speaking university counting a large contingent of international students and located in Montreal, Quebec, Canada, a linguistically and culturally diverse city. In broad cultural terms, Canada can be characterized as an individualistic cultural context (Hofstede, 2001). Sixty recently-arrived international undergraduate and graduate students were recruited during orientation sessions for international students. In order to recruit a homogeneous sample in terms of initial social integration, the inclusion criteria were: (1) had arrived to the host city less than one month prior to the first assessment; (2) did not have any friends or relatives that were residents of the host city prior to their arrival; (3) were not involved in a romantic relationship; (4) migrated alone; (5) were committed to staying in the host country for two years or more; and (6) had a score of 600 or more on the Test of English as Foreign Language (TOEFL). In addition, participants were excluded from the study if they reported any chronic health problems or were taking any prescribed medications regularly.

The average age of the sample was 23.77 years (SD = 3.49). There were 31 males (51.7%) and 29 females (48.3%) in the sample. Participants came from a wide variety of countries and cultural backgrounds: 19 (31.7%) participants were of Asian origin, 13 participants (21.7%) were of South Asian origin, 12 (20%) participants were White, six (10%) participants were Middle Eastern, five (8.3%) participants were Hispanic, one (1.7%) participant was Black, and four (6.7%) participants reported “Other” as their ethnic origin.

Procedure

Participants took part in the first assessment on average 21 days after their arrival in the host country (Time 1; n = 60). Follow-up visits occurred at approximately 2 months (Time 2; n = 57) and 5 months (Time 3; n = 55) after baseline. Five participants missed an assessment point, but among them only one participant missed both the Time 2 and Time 3 assessments. At each visit, RSA was assessed during a 15-minute resting period. Participants were fitted with a telemetric inter-beat interval (IBI) recorder. They were told to remain seated, breathe normally, and try to relax as much as possible during the resting period. Participants also completed questionnaires assessing acculturation orientations at each study visit. Each visit occurred between 9:30 am and 12:30 pm to limit the influence of diurnal variation in RSA (Bernston et al. 1997). Participants abstained from eating, consuming caffeine, smoking, and exercising at least two hours prior to each assessment. Participants received financial compensation for each assessment: $20 for the first visit, $25 for the second visit and $30 for the third visit. The local Institutional Review Board approved the study.

1 The term “predict” is used without any implication of causality, but as a descriptor of a statistical relation between variables whereby the outcome variable is “predicted” by independent variables. Given the present longitudinal design, “predict” is used to describe the statistical association between baseline variables and variation outcomes at later times.

Materials

Cultural orientations. The Vancouver Index of Acculturation (VIA; Ryder, Alden, & Paulhus, 2000) is a 20-item self-report measure that assesses mainstream and heritage cultural orientations on a Likert scale ranging from 1 (*disagree*) to 9 (*agree*). There are 10 pairs of items. Each pair differs by content and the items of each pair represent orientations toward the mainstream cultural group (i.e., Canadians; VIA-M) and toward the heritage cultural group (VIA-H). Example items of a pair include, "It is important for me to maintain or develop the practices of my heritage culture," and, "It is important for me to maintain or develop Canadian cultural practices." Each subscale consists of 10 items, with total scores ranging from 1 to 9, and with higher scores representing a more positive orientation to the cultural group described in the items. Internal consistency in our sample for the VIA-M was $\alpha = .76$ at Baseline, $\alpha = .87$ at Time 2, and $\alpha = .91$ at Time 3. Internal consistency in our sample for the VIA-H was $\alpha = .80$ at baseline, $\alpha = .80$ at Time 2, and $\alpha = .89$ at Time 3.

Extraversion. The Eysenck Personality Questionnaire – Brief Version (EPQ; Sato, 2005) is a 24-item measure that assesses extraversion and neuroticism. For the purpose of the current study, only the Extraversion subscale (EPQ-E) was included. The EPQ-E consists of 12 items that assess the extent to which respondents are extraverted with items such as "Are you a talkative person" and "Do you usually take the initiative in making new friends". Each item is rated on a 5-point Likert scale, ranging from 1 (*not at all*) to 5 (*extremely*). Total scores can range from 1 to 5, with higher scores reflecting greater extraversion. Internal consistency in our sample was $\alpha = 74$.

Depression. The Depression and Somatic Symptoms Scale (DSSS; Hung, Weng, Su, & Liu, 2006) is a 22-item measure where participants rate the severity of depressive and somatic symptoms on a 4-point Likert scale ranging from 0 (*absent*) to 3 (*severe*). A sample depression symptom is "Loss of interest in daily or leisure activities". Total scores can range from 0 to 3, with higher scores reflecting greater depression. Internal consistency in our sample was $\alpha = .90$.

Anxiety. The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) is a 14-item measure that assesses anxiety and depression on a 4-point Likert scale. For the purpose of the current study, only the Anxiety subscale (7 items) was included. A sample item is "I get a sort of frightened feeling as if something awful is about to happen", which participants rate on a scale ranging from "*very definitely and quite badly*" to "*not at all*". Total scores can range from 0 to 3. Internal consistency in our sample was $\alpha = .69$.

Respiratory Sinus Arrhythmia (RSA). A digital interbeat interval recorder (Polar RS800CX) recorded temporal changes in inter-beat intervals (IBI) in milliseconds, using a sampling rate of 1000 samples per second. Only the last 10 minutes of the 15-minute recording period were analyzed, to minimize the impact of physiological responses to the novelty of the research environment. Recording artifacts in inter-beat intervals were manually identified and corrected with integer arithmetic (i.e., adding or dividing IBIs to correct for missed heart beats or spuriously detected heart beats), using CardioEdit software (2007). Fewer than 2% of the total inter-beat intervals required editing across the three visits. The Porges-Bohrer (1990) method for extracting RSA was employed using the Cardiobatch (2007) software. This method consists of applying a moving polynomial filter to the sequential IBI to generate a detrended residual time series. A bandpassed filter is then applied to the detrended time series in order to isolate the oscillations in IBIs associated with spontaneous breathing (i.e., 0.12-0.40 Hz). The natural logarithm of the statistical variance of the bandpassed time series averaged over 30 second epochs is the derived RSA value.

Statistical Analyses

Pearson's correlations were used to examine bivariate associations between the main study variables. Multi-level modeling was used to examine the trajectories of change in VIA-M and VIA-H scores, as well as to examine whether RSA at Time 1 prospectively predicted changes in these measures across the three time points (Singer & Willett, 2003). We first entered time as a predictor (model 1), we then examined the role of resting RSA (model

2, hypothesized effects), and finally we entered all control variables (age, sex, BMI, change in RSA between last and first assessments, extraversion, baseline anxiety, baseline depression, and interactions terms between time and each of the latter three variables; model 3). All models included random intercepts only and were fitted with restricted maximum likelihood (Pinheiro & Bates, 2000). Pseudo R^2 values were derived by comparing variance components (residual and intercept) of substantial models to the null model (Singer & Willett, 2003). The *t* values used in the computation of *p* values were based on the Kenward-Roger approximation of degrees of freedom (Kenward & Roger, 1997). Likelihood ratio tests (LRT) were used to compare model fit and confidence intervals were obtained using parametric bootstrapping (1000 samples). Analyses were conducted with the `lme4` and `pbkrtest` packages in `R` version 3.1.1. Missing data were handled by using restricted maximum likelihood estimation in all models. Assumptions of linear mixed models were checked using model diagnostics. In terms of data preparation, univariate outliers were winsorized to three median absolute deviations around the median (Leys, Klein, Bernard, & Licata, 2013). Data was screened for multivariate outliers using robust Mahalanobis distances evaluated at $p<.001$ (Filzmoser, Garrett, & Reimann, 2005); no multivariate outliers were identified.

Results

Descriptive Results

Upon arrival in the new country, participants reported a positive orientation toward both their heritage (M = 6.54, SD = 0.99) and the mainstream cultural group (M = 5.74, SD = 0.91). The mean RSA value was 6.90 (SD = 0.98), and the mean change in RSA value (RSA during last assessment – RSA at Time 1) was -0.22 (SD = 0.75). Participants reported very low levels of depression (M = 0.41, SD = 0.37), as measured by DSS scores, and moderately low levels of anxiety (M = 1.22, SD = 0.37), as measured by HADS scores. EPQ-E scores (M = 3.28, SD = 0.54) indicate that, on average, participants were moderately extraverted, and BMI values show that, on average, participants had a healthy weight (M = 21.78, SD = 2.96).

Table 1 | Correlations Among Key Study Variables

	2.	3.	4.	5.	6.	7.	8.	9.	Mean (SD)
VIA-M									
1. Time1	.69***	.73***	-.02	.33**	.25†	.27*	-.03	-.08	5.74(0.91)
2. Time2		.76***	.42**	.18	.43**	.18	.10	.05	5.97(1.09)
3. Time3			.69***	.30*	.33*	.44**	.26†	.16	6.15(1.22)
4. Change: T3 - T1				.11	.27*	.37**	.42**	.27*	0.30(.88)
VIA-H									
5.Time1					.66***	.66***	-.23†	-.07	6.54(0.99)
6. Time2						.72***	.23†	-.05	6.72(0.98)
7. Time3							.59***	-.01	6.86(1.15)
8. Change: T3 - T1								.07	0.23(0.86)
9. Baseline RSA									6.90(0.98)

Note. Entries represent correlations between variables, except for the last column, where the variable mean and standard deviation are shown. †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$

Table 1 presents the bivariate correlations among the key study variables. There were no significant correlations between resting RSA at baseline and the VIA-M (mainstream orientation) and the VIA-H (heritage orientation) at any time points. Notably, baseline RSA was significantly correlated with changes in VIA-M scores (difference between Time 3 and Time 1), $r = .27$, $p = .03$, but not with changes in VIA-H scores, $r = .07$, $p = .62$. Baseline

RSA (at time 1) was highly correlated with RSA at time 2 (r = .69; time 2 M = 6.47 and SD = 0.97) and at time 3 (r = .73; time 3 M = 6.72 and SD = 1.03). The correlation between RSA at times 2 and 3 was similarly strong (r = .72). These correlations are similar in magnitude to those found in other studies examining the stability of RSA over time (Bornstein & Suess, 2000; Hatch, Borcherding, & Norris, 1990). Further, given that RSA has been shown to vary across ethnic groups (e.g., Hill et al., 2015), we conducted a preliminary analysis of variance to determine whether resting RSA values at time 1 were related to participants' ethnicity. The results were non-significant (F(6) = 1.61, p = .15), showing that baseline RSA did not vary systematically as a function of ethnicity in this sample. Nevertheless, for the sake of completeness, we ran supplementary analyses where we included ethnicity in the prediction of VIA-M and VIA-H scores. In both cases, this inclusion did not change the pattern of results. Given the large number of degrees of freedom required by the inclusion of ethnicity in the models (seven different ethnicities were recorded in our sample), it is not included in the main analyses reported subsequently.

Table 2 | Multilevel Models Predicting Changes in Mainstream Cultural Orientation Over Time

Predictors	Model 1		Model 2		Model 3	
Intercept	5.70	(0.14)***	6.57	(1.02)***	3.73	(2.14)†
Time	0.003	(0.001)**	-0.01	(0.01)*	-0.01	(0.01)
Resting RSA			-0.13	(0.15)	-0.01	(0.15)
Time x Resting RSA			0.002	(0.001)*	0.002	(0.001) *
Age					0.03	(0.04)
Gender (male)					-0.33	(0.28)
BMI					0.04	(0.05)
Change in RSA					0.37	(0.20)†
Time x Change in RSA					-0.00	(0.00)
Extraversion					0.38	(0.29)
Time x Extraversion					0.00	(0.00)
Baseline depression					0.02	(0.45)
Time x Baseline depression					0.00	(0.00)
Baseline anxiety					-0.34	(0.41)
Time x Baseline anxiety					-0.00	(0.00)
Residual R^2	.06		.11		.09	
Intercept R^2	.02		.00		.18	
AIC[a]	432.8		430.4		424.7	
BIC	445.36		449.3		478.9	
LRT(df)[b]	10.04(1)**		6.35(2)*		22.46(11)**	

Note. Entries represent unstandardized coefficients. Numbers in parentheses represent standard errors. $^{\dagger}p < .10$, $*p < .05$, $**p < .01$. a. Models were refitted using maximum likelihood to compute AIC and BIC values. b. LRT = Likelihood Ratio Test obtained using parametric bootstrapping (1000 samples)

Model 1: Changes in Cultural Orientations over Time

Longitudinal mixed models examined whether the VIA-M (Table 2, model 1) and the VIA-H (Table 3, model 1) changed over time. Results show a significant increase in orientation towards the mainstream culture (VIA-M) over time, β(SE) = 0.14 (0.04), t(112.64) =3.21, p =.002, 95% CI = [0.05; 0.22]). Entering time as a predictor accounted for 6% of residual variance and 2% in intercept variance in VIA-M scores. Post hoc tests indicated that the VIA-M significantly increased from baseline to Time 3, t(54) = -2.93, p = .005. There was also a significant increase in orientation towards the heritage culture (VIA-H) over time, β(SE) = 0.10 (0.04), t(112.49)

=2.25, p =.03, 95% CI = [0.02; 0.18]). Entering time as a predictor accounted for 3% of residual variance and 1% in intercept variance in VIA-H scores. Post hoc tests indicated that the VIA-H significantly increased from baseline to Time 3, $t(54) = -1.97$, $p < .05$. These results suggest that cultural orientations to the mainstream and the heritage cultural groups both increased over time, as individuals were immersed in the new cultural environment. However, these changes were more pronounced for mainstream than for heritage orientation.

Table 3 | Multilevel Models Predicting Changes in Heritage Cultural Orientation Over Time

	Model 1		Model 2		Model 3	
Intercept	6.53	(0.14)***	7.16	(1.00)***	7.08	(2.22)***
Time	0.002	(0.001)*	-0.002	(0.001)	-0.01	(0.01)
Resting RSA			-0.09	(0.14)	-0.01	(0.15)
Time x Resting RSA			0.000	(0.001)	0.00	(0.00)
Age					-0.02	(0.04)
Gender (male)					-0.15	(0.29)
BMI					-0.03	(0.05)
Change in RSA					0.32	(0.20)
Time x Change in RSA					-0.00	(0.00)
Extraversion					0.16	(0.30)
Time x Extraversion					0.00	(0.00)
Baseline depression					-0.75	(0.47)
Time x Baseline depression					0.00	(0.00)
Baseline anxiety					0.45	(0.42)
Time x Baseline anxiety					-0.00	(0.00)
Residual R^2	.03		.03		.04	
Intercept R^2	.01		.00		.01	
AIC[a]	429.6		433.0		432.7	
BIC	442.2		451.9		485.6	
LRT(df)[b]	5.02(1)*		0.63(2)		22.4(11)*	

Note. Entries represent standardized coefficients. Numbers in parentheses represent standard errors. $^{\dagger}p < .10$, $*p < .05$, $**p < .01$. a. Models were refitted using maximum likelihood to compute AIC and BIC values. b. LRT = Likelihood Ratio Test obtained using parametric bootstrapping (1000 samples)

Model 2: Baseline RSA and Trajectories of Change in Cultural Orientations

Longitudinal mixed models tested whether between-person differences in baseline RSA statistically predicted the trajectory of change in cultural orientations (Table 2, model 2 for mainstream orientation, and Table 3, model 2 for heritage orientation) over time by entering an interaction between time and resting RSA. Baseline resting RSA was positively associated with the trajectory of change in VIA-M scores (β(SE) = 0.10 (0.04), $t(111.29) = 2.51$, $p = .01$, 95% CI = [0.02; 0.18]), such that participants with higher baseline RSA reported a greater increase in mainstream cultural orientation over time (see Figure 1). However, there was no main effect of baseline resting RSA (β(SE) = 0.04 (0.12), $t(57.95) = 0.35$, $p = .73$, 95% CI = [-0.18; 0.27]). Introducing baseline resting RSA in the model accounted for an additional 5% in residual variance in VIA-M scores. In contrast, baseline resting RSA was not significantly associated with the trajectory of change in the VIA-H (β(SE) = 0.03 (0.04), $t(111.12) = .72$, $p = .47$, 95% CI = [-0.05; 0.12]), indicating that changes in heritage cultural orientation were unrelated to RSA (see Figure 2).

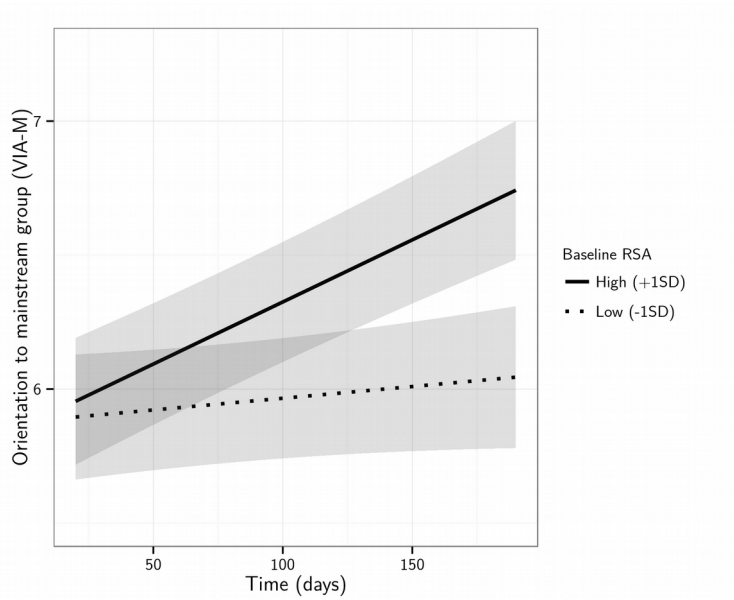

Figure 1 | Full model prediction of changes in VIA-M scores as a function of resting RSA

Time (days) represents the number of days since arrival to the host country. The shaded area represents one standard error around the prediction line. Reference levels for other variables are mean age, mean BMI, mean RSA change, mean extraversion, mean baseline depression, and mean baseline anxiety.

Model 3: Including Control Variables

All control variables were entered in the last step (Table 2, model 3 for the mainstream orientation and Table 3, model 3 for the heritage orientation) in order to further establish the specificity of the relation between baseline RSA and mainstream cultural orientation. EPQ-E scores (extraversion) were significantly associated with VIA-M scores (mainstream orientation) (β(SE) = 0.26(0.12), t(50.00) = 2.11, p = .04, 95% CI = [0.02; 0.51]). The main effect of change in RSA was marginally significant in the prediction of VIA-M scores (β(SE) = 0.22(0.12), t(49.81) = 1.87, p = .07, 95% CI = [-0.01; 0.48]). No other control variables were related to VIA-M scores, showing that RSA change, extraversion, baseline depression and baseline anxiety did not predict the trajectory of change in mainstream cultural orientation. Similarly for the heritage cultural orientation, none of the relations between predictors and VIA-H scores were statistically significant.

Importantly, and fully supporting our hypothesis, the interaction term between baseline RSA and time was still significantly associated with VIA-M scores (β(SE) = 0.09(0.04), t(105.30) = 2.09, p = .04, 95% CI = [0.004; 0.18]) after taking into account all control variables. Similarly, this interaction term remained non-statistically significant in the model predicting VIA-H scores. These results indicate that baseline RSA statistically predicted the trajectory of change in orientation towards the mainstream culture, but was not related to the trajectory of change in orientation towards the heritage culture, after controlling for potential confounds, namely, age, sex, BMI, RSA change, extraversion, baseline depression and baseline anxiety. Figures 1 and 2 depict changes in mainstream (VIA-M scores) and heritage (VIA-H scores) cultural orientations as predicted by the full model, respectively, as a function of low (one standard deviation below the mean) and high (one standard deviation above the mean) levels of baseline resting RSA.

Discussion

The current work aimed to contribute to research on the antecedents and temporal dynamics of cultural orientations. In keeping with a perspective that construes acculturation as an inherently social phenomenon, the

present study examined whether resting RSA, a physiological index of social engagement capacities, was associated with patterns of change in migrants' cultural orientations over the first five months post settlement.

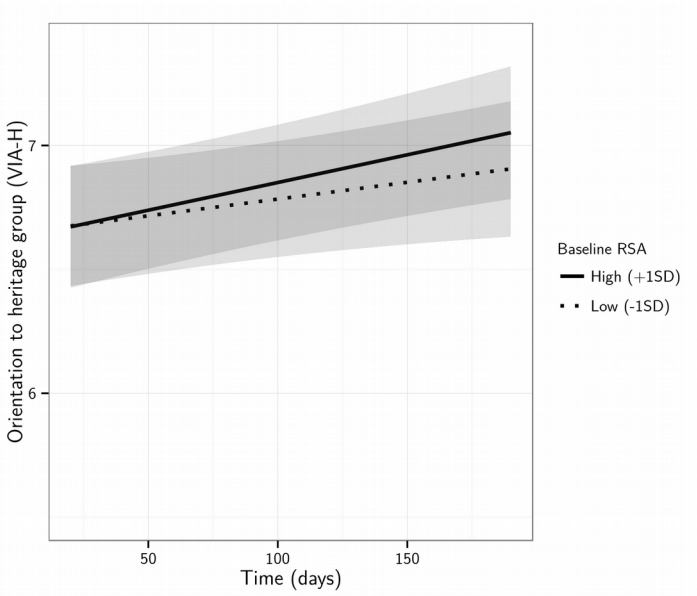

Figure 2 | Full model prediction of changes in VIA-H scores as a function of resting RSA

Time (days) represents the number of days since arrival in the host country. The shaded area represents one standard error around the prediction line. Reference levels for other variables are mean age, mean BMI, mean RSA change, mean extraversion, mean baseline depression, and mean baseline anxiety.

We found that cultural orientations to both mainstream and heritage cultural groups increased linearly over the first five months in the host country. Although we hypothesized that mainstream cultural orientations would become more positive, we formed no expectation regarding changes in heritage cultural orientations. The present finding that cultural orientations to the heritage cultural group became more positive over time was in line with some longitudinal acculturation studies (Brown et al., 2013; Rogers-Sirin & Gupta, 2012) but contradicting results from other studies that observed stable or declining levels of heritage cultural orientations/cultural identification (Kiang, Witkow, & Champagne, 2013; Updegraff, Umaña-Taylor, McHale, Wheeler, & Perez-Brena, 2012). Given that these longitudinal studies are heterogeneous in terms of populations sampled (e.g., adolescents vs. adults, Asian-Americans vs. Mexican-Americans), time frames (a few months vs. several years), and constructs assessed (cultural orientation vs. identity), it is difficult to ascertain what variables are responsible for the discrepancies in findings across studies.

The present study captured young adult migrants at the very early stages of cultural adaptation, in a sociocultural environment where multiculturalism is visible, valued, and encouraged. Indeed, the city where this study was conducted is characterized by great linguistic and cultural diversity (Statistics Canada, 2013). In this particular context, a contrast and salience effect might explain the observed increase in heritage orientations (Brewer, 1991). When persons live in the same cultural environment since birth, they tend to experience the world, “in a manner that simply seems irreducibly true due to the verisimilar objectivity into which one has been socialized” (Cresswell, 2009, p. 167). As a result of migration and immersion in a new cultural environment, “what feels like obvious givens are plunged into question” (p.167). Thus, to some extent, one's heritage cultural tradition acquires new meaning when contrasted to another one. In parallel, because of migration, participants' cultural heritage took on a minority status. The corresponding decrease in the distinctiveness of that particular social category is likely to be associated with increased salience of the heritage cultural identity (McGuire, McGuire, Child, & Fujioka, 1978) and importance attached to membership in that group (Brewer, 1991). A possible outcome of these changes is an increased appreciation for one's heritage cultural tradition, as evidenced

by higher heritage cultural orientation scores.

In line with other longitudinal studies (e.g., Brown et al., 2013; Stoessel et al., 2012), the results showed an increase in mainstream orientation scores. The rapid changes observed here – within a few months – raise interesting questions when contrasted with changes in orientations reported over longer time periods (e.g., Stoessel et al., 2012). For example, do similar processes underlie early vs. long-term changes? Revisiting conceptual definitions of cultural orientations may shed some light on this issue. Involvement in a culture comprises both openness toward cultural contact and appreciation of the cultural tradition. While the former facet reflects motivational processes, the latter implies knowledge of and experience in the cultural tradition. Different acculturation stages are likely to be associated with a differential emphasis on motivation vs. experiential constituents of orientations. Let's take the example of the VIA item, "I am comfortable working with typical Canadian people". Two weeks after settlement, a high score on this item can only reflect comfort with the idea of working with Canadians; however, ten years later, a high score on this item reflects a more experientially grounded willingness to work with Canadians. Thus, motivational processes might underlie early changes in cultural orientations and gradually give way to, or incorporate, other mechanisms supporting the cultural knowledge and experience elements of orientations. In other words, changes in cultural orientations on different time-scales may reflect different underlying processes of change. In future research, it would be important to examine the internal temporal dynamics of cultural orientations: does their meaning change over time, and what shifts in processes underlie these changes in meaning and content? As noted earlier, the construct of cultural orientations is associated with considerable conceptual heterogeneity. Answering these questions will require clarifying the conceptual underpinnings of cultural orientations.

Porges' Polyvagal Theory (2007) stipulates that RSA indexes a neurophysiological system supporting social engagement behaviours. Prior studies have reported associations between greater resting RSA and different indices of social functioning (e.g., Geisler et al., 2013). The present study extends these results by showing that baseline RSA was prospectively associated with longitudinal changes in mainstream cultural orientation among individuals who recently migrated to a new country. Importantly, RSA prospectively predicted changes in the mainstream orientation specifically, but not in the heritage orientation and it remained an independent predictor over and above individual differences in BMI, extraversion, baseline depression, and baseline anxiety. These relations highlights the specific role of resting RSA in facilitating the affective, cognitive, and behavioural processes promoting an approach-oriented stance toward the mainstream culture, a novel context, in the early months following migration.

Given that the acculturation process is thought to be underlain by affective, cognitive, and behavioural changes triggered by social interactions with members of a new mainstream culture (Hong, Wan, Sun, & Chiu, 2007; Sam & Berry, 2010), RSA might influence changes in mainstream cultural orientation by modulating psychosocial processes facilitating the navigation of the new social and cultural environment. While this study was not designed to examine specific processes, we can speculate that greater RSA may promote increases in migrants' positive attitudes toward and/or identification with the mainstream culture, or facilitate the ability to acquire cultural knowledge from their interactions with members of the mainstream cultural groups. RSA has also been associated with emotion regulation and executive functioning, providing other alternative mechanisms through which RSA can influence acculturation (Thayer & Lane, 2009). The present study took place in Canada, a multicultural but fairly individualistic and approach-oriented sociocultural context. Whether RSA would facilitate changes in migrants' mainstream cultural acculturation orientation similarly in more collectivistic cultural contexts where more avoidance-oriented interpersonal relationships are normative is an open question. Thus, examining the exact mechanisms and processes through which RSA is related to changes in mainstream cultural orientation and how these mechanisms depend on the local cultural context represents an important future direction.

To our knowledge, this study was the first to examine the role of theoretically-relevant neurophysiological factors in acculturation. We believe that this inclusion is meaningful beyond considerations of methodological

novelty. Integrating biological and psychological constituents in the study of acculturation is in line with a theoretical standpoint that views culture, mind, and brain (broadly defined to include its related biological processes) as mutually constituted (Ryder et al., 2011). From this perspective, culture-mind-brain is best understood as a single dynamic and multilevel system: changes and configurations at one level constrain and afford the emergence of configurations at another level in a non-deterministic manner. Beyond the specific contribution to the acculturation literature, this study demonstrates one way in which cultural, mental, and biological processes can be considered simultaneously. In the present case, higher RSA likely does not directly causes more positive mainstream cultural orientation toward Canadians, but it is part of a biological system that, combined with other individual differences and idiosyncratic experiences, increase the likelihood of more positive orientations emerging. Similarly, the cultural context, through its norms, institutions, etc., imposes additional constraints on what orientations are possible or desirable for migrants (Bourhis et al., 2010). This perspective points to a conceptualization of acculturation as a dynamic process of change that is both embodied (Tardif-Williams & Fisher, 2009) and context-dependent. Thus moving away from more static 'trait-like' conceptualizations of acculturation (Ryder & Dere, 2010) opens new possibilities for research.

This study has several noteworthy strengths. First, the current findings contribute to the limited longitudinal research on acculturation. Despite acculturation being defined as a process of change (Sam & Berry, 2010), acculturation is often studied using cross-sectional study designs. Longitudinal studies are necessary to gain a better understanding of this dynamic process and to evaluate antecedents of acculturative changes over time. Second, to our knowledge this study is the first to examine a theoretically-relevant biomarker of stable individual differences to understand the unfolding of the acculturation process after migration to a new cultural environment. Third, in an attempt to standardize the migration experience, we selected participants who were relatively homogeneous in terms of social functioning at baseline. That is, the use of international students allowed us to study naturalistically occurring changes in social dynamics among a cohort of individuals experiencing broadly similar social changes following migration to a new country. In addition, our sample was quite heterogeneous in terms of cultural origins. While this enhances the generalizability of the current findings, future studies could examine more homogeneous cultural groups to assess potential cross-group differences.

The study also had some limitations. First, the sample size was relatively small. Given that participants came from diverse ethnocultural backgrounds, this sample size precluded a closer examination of the relation between RSA and ethnicity (Hill et al., 2015). In a related vein, the present study did not control for participants' alcohol consumption or exercise level, two potentially confounding factors that have been associated with RSA (Melanson, 2006; Thayer, Hall, Sollers, & Fischer, 2006). Similarly, although examining separately the prospective association between baseline RSA and mainstream vs. heritage cultural orientations provided a form of control condition testing the specificity of the role of RSA, future research would benefit from including a matched control group, such as members of cultural minorities born in the receiving country.

International students were recruited within five weeks of their arrival in the new country, which may have allowed some participants to at least begin to adjust to the new social settings. Future studies should aim to recruit participants closer to their arrival date or even before migration, and continue to follow them over a longer duration, as important changes in cultural orientations may continue to occur after the first five months of arrival to the host country. Furthermore, although the current study focused on resting RSA, RSA reactivity to challenges is another measure of autonomic flexibility that has been related to one's sensitivity to the social context (Porges, 2007). Indeed, people with less RSA reactivity to both positive and negative social challenges have elevated levels of anxiety and depression and respond in a less context-sensitive manner to social feedback (Shahrestani, Stewart, Quintana, Hickie, & Guastella, 2015; Muhtadie, Koslov, Akinola, & Mendes, 2015). Future studies should assess whether RSA reactivity predicts changes in cultural orientations among new migrants, over and above differences in resting RSA.

In summary, this study contributes to the literature on the social psychology of migration by: (1) characterizing how cultural orientations change over time in the early period following migration; and (2)

examining the role of RSA, an autonomic index of social functioning, in prospectively predicting cultural orientation toward the mainstream culture. This study is, to our knowledge, the first one to empirically examine the contention that becoming multicultural is an embodied process (Tardif-Williams & Fisher, 2009). Furthermore, this study provides evidence that RSA represents a unique physiological index of individual differences in social engagement capacities, which likely also exerts influence on affective, cognitive, and behavioural processes promoting an approach-oriented stance toward a new culture. In times of social novelty, greater RSA appears to promote long-term adaptive social behaviours.

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