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Atypical autonomic regulation, auditory processing, and affect recognition in women with HIV

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ABSTRACT

This study examined the effect of HIV on visceromotor (i.e., heart rate and heart rate variability) and somatomotor (i.e., auditory processing and affect recognition) components of a Social Engagement System defined by the Polyvagal Theory (Porges, 1995) that links vagal regulation of the heart with brainstem regulation of the striated muscles of the face and head. Relative to at risk HIV-seronegative women, HIV-seropositive women had less heart rate variability (i.e., respiratory sinus arrhythmia) and had poorer performance on auditory processing and affect recognition tasks. CD4 was negatively correlated with the accuracy to detect specific emotions. The observed indices of atypical autonomic and behavioral regulation may contribute to greater difficulties in social behavior and social communication between HIV-infected women and other individuals in their social network.

1. Introduction

HIV-infected individuals are at risk for various physical and psychiatric illnesses that may negatively impact their social interactions (e.g., Applebaum et al., 2010; Ciesla & Roberts, 2001; Pence, Miller, Whetten, Eron, & Gaynes, 2006). For example, studies suggest that individuals living with HIV are at high risk for depressive symptoms (Lyon & Munro, 2001; Prachakul, Grant, & Keltner, 2007; Schrimshaw, 2003), which may impede the ability to negotiate stable long-term relationships and social support (Prachakul et al., 2007). We investigated and compared neurophysiological and biobehavioral features that may contribute to compromised social behavior in HIV-infected and socio-demographically similar at risk uninfected women in Chicago. An understanding of these features may enable HIV clinicians and members of support networks to be more aware of the direct and indirect impact of HIV on social and psychological functioning and adapt communication accordingly.

The Polyvagal Theory (Porges, 1995, 2003, 2004, 2007, 2009, 2011; Porges & Furman, 2011) provides a theoretical framework to investigate the impact of HIV on the neural regulation of the autonomic nervous system, auditory processing, and social behavior. The theory describes the integration of the neural regulation of the heart, via the vagus, with the neural regulation of the striated muscles of the face and head, including the neural regulation of middle ear muscles, via other cranial nerves. This heart-face connection operates as an adaptive and functional Social Engagement System during face-to-face interactions. The Social Engagement System is a convergence of neural mechanisms, with synergistic visceromotor and somatomotor components, that interact with ingestion, state regulation and social engagement processes (Porges, 2007) to support social behavior. The system incorporates a visceromotor component that regulates the heart and bronchi via a myelinated branch of the vagus and a somatomotor component that regulates the striated muscles of the face and head via the special visceral efferent neural pathways traveling through several cranial nerves. The somatomotor component regulates several muscles with specific social engagement functions, namely (1) middle ear muscles via cranial nerves V and VII to extract human voice from backgrounds sounds; (2) laryngeal and pharyngeal muscles via cranial nerves IX and X to express affect in vocalizations; (3) muscles of mastication

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for ingestion via cranial nerve V; (4) muscles of the face for emotional expression via cranial nerve VII; and (5) muscles that tilt the head for gesturing via cranial nerve XI. Studies have shown support for a down-regulated Social Engagement System in populations with difficulties in social behavior. Indicators of a down-regulated Social Engagement System may include difficulties with state regulation, auditory processing, prosody, and/or eye gaze. For example, several studies have reported atypical vagal regulation, indexed via respiratory sinus arrhythmia (RSA) (i.e., the high-frequency component of heart rate variability within the frequency of spontaneous breathing), in clinical disorders characterized by atypical social behavior, such as autism spectrum disorder (Daluwatte et al., 2012; Patriquin, Scarpa, Friedman, & Porges, 2013) and fragile X syndrome (Hall, Lightbody, Huffman, Lazzeroni, & Reiss, 2009; Roberts, Boccia, Bailey, Hatton, & Skinner, 2001) and in children at risk for the development of externalizing/internalizing behavioral problems (Calkins, Graziano, & Keane, 2007).

As proposed by the Polyvagal Theory, if HIV is associated with a down-regulated Social Engagement System, HIV-infected individuals may have difficulty detecting positive emotional states of partners, family members, caregivers and other individuals involved in their social support. Thus, in understanding the social dynamics of care and support of HIV-infected women, it is important to evaluate the features of the Social Engagement System.

Several factors related to HIV infection may lead to down regulation of the Social Engagement System. First, HIV may affect the neural (vagal) regulation of the heart reflected in measures of heart rate and heart rate variability including respiratory sinus arrhythmia (RSA). Several researchers have reported that individuals with HIV had faster heart rates (Cade et al., 2008; Lebech et al., 2007; Mittal, Wig, Mishra, & Deepak, 2004) and less heart rate variability (Mittal et al., 2004). However, other studies have not supported these findings and have reported that HIV-infected individuals did not have significantly faster heart rate (Brownley et al., 2001; Correia et al., 2006; Sakhuja et al., 2007) or less heart rate variability (Brownley et al., 2001; Correia et al., 2006; Lebech et al., 2007; Sakhuja et al., 2007).

HIV disease progression may impact directly on central processes as well as the neural pathways of both the visceromotor (i.e., vagal) and somatomotor (i.e., neural regulation of the striated muscles of the face and head) components of the Social Engagement System. Cognitive deficits associated with the HIV virus and/or treatment are common (e.g., Robertson et al., 2007; Weber, Blackstone, & Woods, 2013). Deficits in central cholinergic function have been studied as a potential mechanism for cognitive deficits (Martin-Ruiz et al., 2000; Marubio & Paylor, 2004). Pharmacologic manipulations dampening central cholinergic function with drugs such as scopalomine have degraded performance on dichotic listening tasks (Drachman, Noffsinger, Sahakian, Kurdziel, & Fleming, 1980). Similarly peripheral function dependent on cholinergic systems (e.g., parasympathetic tone and middle ear muscle function) also reflects indices of a deficit. A negative relation has been reported (Compostella et al., 2008) between HIV disease progression [depletion of CD4+ T cells (CD4 hereafter)] and heart rate. Moreover, since HIV is neurotoxic, it may result in peripheral nerve damage (Simpson & Tagliati, 1994) including damage to cranial nerves regulating the striated muscles of the face and head. Consistent with this hypothetical pathway, there is a report (Komolafe et al., 2009) that the extra-axial segment of the facial nerve is typically involved in the early stages of HIV infection. Since the facial nerve also innervates the muscles of the middle ear, damage to the facial nerve might also affect auditory processing making it difficult to extract human speech from background noise.

The current study assessed the degrading effects of HIV on both the functioning of the visceromotor component (i.e., RSA) and the functioning of the somatomotor component (i.e., auditory processing and affect recognition) of the Social Engagement System. The study tested the following four hypotheses (1) HIV-infected women will have dampened vagal regulation of the heart, reflected in faster resting heart rate and lower amplitude RSA; (2) HIV-infected women will have auditory processing difficulties and perform poorer on a dichotic listening task; (3) HIV-infected women will have affect recognition difficulties and make more errors and respond slower on an affect recognition task; and (4) virologic and immunologic indices of HIV disease progression will be related to heart rate, RSA, auditory processing and affect recognition.

2. Methods

2.1. Participants

This investigation was conducted between February 2006 and February 2009 at the Chicago site of the NIH funded Women's Interagency HIV Study (WIHS), an ongoing cohort study of the treated history of HIV infection and related health conditions among HIV-seropositive and at-risk demographically similar women who were HIV-seronegative. Recruitment, retention, protocols, procedures, and demographics of the WIHS have been described elsewhere (Barkan et al., 1998; Hessol et al., 2009). Enrollment began in 1994 with an expansion during 2001–2002 (Bacon et al., 2005). HIV serostatus was determined by Elisa and confirmed by Western blot at study entry for all participants and semiannually thereafter for those initially seronegative. WIHS study participants are interviewed twice yearly about medical history and behaviors and undergo an examination and collection of study specimens to determine current clinical status. Chicago participants were recruited and evaluated in the experimental protocol if they were between ages 25 and 60 years and were English-speakers and excluded if they were unable to abstain from using illicit substances for 24 h prior to the research session, had a confirmed psychiatric diagnosis of psychosis, had a chronic medical condition (other than HIV infection) that was not controlled with medications (current high blood pressure or high blood sugar), showed evidence of current HCV viremia had medically documented auditory or visual impairment, had a documented heart condition and/or history of stroke, or were currently pregnant, post-partum or lactating. Written informed consent was obtained after local human subjects' committee approval.

Seventy-three HIV-seropositive (HIV-SP) and 25 HIV-seronegative (HIV-SN) women were enrolled. The ratio of HIV-seropositive to HIV-seronegative participants in the study reflected the serostatus ratio of individuals who were enrolled in the Chicago WIHS cohort.

2.2. Apparatus and materials

2.2.1. Physiological measures

Heart rate and RSA were recorded from all participants during the experimental protocol. A LifeShirt® (Vivometrics) was used to collect cardiac data and respiration rate. The LifeShirt® has been benchmarked against the Biopac system and provides measures with sufficient accuracy to generate sensitive measures of heart rate and RSA (see Heilman & Porges, 2007). For all participants, three Ag/AgCl self-adhering electrodes (Conmed Corp., Utica, NY) with a contact area of 10 mm diameter were placed directly onto the upper chest and on the lateral surface of the abdomen for data collection.

2.2.2. Cognitive measure

The Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) was used as a measure of intellectual functioning and has been co-normed with the Wechsler Adult Intelligence Scale.

2.2.3. Immunologic and virologic indices of HIV disease progression

Immune function parameters and HIV viral load were obtained from labs certified by the NIH Viral and Immunology Quality Assurance Programs. Analytic approaches using these measures were previously described in Cole, Hernan, Anastos, Jamieson, and Robins (2007). Flow cytometry was performed at NIH ACTG-certified laboratories. HIV viral load was measured using a lower level of detection of 40 copies per ml. HIV viral load was log 10 transformed to normalize the distribution.

2.3. Procedures

Participant consent was obtained prior to the start of the study. After obtaining consent, the physiological monitoring equipment was demonstrated to the participant, the ECG electrodes were placed and the study protocol initiated. All protocol and task instructions were presented verbally. Due to the consent process, paperwork and equipment placement, there was an approximate time lapse of 30 min between arrival to the study and the physiological baseline recording. The protocol consisted of several sequential components (1) a physiological baseline recording during which the participant was encouraged to sit as quietly as possible and to