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The Emotional Toll of HIV: Exploring Facial and Auditory Emotion Recognition and Emotion Regulation in People Living With HIV

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People living with Human Immunodeficiency Virus (PLHIV) have been reported to show poor facial emotion recognition. However, these studies presented participants with facial emotion photographs whereas in real life facial emotion recognition hardly involves inferring emotions from static faces. Moreover, emotion recognition from other sensory modalities, such as auditory, has hardly been explored. There's also a dearth of studies examining emotion regulation difficulties in this group. The present study, thus, explored facial (using facial emotion videos) and auditory emotion recognition as well as difficulties in emotion regulation (using the Hindi version of Difficulties in Emotion Regulation Scale) in 60 PLHIV and 60 people without HIV (PWoHIV). Additionally, the association of HIV duration (duration since diagnosis of HIV), viral load, and Clusters of differentiation 4 (CD4) count with emotion recognition and regulation difficulties in PLHIV was explored. Findings from one-way ANCOVA (with education and socioeconomic status as covariates) revealed significantly impaired auditory emotion recognition (particularly for fear) among PLHIV than PWoHIV. The former also showed significantly poorer facial emotion recognition for surprise. PLHIV also self-reported significantly more emotion regulation difficulties than PWoHIV, specifically Nonacceptance of their response to negative emotions and limited access to emotion regulation Strategies. CD4 count was negatively correlated with emotion regulation difficulties, particularly for accomplishing goal-directed behaviour when experiencing negative emotions (Goals) and Strategies. Besides the novel addition to the literature regarding impaired auditory emotion recognition in PLHIV, these findings can help develop targeted interventions to improve emotion recognition and emotion regulation for PLHIV.

Keywords: HIV; PLHIV; auditory emotion recognition; facial emotion recognition; emotion regulation

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Introduction

The Human Immunodeficiency Virus (HIV) is a chronic global health threat. The global HIV prevalence among the adult population in the year 2020 was found to be 0.7%, which in numeric terms equals an estimated 36 million adults and 1.7 million children (The Joint United Nations Programme on HIV/AIDS (UNAIDS), 2021). From among these 37.7 million affected individuals worldwide, 6.1 million (nearly 16%) are unaware that they are infected with the virus (UNAIDS, 2021). In the year 2020, 680, 000 people died due to HIV-linked causes while 1.5 million individuals contracted the HIV (World Health Organisation (WHO), 2021). However, at the global level, the number of new HIV infections has been decreasing over the years. The world witnessed a decline of 23% in new HIV cases from the year 2010 to the year 2019 with an estimated 17 million people acquiring the disease in 2019. The cases of HIV, however, have been decreasing comparatively more rapidly among females (27% decline in new infections from 2010 to 2019) than males (18% decline in new infections from 2010 to 2019) (UNAIDS, 2020). Even with this rate of decline, we are far from achieving the target reduction in new cases. For instance, the estimated new HIV infection cases in the year 2019 were more than thrice above the target set by the UNAIDS for 2020, which was 500, 000 (UNAIDS, 2020).

A large majority of HIV-infected people reside in low- and middle-income countries, such as India. The estimated number of people living with HIV (PLHIV) in India in 2021 is 2.401 million (National AIDS Control Organisation (NACO), Ministry of Health & Family Welfare, Government of India (GoI), 2022). Within India, the states with the highest estimated number of PLHIV are Maharashtra (0.394 million), Andhra Pradesh (.321 million), Karnataka (0.276 million), Uttar Pradesh (0.178 million), Tamil Nadu (0.163 million), Telangana (0.156 million), Bihar (0.143 million), and Gujarat (0.114 million). In terms of annual new infections reported in 2021, the highest number of cases were reported in the state of Bihar (8.83 thousand) (NACO, GoI, 2022).

HIV-infected people are at an increased risk for developing various physical and psychiatric disorders (Benton, 2008; Do et al., 2014; Paul et al., 2005), that may have a negative influence on their social interactions (e.g., Applebaum et al., 2010; Pence et al., 2006). For instance, findings from previous studies indicate the HIV-infected individuals are at an elevated risk for symptoms of depression (Lyon & Munro, 2001; Prachakul et al., 2007; Schrimshaw, 2003). This may impact their ability to initiate and maintain long-term and stable relationships and make it difficult for them to engage in social interactions (Prachakul et al., 2007). Social interactions, and consequently, family and social support may also be impeded for people living with HIV (PLHIV) individuals if they show poor emotional processing. For instance, studies (e.g., Adolphs, 2002a) have shown that emotion processing involves a wide network of brain areas, the core areas of which are implicated in HIV-related neuropathology, such as the amygdala (Ances et al., 2012; Clark et al., 2012), structures of the basal ganglia (Ances et al., 2012) and frontal cortices (Kallianpur et al., 2012; Kuper et al., 2011; Pfefferbaum et al., 2012). These brain areas (amygdala, orbitofrontal cortex, basal ganglia, among others) have been found to be involved in facial emotion processing (see review by Adolphs et al., 2002b). For instance, impairment in the auditory recognition of the emotions of fear and anger is noted after bilateral damage to the amygdala (Scott et al., 1997). Amygdala also responds more selectively to emotional as compared to non-emotional sounds (Zhang et al., 2019). Similarly, basal ganglia have been implicated in affective processing (Arsalidou et al., 2012; Sprengelmeyer et al., 1997). A clinical model of the dysfunction of basal ganglia also suggests that this structure may play a role in facial emotion recognition (van Asselen et al., 2012). Basal ganglia's crucial contribution has been identified in effective decoding of and responding to vocally-expressed emotions in a recent fMRI investigation (Ceravolo et al., 2021). These research findings lead to the speculation that such cortical and sub-cortical structures may be implicated in the emotion processing deficits among individuals with HIV.

HIV-positive patients have also been found to show poor processing of negative emotions (Baldonero et al., 2013; Clark et al., 2010; Lane et al., 2012). Emotion recognition, particularly facial emotion recognition is a key component of human experience (Darwin, 1872). Thus, deficits in facial emotion recognition have been linked to interpersonal problems in patients suffering from various disorders (Clark et al., 2008), including HIV (Clark et al., 2010). Quite a number of studies have found that HIV-infected individuals show broad emotion processing difficulties, including problems with facial emotion recognition (Baldonero et al., 2013; Clark et al., 2010; Heilman et al., 2013; Lane et al., 2012). For instance, Baldonero et al. (2013) found that people with HIV have impaired recognition of facial emotion of fear compared to controls, and this impairment was independent of the severity of cognitive impairment. On similar lines, Lane et al. (2012) observed mild facial emotion recognition deficits among clinically stable HIV patients which was dissociated from neuropsychiatric complications. Such deficits in facial emotion recognition among PLHIV have been associated with increase in interpersonal difficulties (Clark et al., 2010), which are likely to further exacerbate their psychiatric symptoms (Fleishman et al., 2000). However, except for a handful of studies (Baldonero et al., 2013; Clark et al., 2010; Heilman et al., 2013; Lane et al., 2012), facial emotion recognition in PLHIV has not been much investigated.

In addition to the dearth of studies dealing with the link of HIV infection with facial emotion recognition, another striking gap in the literature is that the studies that have examined the such facial emotion recognition presented participants with static facial expressions to recognise and label the emotion (e.g., Clark et al., 2010). In real life, dynamic stimuli are encountered more frequently than static facial expressions and therefore dynamic stimuli are closer to real-life social interactions and have higher ecological validity (Dobs et al., 2018). Dynamic facial stimuli can convey spontaneous expressions while the posed expressions look more artificial (Cohn & Schmidt, 2004; Kaulard et al., 2012). Dynamic facial emotions have been found to not only improve the recognition of emotions (Ambadar et al., 2005) but are also associated with greater activation of the visual cortex and the amygdala compared to static facial expressions (Yoshikawa & Sato, 2006; Trautmann et al., 2009). Thus, the use of dynamic facial emotion recognition tasks to check facial emotion recognition in PLHIV would give us a better understanding of the severity of their deficits and such a finding would have greater external validity.

Another caveat in previous studies of emotion recognition is that very few studies have explored auditory emotion recognition in HIV patients, and proportionately more studies have focussed on exploring facial emotion recognition. However, emotional information may be processed in sense modalities other than the visual sense. Emotional events are usually characterized by different information coming from different sense modalities. A recent fMRI study (Vaessen et al., 2023) revealed a modality-specific brain organization of emotional signals, suggesting that perception of facial, bodily, and vocal expressions may each have sensory modality-specific emotion representations in the brain. Moreover, such researches as by Hawk et al. (2009), which found that people show poorer emotion recognition for speech-embedded vocal prosody compared to non-linguistic affective vocalisations and facial cues, also indicate that emotion recognition may be localised differently for different sensory modalities in the brain. However, few studies (e.g., Heilman et al., 2013) have explored auditory processing in HIV patients and practically none have explored auditory emotion recognition in such patients. The information about whether emotion recognition in HIV patients is limited to facial emotion recognition or extends to auditory emotion recognition will help design therapeutic interventions targeting such emotion recognition deficits, which would in turn benefit such individuals' social interactions and enhance physical and mental well-being. Thus, it is imperative to explore auditory emotion recognition in addition to facial emotion recognition in PLHIV.

Apart from emotion recognition, emotion regulation may also be a pertinent factor associated with HIV infection. Moreover, emotion recognition and emotion regulation are intricately connected. Emotion recognition has been considered a necessary precursor to emotion regulation (Izard, 2001; Lane, 2000; Mayer et al., 2001). In fact, as per the ability model of emotional intelligence, perceiving emotions is a fundamental skill which leads to the development of more advanced skills, like emotion regulation (Mayer et al., 1999). Recognition of emotions is a prerequisite before a person can use, understand, or regulate them (Mayer et al., 1999). Thus, along with emotion recognition, it is imperative to assess emotion regulation among individuals with HIV. Emotion regulation is the capacity of managing one's emotions (Salovey & Mayer, 1990). Emotional regulation has been defined as "the ways individuals influence which emotions they have, when they have them, and how they experience or express these emotions" (Gross, 1999, p. 542). Depression and anxiety are some of the frequently reported psychiatric comorbidities in HIV-positive individuals (Charlson et al., 2016; Pappin et al., 2012), and researches have shown that the overuse of certain emotion regulation strategies such as suppression, rumination, catastrophising, and underuse of other strategies like reappraisal and self-disclosure are linked to anxiety and depression (e.g., Campbell-Sills et al., 2006; Garnefski & Kraaij, 2006; Garnefski & Kraaij, 2007; Gross & John, 2003). A study noted that the severity of HIV symptoms is associated with poorer quality of life among those PLHIV who have poorer emotion regulation than those who have higher (Brandt et al., 2017). Thus, emotion regulation may play a major role in the mental health of HIV-infected individuals. However, very few studies have attempted to explore emotion regulation difficulties, among PLHIV compared to individuals uninfected with HIV.

Taking the above-mentioned gaps in literature into account, the present study aimed at exploring and comparing facial and auditory emotion recognition among PLHIV and people without HIV (PWoHIV). It was hypothesised that PLHIV would demonstrate significantly poorer facial as well as auditory emotion recognition than PWHA. The study also explored and compared difficulties in emotion regulation across PLHIV and PWoHIV. While it was hypothesised that PLHIV would report more difficulties in the use of emotion regulation overall compared to PWoHIV, no specific hypothesis was made regarding which particular difficulties in emotion regulation would be demonstrated by PLHIV.

Method

Participants

The study protocol and procedures were approved by the Institutional Ethics Committee [blinded for review] (Ref No.: Psy/18/23). For the present research, the required sample size for conducting an ANCOVA was calculated using power analysis. The power analysis calculation using a power of 0.95, an alpha of 0.05, and an effect size of 0.40 revealed a desired total sample size of 84. Therefore, a minimum sample size of 42 per group of PLHIV and PWoHIV in the age range of 20 to 60 years was targeted. PLHIV in the age range of 20-60 years visiting the Integrated Counseling and Testing Center (ICTC) in [blinded for review] Hospital, [blinded for review] were requested to participate in the study. To ensure similarity of socio-economic status, education, etc., PWoHIV were recruited from among the family members of PLHIV visiting the testing centre or people obtaining an HIV negative report after getting tested. Those who showed interest in participation were given a Medical Report Form (to screen for comorbidities) to fill and hand over to the researcher. Participants with a history or current substance abuse, traumatic head injury, vision or hearing difficulties, any medical diagnosis (for PWoHIV) apart from HIV infection (only for PLHIV), any regular medical prescription, substance use, pregnancy or lactation were excluded. Participants who did not have a basic understanding (reading, speaking, writing) of Hindi language were also excluded. The final sample comprised of 60 participants each in the PLHIV and PWoHIV groups.

The researcher made note of the viral load and Clusters of differentiation 4 (CD4) cell count from the medical record of PLHIV. The amount of HIV in blood is referred to as viral load. The greater the amount of HIV in blood, the quicker the CD4 cell count will decrease and the greater the risk of developing an HIV-related illness (Pebody, 2021). CD4 cells are white blood cells (WBC). CD4 cell count indicates how healthy the immune system is. The CD4 cell count is the number of WBC per millilitre of blood. The higher the number, the stronger the immune system. The CD4 cell count of an individual without HIV can range between 500 and 1500. PLHIV who have a CD4 count greater than 500 are typically in excellent health. Those with HIV who have a CD4 cell count below 200 are at a significant risk of developing life-threatening conditions (Pebody, 2021). For PLHIV, the duration (in months) since they were diagnosed as HIV-positive was also noted.

The socio-economic status (SES) of the participants was defined in terms of the monthly per capita income of the participants. The demographic information of the participants, including their educational attainment (i.e., number of years of formal education), their age, sex, SES, viral load, and CD4 count (the latter two were recorded for PLHIV only) are shown in Table 1.

Table 1: Demographic information of the participants

	PLHIV† **(n = 60)**	**PWoHIV** **(n = 60)**
Age range (years)	18-50	18-52
Avg. Age (Mean ± SD years)	29.95 ± 7.53	28.98 ± 7.21
Sex	37 females, 23 males	37 females, 23 males
Education (Mean ± SD years)	11.40 ± 1.97	13.55 ± 2.02
SES (Mean ± SD years (in INR))	2660.79 ± 2103.28	3984.28 ± 3650.58
Duration since diagnosis of HIV/AIDS Range, Mean ± SD (in months)	0.12-192, 24.90 ± 34.91	---
Viral Load Range, Mean ± SD (in copies/ml)	20-56, 22.48 ± 8.39	---
CD4 cell count Range, Mean ± SD (in cells/mm3)	156-824, 463.41 ± 150.55	---

†All PLHIV (except one) reported being on Anti-Retroviral Therapy (ART) since their diagnosis. INR= Indian National Rupee

The two groups of PLHIV and PWoHIV did not differ significantly in mean age, t(118) = 0.72, p= .47. Similarly, the groups did not differ in terms of sex composition, $\chi 2$ (1, N=120) = 0.00, p =1.00. However, as evident from Table 1, PWoHIV had attained more number of years of formal education compared to PLHIV, t(118) = 5.91, p<.001. In terms of SES, PLHIV belonged to lower SES compared to PWoHIV, t(118) = 2.43, p< .05. Since education and SES differed significantly across the groups, these variables were controlled for by including them as covariates in statistical analyses.

Instruments

Performance-based measures

Visual Explicit Emotion Recognition Task: In the visual explicit emotion recognition task (Shukla et al., 2019; Figure 1), full face videos displaying different emotions were presented in the upper centre of the computer screen with four response options (out of the six basic emotion names of Happy, Sad, Fear, Anger, Surprise, and Disgust) given below. One of the labels was the correct response option denoting the emotion expressed in the facial video while the remaining three were distractor labels. Accuracy of emotion recognition was calculated as an index of dynamic visual emotion recognition. Response Time (RT) for each trial was also recorded. There were 24 trials in all (two male and two female facial videos for each of the six basic emotion categories).

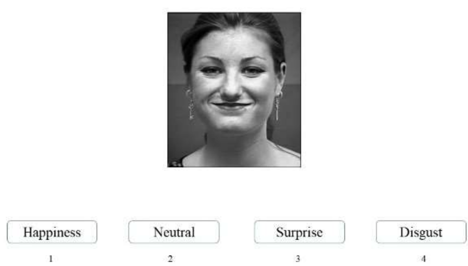

Figure 1 Schematic representation of the Visual Explicit Emotion Recognition Task (Images © Jeffrey Cohn)

Auditory Explicit Emotion Recognition Task: The auditory explicit task (Shukla et al., 2019; Figure 2) presented participants with a target audio clip and four emotion labels (in Hindi). One of the emotion labels in each trial was neutral while another was the correct emotion label for the emotion presented in the sound clip. The other two labels served as distractors, chosen randomly from the remaining five basic emotions. The audio clip played in loops throughout the trial or until a response was entered. The participants were required to label the emotion expressed in the sound-clip. The accuracy and RT of emotion recognition formed the indices of auditory explicit emotion recognition.

The tasks were developed and presented using Paradigm software (v 2.4.0.191).

Self-report measure

The Hindi version of the Difficulties in Emotion Regulation Scale (DERS-H): The 25-item Hindi version of the Difficulties in Emotion Regulation Scale (DERS-H; Bhatnagar et al., 2020) is a psychometrically sound scale for measuring emotion regulation difficulties. It is comprised of five subscales namely, nonacceptance of negative emotional responses (Nonacceptance; 5 items), difficulties engaging in goal-directed behaviour when experiencing negative emotions (Goals; 3 items), impulse control difficulties when experiencing negative emotions (Impulse; 5 items), limited access to emotion regulation strategies (Strategies; 8 items), and lack of emotional clarity (Clarity; 4 items). The internal consistency reliability of the scale is .908, with that of the subscales ranging from .673-.807 (Bhatnagar et al., 2020). The scale also demonstrates adequate construct validity (Bhatnagar et al., 2020).

Figure 2 Schematic representation of the auditory explicit emotion recognition task

Procedure

Prospective participants (PLHIV and PWoHIV) arriving at the ICTC were given an Information Sheet detailing the study. If they expressed interest in participating, they were handed over a Medical Report Form (to screen for comorbidities) to fill. If the participants met the inclusion criteria, they were presented with an Informed Consent Form and were requested to read and sign it. Following this, demographic information was collected from the participants using a Demographic Information Sheet. Next, both the experimental tasks were presented first (for half the participants, the order of presentation of the two tasks was reversed). Participants sat facing the laptop and were given a short practice session before the main task commenced. Participants were allowed to take a brief rest pause between tasks (if needed by the participant). After the completion of both the tasks, the participants completed the self-report measure. After completing the tasks and the questionnaire, the participants were debriefed regarding the purpose of the study and thanked for their participation.

Data analyses

To explore the effect of HIV status on accuracy and RT of overall visual and auditory emotion recognition as well as emotion recognition for each of the six basic emotions of happiness, sadness, fear, anger, surprise, and disgust, after controlling for education and SES, separate one-way ANCOVAs were conducted. The same analysis was conducted to explore the effect of HIV status on the subscale and total scores on the DERS-H. One-way ANOVAs were conducted for analysing the findings with respect to each level of sex. Partial correlations (controlling for education and SES) of duration since being tested positive for HIV (HIV duration), viral load, and CD4 count of PLHIV with accuracy and RT of visual and auditory emotion recognition as well as the subscale and total scores of DERS-H were also conducted.

Results

Results of the one-way ANCOVA (controlling for education and SES) conducted to explore the effect of HIV status (PLHIV, PWoHIV) on the accuracy of visual explicit emotion recognition (i.e., facial emotion labelling) revealed no significant effect of HIV status on the accuracy of visual emotion recognition, $F(1, 116) = 0.50$, $p= .482$, $\eta p2 = .004$ (see Table 2 for means). No effect of HIV status was noted for the RT taken in correct visual emotion recognition as well, $F (1, 116) = 0.01$, $p= .905$, $\eta p2 = .000$. On the auditory explicit emotion recognition task, however, one-way ANCOVA revealed a significant effect of HIV status on the accuracy of auditory emotion recognition, $F (1, 116) = 4.19$, $p< .05$, $\eta p2 = .035$, such that PLHIV demonstrated significantly poorer recognition of auditorily-presented emotions as compared to PWoHIV. The two groups of participants, however, did not differ significantly in terms of the mean time taken in correct recognition of emotions presented in audio clips, $F (1, 116) = 0.82$, $p= .37$, $\eta p2 = .007$. These findings suggest that PLHIV are deficient at recognising emotions from auditory stimuli compared to PWoHIV, but this deficit is specific to emotions processed auditorily and not to those presented visually in faces.

Table 2: Mean accuracy and RT of the participants (PLHIV and PWoHIV) on the visual and auditory emotion recognition tasks

Task		Accuracy (in %)		RT (in ms)	
		PLHIV Mean ± SE [95% CI]	**PWoHIV Mean ± SE [95% CI]**	**PLHIV Mean ± SE [95% CI]**	**PWoHIV Mean ± SE [95% CI]**
Visual Explicit Emotion Recognition Task	**Happiness**	.76 ± .04 [.68, .84]	.82 ± .04 [.74, .90]	6893.98 ± 580.06 [5744.32, 8043.65]	6139.83 ± 551.93 [5045.92, 7233.75]
	Sadness	.61 ± .04 [.53, .70]	.56 ± .04 [.47, .64]	7927.31 ± 579.36 [6778.68, 9075.94]	8462.60 ± 567.63 [7337.22, 9587.98]
	Fear	.48 ± .04 [.40, .56]	.40 ± .04 [.32, .48]	8582.33 ± 650.80 [7291.16, 9873.51]	8232.08 ± 695.76 [6851.72, 9612.43]
	Anger	.43 ± .04 [.35, .51]	.33 ± .04 [.25, .41]	8955.43 ± 611.95 [7739.87, 10170.98]	8519.70 ± 649.22 [7230.10, 9809.30]
	Surprise	.51 ± .05 [.41, .60]	.73 ± .05 [.64, .82]	8097.28 ± 626.44 [6852.74, 9341.82]	7822.80 ± 556.21 [6717.79, 8927.81]
	Disgust	.47 ± .05 [.38, .56]	.59 ± .05 [.50, .68]	7972.91 ± 702.53 [6578.76, 9367.06]	8324.13 ± 656.76 [7020.81, 9627.45]
	Total	54.40 ± 2.56 [49.32, 59.48]	57.13 ± 2.56 [52.05, 62.20]	778967.84 ± 44371.55 [691084.40, 866851.28]	770979.97 ± 44371.55 [683096.53, 858863.41]
Auditory Explicit Emotion Recognition Task	**Happiness**	.67 ± .04 [.60, .75]	.74 ± .04 [.67, .82]	7067.30 ± 450.83 [6174.03, 7960.57]	7211.91 ± 433.53 [6352.92, 8070.89]
	Sadness	.47 ± .04 [.38, .54]	.49 ± .04 [.41, .57]	8553.73 ± 502.01 [7557.64, 9549.82]	9037.49 ± 464.91 [8115.01, 9959.96]
	Fear	.58 ± .04 [.50, .66]	.74 ± .04 [.66, .83]	10577.58 ± 875.56 [8842.24, 12312.92]	8899.11 ± 833.23 [7247.69, 10550.54]
	Anger	.49 ± .04 [.40, .58]	.61 ± .04 [.52, .70]	8681.78 ± 513.40 [7662.86, 9699.50]	8471.50 ± 471.39 [7536.50, 9406.50]
	Surprise	.37 ± .04 [.29, .46]	.47 ± .04 [.38, .55]	8097.28 ± 626.44 [6852.74, 9341.82]	7822.80 ± 556.21 [6717.79, 8927.81]
	Disgust	.34 ± .04 [.26, .42]	.32 ± .04 [.24, .39]	9492.71 ± 700.48 [8099.49, 10885.94]	8442.59 ± 691.39 [7067.45, 9817.74]
	Total	48.73 ± 2.46 [43.86, 53.61]	56.34 ± 2.46 [51.46, 61.21]	875221.70 ± 37864.02 [800227.24, 950216.15]	823494.01 ± 37864.02 [748499.56, 898488.46]

Further, emotion-wise analyses were conducted to explore if PLHIV showed deficit in emotion recognition for any particular emotion, compared to PWoHIV. Results of one-way ANCOVA (controlling for education and SES) exploring the effect of HIV status on the accuracy of visual recognition for the emotions of anger, happiness, sadness, fear, and disgust revealed non-significant effects (all ps> .05), except for the emotion of surprise, $F (1, 116) = 10.00$, $p< .01$, $\eta p2 = .079$, for which PLHIV showed poorer accuracy of recognition ($M = .51$, $SE= .047$) compared to PWoHIV ($M = .73$, $SE = .047$). The same analysis when repeated for RT of visual emotion recognition for each of the six basic emotions revealed non-significant results, all ps> .05. One-way ANCOVA for accuracy of auditory emotion recognition showed no significant effect of HIV status on accuracy of recognition of anger, happiness, sadness, surprise, and disgust (all ps> .05), except for fear, $F (1, 116) = 6.90$, $p< .01$, $\eta p2 = .056$. In comparison to PWoHIV ($M = .74$, $SE = .041$), PLHIV ($M = .58$, $SE = .041$) demonstrated significantly poorer accuracy of recognising fear. The groups, however, did not differ in terms of RT for the recognition of the six emotions, all ps> .05.

When the two groups of participants were compared with respect to difficulties in emotion regulation self-reported by them, it was found that, overall, PLHIV reported significantly more emotion regulation difficulties than PWoHIV, $F (1, 116) = 3.92$, $p< .05$, $\eta p2 = .033$ (see Table 3 for means). Comparison across subscale scores of DERS-H showed that PLHIV reported more difficulties of Nonacceptance of negative emotions compared to PWoHIV, $F (1, 116) = 3.93$, $p< .05$, $\eta p2 = .033$, and limited access to emotion regulation Strategies, $F (1, 116) = 4.02$, $p< .05$, $\eta p2 = .034$. The groups did not differ on other subscale scores, viz., difficulty engaging in goal-directed behaviour when experiencing negative emotions (Goals), $F (1, 116) = 3.81$, $p= .054$, $\eta p2 = .032$; difficulties of Impulse-control, $F (1, 116) = 1.81$, $p=181$, $\eta p2 = .015$; and lack of emotional Clarity, $F (1, 116) = 2.92$, $p= .090$, $\eta p2 = .025$.

Table 3
Mean scores of the participants (PLHIV and PWoHIV) on the Difficulty in Emotion Regulation Scale-Hindi version (DERS-H) and its subscales

Subscales of DERS-H	**Scores obtained on DERS-H**	
	PLHIV Mean ± SE [95% CI]	**PWoHIV Mean ± SE [95% CI]**
Nonacceptance	15.01 ± .72 [13.58, 16.44]	12.85 ± .72 [11.42, 14.28]
Goals	11.02± .57 [9.89, 12.15]	9.34± .57 [8.22, 10.47]
Impulse	12.93± .68 [11.57, 14.28]	11.54±.68 [10.19, 12.89]
Strategies	19.45± .98 [17.51, 21.40]	16.48±.98 [14.53, 18.43]
Clarity	11.67± .56 [10.55, 12.79]	10.22±.56 [9.10, 11.33]
Total DERS-H	70.08 ± 3.23 [63.69, 76.48]	60.444 ± 3.23 [54.04, 66.83]

Partial correlations (controlling for education and SES) of HIV duration, viral load, and CD4 count with accuracy and RT of emotion recognition of the PLHIV on the visual and auditory emotion recognition tasks were not significant. However, significant partial correlation of CD4 count with the total score of difficulties in emotion regulation, $r(23) = -.40$, $p< .05$, was obtained. CD4 count also correlated significantly and negatively with subscale scores of Goals, $r(23) = -.49$, $p< .05$, and Strategies, $r(23) = -.41$, $p< .05$. These findings suggest that increase in CD4 count was associated with decrease in difficulties of emotion regulation among PLHIV.

Discussion

The present study brought to the fore this novel finding that PLHIV are deficient at recognising emotions presented in auditory information, which was reflected in the poor accuracy of emotion recognition compared to the PWoHIV. This deficit among PLHIV was even more prominent for the recognition of fear. In terms of overall accuracy and RT of visual emotion recognition, however, PLHIV and PWoHIV did not differ significantly. Nevertheless, compared to PWoHIV, PLHIV showed a significant decline in the accuracy of facial emotion recognition for surprise. In terms of self-reported difficulties of emotion regulation, PLHIV reported significantly more difficulties of emotion regulation overall, as well as difficulties of Nonacceptance and Strategies, compared to the PWoHIV. Furthermore, while HIV duration and viral load did not associate significantly with either the emotion recognition performance or the self-reported emotion regulation difficulties of the PLHIV, CD4 count showed significant negative association with overall difficulties in emotion regulation as well as with Goals and Strategies.

The finding that PLHIV show deficits in the auditory processing of emotions (assessed in terms of recognition of emotions conveyed through audio clips) adds to the existing literature since most of the few studies that have been conducted earlier (e.g., Baldonero et al., 2013; Clark et al., 2010) on PLHIV have reported only facial emotion recognition difficulties among them. Interestingly, though, our emotion-specific findings for auditory emotion recognition corroborate the findings from earlier literature which are based on visual emotion recognition. Clark et al. (2010) reported impairments in facial emotion recognition among HIV patients, specifically for the emotion of fear, and we found that PLHIV showed significant impairments in the recognition of fear from audio clips as compared to PWoHIV. Such a difference between the two groups was not noted for any of the five other emotions when assessing auditory emotion recognition. Fear is an intensely-negative emotion, and generally, basic negative emotions tend to be identified less promptly and accurately than positive emotions. This phenomenon could stem from the interference caused by the expression of fear, potentially hindering the recognition process by directing perceivers towards potential threats (Tracy & Robins, 2008). Earlier research (e.g., Clark et al., 2010) indicates that abnormalities in recognizing fear in individuals with HIV might result from a disturbance in the overall neural network responsible for emotion recognition, which relies on the proper functioning of the frontal system. Regrettably, we lack direct evidence of the participation of these neural substrates in our sample. Nevertheless, given the demonstrated impairment (Towgood et al., 2012), we cannot rule out the possibility that the reduced performance in fear recognition observed in our patients may be attributable, at least in part, to the impact of the infection.

Contrary to our expectation, both the accuracy as well as the recognition time of visual emotion recognition were not found to differ significantly between PLHIV and PWoHIV in our study. This goes against the findings reported previously for facial emotion recognition (e.g., Baldonero et al., 2013; Clark et al., 2010). It is important to note, however, that previous studies presented participants with facial photographs in order to assess their facial emotion recognition while we used facial emotion videos in the present study. The latter, though more ecologically valid, failed to replicate the findings reported in previous studies. One potential explanation for this issue is the cross-race effect. The facial emotion videos used in this study include posers who are mainly Caucasian, a different race than of the participants in this study. Although the photographs of the six basic emotions which are considered to be universal were used in the development of these facial emotion videos (Shukla et al., 2019), emotion recognition is found to be influenced by cross-race effect, which refers to a reduced recognition of facial emotions in a person belonging to a different race (Elfenbein & Ambady, 2002). The cross-race effect also explains why recognition of emotions in the present study was clearer from auditory than visual modality, as the auditory stimuli contained statements spoken in the native language of the participants of the study. Our findings also failed to support the earlier evidences of greater decline in the recognition of fear among PLHIV. Instead, for facial emotion recognition, we observed a greater decline in the recognition of surprise among PLHIV. Fear and surprise are the two basic emotions that are confused most often (Jack et al., 2009; Matsumoto & SungHwang, 2011), probably because of greater similarity than distinction of muscle movements involved in producing them (Ekman, 2003). It is possible that since PLHIV are deficient in recognising fear, they might be deficient in recognising surprise, an emotion similar to fear. However, this still does not explain why PLHIV were not significantly impaired in recognising the emotion of fear itself. Future researches need to use ecologically-valid facial emotion stimuli (images and/or videos) developed and standardised on Indian posers, so as to eliminate the cross-race effect.

It is pertinent to mention here that even though PLHIV showed significantly poorer recognition of visually-presented (for the emotion of surprise) and auditorily-presented emotions as compared to PWoHIV, PWoHIV did not show a high accuracy on the tasks of emotion recognition (slightly more than 55% in both the tasks). A possible reason for this is that the sample in the current study belonged to middle SES, as per the latest criteria indicated in the modified B. G. Prasad socioeconomic scale 2022 for India (Sood et al., 2023) which classifies Indians with a monthly per capita income in the range of 2460-4155 INR (Indian National Rupee) as belonging to middle class SES. These individuals also had low educational attainment (13 years of formal education in the case of PWoHIV).

In terms of emotion regulation, PLHIV reported significantly more difficulties in regulating their emotions compared to PWoHIV. Specifically, PLHIV expressed more difficulties in the domains of Nonacceptance and Strategies. Nonacceptance means having a nonaccepting tendency for one's own negative emotional experiences and feelings, for instance, being angry at oneself for feeling upset. Strategies implies not having enough access to healthy and adaptive emotion regulation strategies while experiencing negative emotions. For PLHIV, this means that they tend to be rather unaccepting of their negative emotions and believe that there is not much that they can do to improve their negative emotions. These findings find some support from previous studies that show emotion dysregulation among PLHIV (Brandt et al., 2017), especially emotional suppression and low cognitive appraisal compared to their normal counterparts (Tiwari, 2015). Studies (e.g., Wei et al., 2016) also indicate that better emotion regulation can mediate the effects of HIV stigma on the experiences of negative emotions. We also observed (through partial correlation) that a decrease in emotion regulation difficulties, particularly Strategies and Goals (which involves difficulty concentrating on and accomplishing current task(s) when experiencing negative emotions) was associated with an increase in the CD4 count. This suggests that timely initiation and proper adherence to the Antiretroviral Therapy (ART) is vital in PLHIV, as this will ensure increase in the CD4 count, which would also be associated with better emotion regulation. However, based on the present findings, we cannot say if an increase in CD4 can lead to a decrease in maladaptive emotion regulation or vice-versa, since correlational analyses done in the present study precludes such inferences. Future researches are needed to explore a causal link between CD4 count and emotion regulation.

The findings of the present study can have important implications for future researches on PLHIV as well as for the design of psychological and psychosocial interventions aimed at improving their mental health. Non-adherence to ART was found more among people having difficulty recognising the emotions of others (Sofia et al., 2018). Thus, behavioural interventions targeting improvement in emotion recognition, particularly auditory emotion recognition, need to be developed for PLHIV. Teaching PLHIV adaptive emotion regulation strategies is also important since the key determinants of lack of adherence to treatment in PLHIV are a negative mood, mental health issues, and emotional difficulties (Nasibehzanjari et al., 2020; Rowell-Cunsolo & Hu, 2020).

The present study is not without limitations that must be considered to understand the generalisability of the findings. First, we failed to take into account the psychological and social consequences of HIV infection, along with their potential influence on emotion recognition ability (Atkins et al., 2010), as well as the psychological premorbid traits. For instance, studies show the presence of hearing impairment in a fair number of HIV-infected individuals (Luque et al., 2014; Maro et al., 2014). However, this was not accounted for in the present study and such hearing impairment may have possibly confounded the impaired emotion recognition of fear observed in PLHIV. It should be noted though that emotion recognition impairment for other emotion categories was not observed between PLHIV and PWoHIV. Future researches need to first evaluate the level of hearing ability of PLHIV and account for it in analysing their emotion recognition from auditory stimuli, or require a minimum level of hearing ability in the participants at the time of recruitment.

Second, due to the design of the study, it was not possible to infer causal relations between the variables in the study. For example, we cannot say based on the present findings if increase in CD4 count caused or resulted from decline in emotion regulation difficulties. Third, small sample size was also a limitation since a larger sample size would have allowed for analysing differences in emotion recognition and emotion regulation difficulties as per the duration since

diagnosis. For instance, participants could have been divided into groups of those who had been recently diagnosed (<6 months), diagnosed since the last 12 months, 18 months, 24 months, and so on, to explore how this duration influenced their emotion recognition.
On a related note, future studies may seek to explore how PLHIV showing varied strictness of treatment adherence differ in terms of emotion recognition and emotion regulation. As a further direction for future research, it is important to consider that PLHIV, because of their life-threating condition, are likely to be more prone to experiencing fear. It is conceivable that they might thus try to avoid/ignore fear in general to prevent being overwhelmed – a likely reason behind their performing poorly in the recognition of the emotion of fear. The fact that PLHIV scored higher on Nonacceptance of negative emotions as well as on limited access to emotion regulation Strategies further supports the speculation that HIV-related fear may negatively influence the recognition of fear among PLHIV. However, this needs to be verified in future researches.

Conclusion

In conclusion, findings of the present study highlight that PLHIV are impaired at recognising emotions from auditorily-presented emotional information, particularly fear and also show reduced accuracy of recognising the emotion of surprise from facial emotion videos. PLHIV also report significantly greater difficulties in regulating their emotions than PWoHIV, particularly nonacceptance of their responses to negative emotions and having limited access to adaptive emotion regulation strategies. The present study showed that an increase in CD4 count (an indicator of better immunity) among PLHIV is associated with reduction in emotion regulation difficulties, specifically in the lack of access to emotion regulation strategies and in the inability to engage in goal-oriented behaviour while experiencing negative emotions. These findings can help develop targeted interventions aimed at improving emotion recognition and emotion regulation for PLHIV.

Conflict of interests: The authors report there are no competing interests to declare.

Compliance with Ethical Standards: The study protocol was approved by the Institutional Ethics Committee of the first author's affiliation (Ref. No.: Psy/18/23).

Informed Consent: All the participants provided written informed consent before participating in the study.

Data availability: The dataset generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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