Acculturative orientations among Hispanic/Latinx caregivers in the ABCD Study: Associations with caregiver and youth mental health and youth brain function

Alan Meca[1], Julio A Peraza[2], Michael C. Riedel[2], Erica D. Musser[3], Taylor Salo[3], Jessica S. Flannery[4], Katherine L. Bottenhorn[5], Anthony S. Dick[3], Rosario Pintos Lobo[3], Laura M. Ucros[6], Chelsea A. Greaves[6], Samuel W. Hawes[3], Mariana Sanchez[7], Marybel R. Gonzalez[8], Matthew T. Sutherland[3], Raul Gonzalez[3], Angela R. Laird[2]

[1] Department of Psychology, University of Texas San Antonio, San Antonio, TX, USA
[2] Department of Physics, Florida International University, Miami, FL, USA
[3] Department of Psychology, Florida International University, Miami, FL, USA
[4] Department of Psychology and Neuroscience, University of North Carolina, Chapel Hill, NC, USA
[5] Department of Population and Public Health Sciences, University of Southern California, Los Angeles, CA, USA
[6] School of Integrated Science and Humanities, Florida International University, Miami, USA
[7] Department of Health Promotion and Disease Prevention, Florida International University, Miami, FL, USA
[8] Department of Psychiatry, University of California, San Diego, CA, USA

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Corresponding Author: **Dr. Alan Meca**, Assistant Professor of Psychology, University of Texas San Antonio | Email: alan.meca@UTSA.edu

ABSTRACT

Background: Population-based neuroscience offers opportunities to examine important but understudied sociocultural factors, such as acculturation. Acculturation refers to the extent to which an individual retains their cultural heritage and/or adopts the receiving society's culture and is particularly salient among Hispanic/Latinx immigrants. Specific acculturative orientations have been linked to vulnerability to substance use, depression, and suicide and are known to influence family dynamics between caregivers and their children. Methods: We investigated first- and second-generation Hispanic/Latinx caregivers in the ABCD Study and examined how caregivers' acculturative orientation impacts their mental health, as well as the mental health and brain function of their children. Neuroimaging analyses focused on regions associated with self- and affiliation-based social processing (ventromedial prefrontal cortex, insula, and temporoparietal junction). Results: We identified two profiles of caregiver acculturation: bicultural (retains heritage culture while adopting US culture) and detached (discards heritage culture and rejects US culture). Bicultural caregivers exhibited fewer internalizing and externalizing problems compared to detached caregivers; further, youth exhibited similar internalizing effects across caregiver profiles. In addition, youth with bicultural caregivers displayed increased resting-state brain activity (i.e., fALFF and ReHo) in the left insula, which has been linked to psychopathology; however, differences in long-range functional connectivity were not significant. Conclusions: Caregiver acculturation is an important familial factor linked to significant differences in youth mental health and insula activity. Future work should examine sociocultural and neurodevelopmental changes across adolescence to assess health outcomes and determine whether localized, corticolimbic brain effects are ultimately translated into long-range connectivity differences.

INTRODUCTION

Large, population-based neuroscience studies offer opportunities to investigate research questions among more diverse and representative samples (1). However, this diversity may often implicitly serve as an encouragement for neuroimaging researchers to stratify samples and examine brain-based group differences on the basis of ethnicity, gender, race, sex, or other relevant demographic information. Such analyses often unintentionally provide support for a biological deficits-based framework, which argues that lower rates of achievement and/or poorer life outcomes among minoritized groups are the result of "biological determinism." Responsible and ethical data analyses should strive to prevent stigmatizing and marginalizing research through consideration of potentially harmful impacts research could have (2–5). Importantly, it is critical that researchers consider the impact of factors related to social determinants of health (6). The goal of this study was to demonstrate the importance of considering cultural variables, with a focus on the exemplar domain of acculturation, which has been linked to a variety of outcomes, including alcohol use (7), cigarette smoking (8), and suicide risk (9).

Acculturation broadly refers to the extent to which an individual retains their cultural heritage and/or adopts the receiving society's culture (10). Within the United States (US), Hispanic/Latinx people are among the largest and fastest-growing immigrant groups (11) and acculturative processes are particularly salient among first- and second-generation, and to some extent, third-generation, Hispanic/Latinx immigrants (10). Contemporary views of acculturation draw on Berry's model (12),

which casts acculturation as a bidimensional process consisting of receiving/US culture acquisition and heritage culture retention. This bidimensional conceptualization proposes that individuals can acquire receiving culture without discarding their heritage culture (10). Berry's model (13,14) proposes four distinct acculturative orientations: (1) **bicultural** (i.e., acquires the receiving culture and retains the heritage culture); (2) **assimilated** (i.e., acquires the receiving culture and discards the heritage culture); (3) **separated** (i.e., rejects the receiving culture and retains the heritage culture); and (4) **detached** (i.e., rejects the receiving culture and discards the heritage culture)[1] (**Fig. 1**). A number of studies have provided mixed support for Berry's (1980) model using person-centered methods that empirically derive acculturation groupings (15–22). However, across studies, biculturalism has been consistently identified and characterized as the most adaptive orientation (15,23,24). Despite this, limited research has focused on understanding underlying mechanisms between acculturation and youth mental health.

Figure 1. Acculturative Orientation Profiles. Berry's model (13,14) proposes four distinct acculturative orientations. Among Hispanic/Latinx immigrants in the US, these profiles include: (1) **bicultural** (i.e., acquires US culture and retains the heritage culture), (2) **assimilated** (i.e., acquires US culture and discards the heritage culture), (3) **separated** (i.e., rejects US culture and retains the heritage culture), and (4) **detached** (i.e., rejects US culture and discards the heritage culture).

Increasingly, scholars have argued that it is not acculturation itself, but the dynamics between caregiver and adolescents acculturation within a family system that impacts youth mental health and behavioral problems (25,26). Indeed, caregivers' own acculturative orientation impacts the degree to which they socialize their children to gravitate towards (or away) from the receiving and heritage cultures (27–29). Moreover, caregivers' own acculturation orientation impacts the way they approach parenting (30). Parenting behaviors are broadly associated with youth mental health (31,32) and influence neurodevelopment (33,34), with evidence that regions associated with social functioning are particularly implicated (35,36). Prior studies of the neurobiological bases of acculturation highlight the relevance of self-referential processing in the medial prefrontal cortex (37,38), although there is limited work in this

[1] Although Berry (1997) originally used the term "Integration", the dual endorsement of heritage and US cultures has been increasingly referred to as "Biculturalism" (10). Moreover, although Berry used the term "Marginalized" to represent detachment from both heritage and US cultures, we use the term "Detached" as a better representation of individuals' lack of connection to either cultural stream.

domain. Adolescence is a critical period for sociocultural processing and social brain development (39); however, it is unclear how caregiver acculturation may impact youth neurodevelopment.

The objective of the current study was to evaluate the acculturative orientations of first- and second-generation Hispanic/Latinx immigrant caregivers in the Adolescent Brain Cognitive Development℠ Study (ABCD Study®) (40). We focused on ABCD data acquired at baseline (i.e., 9-10-year-old youth) to establish an understanding of caregiver acculturation among ABCD Hispanic/Latinx families as an important familial influence at the onset of adolescence. Baseline assessment of ABCD caregiver-youth dyads offers an opportunity to explore how specific caregiver acculturative orientations may lead to adverse outcomes among youth, including mental health and substance use problems. To this end, and building on prior work among adult populations (16,18), we aimed to further empirically validate Berry's model of acculturation by identifying data-driven groupings of ABCD caregivers at baseline using latent profile analysis (LPA). Once we identified acculturative orientation profiles, we investigated associations with caregiver and youth mental health and youth brain function. Given the large and demographically diverse ABCD sample (41), and in line with current theory (13–15) and prior results among adult populations (15–22), we hypothesized that LPA would reveal four acculturation profiles (i.e., bicultural, assimilated, separated, and detached profiles). We further expected that biculturalism would be associated with fewer mental health problems among caregivers and their children. We leveraged prior meta-analytic results to guide analyses of brain regions associated with self- and affiliation-based social processing, including the ventromedial prefrontal cortex (vmPFC), insula, and temporoparietal junction (TPJ) (42). Finally, we discuss additional research needed to more fully understand neurobiological mechanisms linked with acculturative experiences.

METHODS

Participants

Participants were selected from the ABCD Study, the largest longitudinal study of brain development and child health in the US (40). Approximately 11,800 youth aged 9.00 to 10.99 years old were enrolled in the ABCD Study across 21 sites in the US (43). Participants within the ABCD Study were recruited through geographically, demographically, and socioeconomically diverse school systems using epidemiologically informed methods to enroll a population-based, demographically diverse sample (41). Data from the ABCD Study are made available by the NIMH Data Archive and the current study utilized data from the ABCD Curated Annual Release 3.0.

Measures

Caregiver-Reported Demographics

Demographic information was provided at baseline by a child's caregiver, including the child's age, gender, ethnicity, race, as well as the caregiver's age, gender, ethnicity, race, education, and combined family income. In addition, caregivers reported the nativity (i.e., country of origin) for the child, parent/guardian, and grandparents (44).

Caregiver-Reported Acculturation

Within the robust culture and environment battery at baseline (45), caregivers completed the Vancouver Index of Acculturation (VIA) in English or Spanish. The VIA is a 20-item bidimensional measure with subscales that separately measure heritage and U.S. acculturation (46). Items addressed a range of topics, including traditions, social activities, media, cultural values and behavioral preferences. Caregivers were asked to provide their heritage culture as an open-ended item with specific examples provided as prompts (e.g., "*Asian*", "*Black/African American*", "*Hispanic*", "*Native American*", "*Jewish*"); those who did not identify a heritage culture were told not to complete the VIA. Initial assessment of VIA data at ABCD baseline indicated high internal consistency across the heritage (α=0.92) and US (α=0.90) subscales, with early data suggesting higher VIA subscale scores for both heritage and US cultures among families at lower risk compared to those at higher risk for adolescent substance use (45).

Caregiver and Youth Measures of Mental Health

In addition to measures of demographics and acculturation, the ABCD baseline mental health battery included measures of caregiver and youth mental health (44). Caregivers completed the Adult Self Report (ASR), which assesses behavioral dimensions relevant to adult psychopathology (47) and the Child Behavior Checklist (CBCL) (47), which assesses behavioral dimensions relevant to child psychopathology. NDA provides the age- and gender-normed syndrome and DSM-oriented scale scores of the ASR and CBCL, both of which were used in the present study.

Hispanic/Latinx Sample Selection

A total of 11,878 ABCD participants were recruited at baseline. Data for the present analyses were downloaded from NDA for 2,411 participants who completed their baseline assessment for the ABCD Study and responded "*Yes*" to "*Do you consider the child Hispanic/Latino/Latina?*". We filtered participant datasets to include only caregivers who: (1) were first- or second-generation immigrants to the US, (2) were born (or their parents were born) in Latin America, (3) completed the VIA, and (4) referenced Hispanic/Latinx culture when completing the VIA. The subsequent sample thus consisted of 1,057 caregivers ($Mean_{Age}$=38.31 years, SD=6.64 years; 90.1% mothers, 70.5% foreign born) and 1,158 children (52.7% male, 91.7% US born). Additional details about the sample are provided in the Supplemental Information (SI).

Neuroimaging Data

Youth participants completed a baseline neuroimaging protocol that included structural magnetic resonance imaging (MRI), as well as resting-state functional MRI (fMRI) using high spatial and temporal resolution simultaneous multislice/multiband echo-planar (EPI) (48,49). For Siemens scanners, fMRI scan parameters were: 90×90 matrix, 60 slices, field of view=216×216, echo time/repetition time=30/800ms, flip angle=52°, 2.4mm isotropic resolution, and slice acceleration factor 6. The complete protocols for all vendors and sequences are provided by Casey et al. (48).

Analyses

Latent Profile Analysis (LPA)

To empirically evaluate Berry's model of acculturation by identifying distinct groups of caregivers based on their VIA scores (e.g., US and heritage subscales), we conducted an LPA in `Mplus` 8.7 with a Robust Maximum Likelihood (MLR) estimator and a sandwich covariance estimator (50) to adjust the standard errors and account for the nesting of participants within site. A combination of fit statistics and substantive interpretability were used to decide on the number of profiles (51). First, a solution with *k* profiles was selected only if it provided a significantly better fit than a solution with *k*-1 profiles, to balance parsimony and fit. This was determined using the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LRT), which indicates the extent to which the -2 log likelihood value for a model with *k* profiles is significantly smaller than the corresponding value for a model with *k*-1 profiles. Second, entropy values and posterior probabilities of correct classification should be at least 0.70 (52). Third, to ensure stability of the profile solution, each profile had to represent more than 5% of the sample (53). Fourth, the profiles had to be conceptually and substantively different from one another; one profile could not simply be a variant of another profile.

Next, we estimated a series of path models with acculturative orientation as a categorical predictor to determine if there were differences in terms of caregiver and youth mental health using the ASR and CBCL data, respectively, with separate models using traditional scoring and DSM-aligned scoring. All subsequent path models were estimated in `Mplus` 8.6 (54) with an MRL estimator and a sandwich covariance estimator (50) to account for the nesting of participants within site. Covariates included caregiver education, gender, nativity, and as well as youth gender and family income. Missing data were handled using full-information maximum likelihood estimation.

Although it was not necessary to account for family nesting in caregiver analyses (one caregiver selected per family, see SI), given the presence of siblings in the youth dataset, it was prudent to estimate youth mental health (i.e., CBCL) models using multilevel modeling (MLM) accounting for nesting of children (level 1) within family (level 2) and site (level 3). That said, we note that out of the 1,057 families, only 100 (9.5%) consisted of more than one child, potentially limiting the feasibility of MLM. As such, we estimated all models two different ways: (1) for families with more than two children enrolled, we selected the first sibling to have participated in the study and did not use MLM ("simplified sample"), and (2) we used MLM to account for nesting of children within families and sites ("full sample and MLM").

Neuroimaging Preprocessing

MRI data were processed using `fMRIPrep` 21.0.0, a BIDS-App that automatically adapts a best-in-breed workflow, ensuring high-quality preprocessing with minimal manual intervention (55,56). Anatomical images were intensity-corrected, skull-stripped, segmented, and spatially normalized to a standard brain template in MNI space. Functional MRI preprocessing included motion correction, susceptibility distortion correction, and coregistration. Denoising was performed using AFNI's (57) `3dTproject` (58). Complete details of the MRI preprocessing and analyses are described in the SI.

Resting State fMRI Analyses

Resting state functional magnetic resonance imaging (rs-fMRI) analyses were preregistered (https://osf.io/mkdw3/). We focused on five meta-analytically-defined regions of interest (ROIs)

associated with self- and affiliation-related processing (42), including the (1) vmPFC, (2) left insula, (3) right insula, (4) left TPJ, and (5) right TPJ (Fig. S1). For each resting-state acquisition, voxelwise time series were extracted from each ROI using the unsmoothed, preprocessed, and denoised data via AFNI's `3dmaskave`. Averaged ROI time series were generated by calculating the mean voxel value for each time point across non-zero voxels respective to each region. For each ROI, we computed two measures of rs-fMRI activity: fractional amplitude of low-frequency fluctuations (fALFF) as a measure of local, spontaneous fluctuations during the resting state (59), and regional homogeneity (ReHo) as a measure of local BOLD signal coherence (60). In addition, adjacency matrices were constructed for each participant by computing the pairwise Pearson's correlation coefficients between each pair of ROIs generating a 5x5 connectivity matrix with 10 unique regional pairs. Correlation values were Fisher *z*-transformed to provide a summary measure of pairwise functional connectivity.

Next, we estimated a series of path models to characterize potential differences across caregiver acculturation profiles in terms of rs-fMRI activity and connectivity. Three separate models were tested for: (1) spontaneous fluctuations using fALFF, (2) local signal coherence using ReHo, and (iii) functional connectivity using z-transformed correlation coefficients. Path models were estimated in `Mplus` 8.6 controlling for caregiver education, gender, nativity, and as well as youth gender and family income. As before, given the presence of siblings in the dataset, we generated models using the simplified sample (no MLM) and full sample (with MLM).

RESULTS

Latent Profile Analysis

As shown in **Table 1**, although the 2-profile solution provided significantly better fit compared to the 1-profile solution [LRT=468.392, $p<0.001$], there was no significant improvement in fit between the 2-profile versus 3-profile solution [LRT=143.473, $p=0.065$]. As such, the 2-profile solution was advanced as the championed model.

Table 1. Latent Profile Analysis Model Comparisons.

# of Profiles	AIC	BIC	Adj BIC	Entropy	Smallest	LRT (3)	p-Value
2	5520.457	5555.199	5532.966	0.791	26.68%	468.392	<0.001
3	5376.117	5425.748	5393.987	0.833	4.16%	143.472	0.065
4	5284.536	5349.057	5307.767	0.871	2.37%	93.123	0.188

Note. AIC = Akaike Information Criteria, BIC = Bayesian Information Criteria, LRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test.

Table 2 presents mean *z*-scores for heritage and US cultural orientations across profiles, indicating how far each profile deviated from the total sample average. These *z*-scores can thus be interpreted as an effect size index. The first profile represented 73.3% of the sample ($n=775$) and was marked by high levels of both heritage and US cultural orientation. In line with Berry's conceptualization, this model was labeled "Bicultural". The second profile, labeled "Detached", accounted for 26.7% of the sample ($n=282$) and was characterized by low levels of both heritage and US cultural orientation.

Table 2. Standardized Differences Across the Two Acculturation Approaches.

Acculturation Dimension	Bicultural	Detached
Heritage Orientation	0.452	-1.243
US Orientation	0.380	-1.047

Note. Dimensions were standardized and should be interpreted as average z-scores indicating how far each profile deviates from the total sample average scores and from other profiles.

Next, profile membership and posterior probabilities were saved back into the dataset. To ensure clearly defined class membership, we restricted profile assignment to those whose posterior probabilities were 0.70 or higher. Of the 1,057 total unique caregivers, 981 (92.81%) had posterior probabilities greater than 0.70. This included 747 bicultural and 234 detached caregivers. **Fig. 2** illustrates the *z*-scores for heritage and US cultural orientations across profiles. Differences between the bicultural and detached profiles in terms of caregiver education, gender, nativity, as well as family income and study site are reported in the SI.

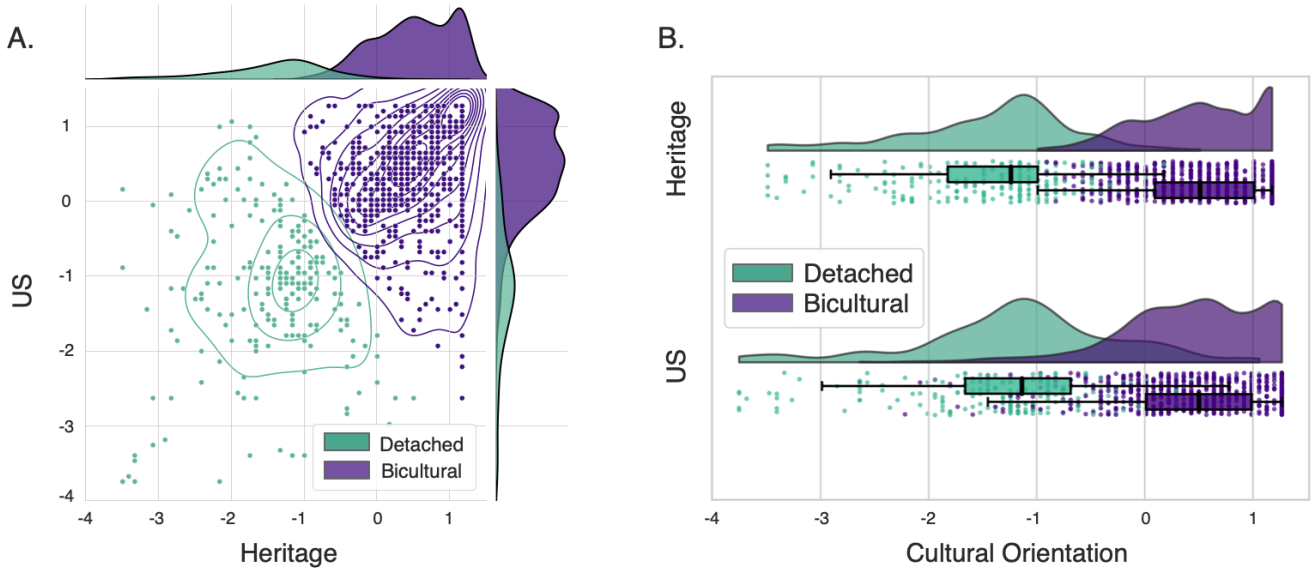

Figure 2. Heritage and US Cultural Orientations Across Profiles. LPA revealed two acculturative orientation profiles among Hispanic/Latinx caregivers in the ABCD Study. Cultural orientation subscale scores were normalized across participants and the resulting z-scored values are shown in: (A) a joint kernel density estimate plot (61) and (B) a raincloud plot (62). In both visualizations, the "Bicultural" profile (*n*=747) demonstrated high levels of both heritage and US cultural orientation (purple), while the "Detached" profile (*n*=234) exhibited very low levels of both heritage and US cultural orientation (green).

Class Membership Effects: Caregiver and Youth Mental Health

Next, we estimated a path model with acculturative orientation included as a categorical predictor (0=detached, 1=bicultural) to determine whether there were significant differences across profiles in terms of caregiver mental health. Based on traditional scoring for the ASR (**Table 3a**), results indicated that being bicultural was associated with higher personal strengths and lower levels of withdrawal and somatic symptoms (e.g., headaches, dizziness), as well as lower levels of thought, attention, and

aggressive problems relative to those within the detached group. In addition, we estimated a separate model using the DSM-aligned ASR scoring (**Table 3b**), which indicated caregivers who had a bicultural orientation had significantly lower symptoms of depression, avoidant, and inattentive behaviors.

Table 3. Class Membership Effects on Caregiver Mental Health.

	Estimate (STDYX)	*p*-value	95% CI L	95% CI H
(a) Caregiver-Reported ASR (Traditional Scoring)				
Personal Strengths	3.290 (0.137)	<0.001*	1.753	4.827
Anxious/Depressed	-0.754 (-0.062)	0.120	-1.704	0.197
Withdrawn/Depressed	-1.585 (-0.133)	<0.001*	-2.472	-0.697
Somatic Complaints	-1.094 (-0.082)	0.001*	-1.765	-0.423
Thought Problems	-0.947 (-0.091)	0.010*	-1.667	-0.226
Attention Problems	-0.959 (-0.072)	0.010*	-1.685	-0.234
Aggressive Behavior	-0.737 (-0.063)	0.035*	-1.420	-0.053
Rule Breaking Behavior	-0.660 (-0.064)	0.059	-1.344	0.024
Intrusive Behavior	0.286 (0.041)	0.214	-0.165	0.737
(b) Caregiver-Reported ASR (DSM Scoring)				
Depression	-1.060 (-0.188)	0.002*	-1.723	-0.397
Anxiety	-0.204 (-0.036)	0.656	-1.103	0.695
Somatic	-0.812 (-0.136)	0.070	-1.690	0.066
Avoidant	-1.245 (-0.231)	0.008*	-2.165	-0.325
ADHD	-1.040 (-0.193)	0.053	-2.091	0.011
Antisocial	-0.559 (-0.121)	0.140	-1.299	0.182
Inattention	-1.280 (-0.198)	0.038*	-2.490	-0.070
Hyperactivity	-0.524 (-0.132)	0.180	-1.291	0.243

Note. ASR = Achenbach Adult Self Report, CI L = Confidence Interval Low, CL H = Confidence Interval High. * (and bold) = significant at *p*-value < 0.05.

We examined whether there were significant differences between caregiver bicultural and detached profiles in terms of youth mental health. Based on traditional CBCL scoring (**Table 4a**), using the simplified sample, children of caregivers with a bicultural orientation were significantly less withdrawn/depressed and had lower somatic complaints and thought problems relative to those with detached caregivers. Using the full sample and MLM to account for family nesting, children of caregivers with a bicultural orientation exhibited significantly lower somatic complaints. Similarly, and based on the DSM scoring of the CBCL (**Table 4b**), children of caregivers with a bicultural orientation had lower symptoms of depression relative to those with detached caregivers. Results from the multilevel model included lower depressed symptoms, as well as lower somatic complaints among children of caregivers with bicultural orientation.

Class Membership Effects: Youth rs-fMRI Activity and Connectivity

Lastly, we examined whether there were significant differences between caregiver bicultural and detached profiles in terms of youth rs-fMRI activity and connectivity. With respect to spontaneous fluctuations during resting state (**Table 5a**), children of caregivers with a bicultural orientation exhibited greater fALFF values in the left insula, according to analyses of both the simplified sample and the full sample using MLM. In terms of regional homogeneity (**Table 5b**), children of caregivers with a bicultural orientation exhibited greater ReHo values also in the left insula, according to analyses of both the

simplified and full sample samples. In terms of pairwise functional connectivity values (**Table 6**), no significant differences in connectivity between the vmPFC, bilateral insula, and bilateral TPJ were observed among youth with bicultural vs. detached caregivers.

Table 4. Class Membership Effects on Youth Mental Health.

	Simplified Sample (No MLM)				Full Sample (MLM)			
	Estimate (STDYX)	***p*-value**	**95% CI L**	**95% CI H**	**Estimate (STDYX)**	***p*-value**	**95% CI L**	**95% CI H**
(a) Caregiver-Reported CBCL (Traditional Scoring)								
Anxious/Depressed	-0.110 (-0.019)	0.802	-0.972	0.752	-0.300 (-0.075)	0.467	-1.107	0.508
Withdrawn/Depressed	-0.838 (-0.139)	0.034*	-1.610	-0.065	-0.574 (0.061)	0.065	-1.183	0.036
Somatic Complaints	-0.943 (-0.148)	0.008*	-1.637	-0.249	-0.970 (0.002)	0.001*	-1.564	-0.375
Social Problems	-0.216 (-0.049)	0.540	-0.907	0.475	-0.134 (0.597)	0.596	-0.631	0.362
Thought Problems	-0.622 (-0.123)	0.040*	-1.214	-0.030	-0.645 (0.192)	0.175	-1.579	0.288
Attention Problems	-0.438 (-0.077)	0.322	-1.303	0.428	-0.463 (0.174)	0.184	-1.147	0.220
Rule Breaking Behavior	-0.564 (-0.141)	0.176	-1.382	0.254	-0.508 (0.105)	0.104	-1.120	0.104
Aggressive Behavior	-0.366 (-0.081)	0.351	-1.135	0.403	-0.316 (0.216)	0.249	-0.853	0.221
(b) Caregiver-Reported CBCL (DSM Scoring)								
Depression	-0.713 (-0.054)	0.042*	-1.402	-0.025	-0.652 (0.043)	0.040*	-1.276	-0.029
Anxiety	-0.363 (-0.024)	0.438	-1.281	0.555	-0.386 (0.375)	0.393	-1.271	0.500
Somatic	-0.798 (-0.050)	0.052	-1.603	0.007	-0.850 (0.033)	0.026*	-1.597	-0.104
ADHD	-0.438 (-0.037)	0.260	-1.201	0.325	-0.371 (0.275)	0.239	-0.989	0.247
Oppositional Defiant	0.017 (0.002)	0.958	-0.615	0.648	-0.036 (-0.012)	0.886	-0.522	0.451
Conduct	-0.745 (-0.073)	0.128	-1.703	0.213	-0.601 (-0.251)	0.142	-1.404	0.202

Note. CBCL = Child Behavior Checklist. Unstandardized estimates of regression coefficients are provided with standardized coefficients (STDYX) in parentheses. CI L = Confidence Interval Low, CL H = Confidence Interval High. * = significant at *p*-value < 0.05; bold indicates significant for both simplified and MLM analyses.

Table 5. Class Membership Effects on Youth rs-fMRI Activity.

	Simplified Sample (No MLM)				Full Sample (MLM)			
	Estimate (STDYX)	*p*-value	95% CI L	95% CI H	Estimate (STDYX)	*p*-value	95% CI L	95% CI H
(a) fALFF								
vmPFC	0.016 (0.031)	0.389	-0.020	0.051	0.015 (0.058)	0.400	-0.020	0.049
Left Insula	0.023 (0.057)	0.013*	0.005	0.040	0.021 (0.112)	0.006*	0.006	0.036
Right Insula	0.010 (0.024)	0.395	-0.013	0.033	0.010 (0.051)	0.418	-0.014	0.035
Left TPJ	-0.018 (-0.032)	0.343	-0.057	0.020	-0.019 (-0.117)	0.394	-0.063	0.025
Right TPJ	-0.007 (-0.016)	0.693	-0.043	0.029	-0.012 (-0.095)	0.417	-0.041	0.017
(b) ReHo								
vmPFC	0.004 (0.006)	0.869	-0.041	0.049	-0.004 (-0.018)	0.850	-0.044	0.036
Left Insula	0.032 (0.055)	0.010*	0.008	0.057	0.030 (0.141)	0.007*	0.008	0.051
Right Insula	0.020 (0.035)	0.241	-0.014	0.054	0.025 (0.091)	0.112	-0.006	0.056
Left TPJ	-0.011 (-0.010)	0.770	-0.082	0.060	-0.015 (-0.037)	0.668	-0.081	0.052
Right TPJ	-0.008 (-0.010)	0.814	-0.077	0.060	<.001 (-0.001)	0.995	-0.059	0.059

Note. fALFF = fractional amplitude of low-frequency fluctuations, ReHo = regional homogeneity, vmPFC = ventromedial prefrontal cortex, TPJ = temporoparietal junction. Unstandardized estimates of regression coefficients are provided with standardized coefficients (STDYX) in parentheses. CI L = Confidence Interval Low, CL H = Confidence Interval High. * = significant at *p*-value < 0.05; bold indicates significant for both simplified and MLM analyses.

Table 6. Class Membership Effects on Youth rs-fMRI Connectivity.

	Simplified Sample (No MLM)				Full Sample (MLM)			
	Estimate (STDYX)	*p*-value	95% CI L	95% CI H	Estimate (STDYX)	*p*-value	95% CI L	95% CI H
Functional Connectivity								
L Insula --- R Insula	0.009 (0.018)	0.594	-0.025	0.044	0.020 (0.086)	0.202	-0.011	0.050
L Insula --- L TPJ	0.003 (0.007)	0.839	-0.029	0.035	-0.001 (-0.002)	0.970	-0.035	0.033
L Insula --- R TPJ	0.028 (0.054)	0.058	-0.001	0.056	0.025 (0.112)	0.107	-0.005	0.056
L Insula --- vmPFC	0.024 (0.051)	0.431	-0.036	0.085	0.022 (0.062)	0.476	-0.038	0.081
R Insula --- L TPJ	-0.002 (-0.004)	0.855	-0.023	0.019	-0.007 (-0.028)	0.490	-0.025	0.012
R Insula --- R TPJ	0.019 (0.037)	0.093	-0.003	0.042	0.016 (0.061)	0.199	-0.008	0.040
R Insula --- vmPFC	0.022 (0.046)	0.354	-0.024	0.067	0.022 (0.066)	0.326	-0.022	0.067
L TPJ --- R TPJ	-0.004 (-0.004)	0.801	-0.032	0.025	0.004 (0.019)	0.819	-0.031	0.040
L TPJ --- vmPFC	-0.009 (-0.009)	0.558	-0.039	0.021	-0.010 (-0.039)	0.471	-0.038	0.018
R TPJ --- vmPFC	0.007 (0.007)	0.694	-0.029	0.043	0.012 (0.048)	0.545	-0.026	0.049

Note. vmPFC = ventromedial prefrontal cortex, TPJ = temporoparietal junction, L = Left, R = Right. Unstandardized estimates of regression coefficients are provided with standardized coefficients (STDYX) in parentheses. CI L = Confidence Interval Low, CL H = Confidence Interval High. * = significant at *p*-value < 0.05; bold indicates significant for both simplified and MLM analyses.

DISCUSSION

Acculturation data from Hispanic/Latinx caregivers in the ABCD Study (*n*=1,057) were analyzed and yielded two caregiver profiles. "Bicultural" caregivers (*n*=747) endorsed high levels of both heritage and US cultural orientation, while "detached" (*n*=234) caregivers endorsed very low levels of heritage and US cultural orientation. Theory (13–15) and prior experimental work (16,18,19) have identified two additional profiles, "assimilated" (high US and low heritage) and "separated" (low US and high heritage), which were surprisingly not observed. It is possible that separated caregivers were less likely to enroll their children in the ABCD Study due to mistrust, documentation concerns, and/or reluctance to participate in a high-profile, national, longitudinal study (63). Lack of the assimilated profile may have stemmed from using the VIA in contrast to more domain-specific measures of heritage and US cultural practices, identifications, and values, which better capture nuances in cultural orientations (19). Comparison of ABCD bicultural and detached profiles indicated similar demographics, with the exception of higher educational attainment among bicultural caregivers. Biculturalism was associated with positive caregiver behaviors and mental health, including increased personal strengths and decreased affective and thought problems, in agreement with a wealth of prior acculturation research (8,9,15,23,24).

From a family systems perspective, these findings within the ABCD sample indicate potential environmental differences as a result of caregiver values, beliefs, and practices. Such differences can lead to significant downstream effects among their children. We showed that this is indeed the case among ABCD Hispanic/Latinx families, as youth of caregivers with a bicultural orientation exhibited significantly lower somatic complaints and depression. In terms of neural differences, youth of bicultural caregivers exhibited greater rs-fMRI activity (both fALFF and ReHo) in the left insula, potentially indicating increased metabolic rate of glucose and oxygen (64); these results are aligned with studies showing the insula is associated with somatic and depressive symptoms (65,66) and psychopathology broadly (67–69). The current person-centered analyses examining youth differences across caregivers profiles likely captured robust effects across a complex range of family environmental factors. As an alternate approach, we examined a more direct association between bidimensional caregiver acculturation and youth brain function (SI, *Alternate Analysis 1*). This variable-centered analysis revealed that among the full sample, bilateral TPJ were significantly negatively associated with US orientation, such that as US orientation increased, fALFF values in the TPJ decreased (**Table S1**). These results likely reflect this region's role in social affiliations (42) and speculate that TPJ hyperactivity may be linked to challenges in identity development as youth navigate US life within a family system that is not fully engaged with the broader US culture.

Importantly, our investigation of ABCD caregiver acculturation profiles at baseline identified a subset of Hispanic/Latinx youth that are at higher risk for adverse outcomes at the beginning of adolescence, a critical socioemotional neurodevelopmental period wherein psychopathology often emerges (70,71). Our neuroimaging analyses focused on meta-analytic ROIs selectively associated with self- and affiliation-related processing; however, this approach may be somewhat neuroanatomically and conceptually limited given the complex family dynamics at play. Specifically, early life stress is known to influence neurodevelopmental alterations in corticolimbic regions (34,72) that are linked to psychopathology (73) and substance use (74). To expand the current analytic framework and examine additional regions sensitive to maladaptive developmental processes, we conducted further analyses on sub-regions of the amygdala, hippocampus, insula, and striatum (SI, *Alternate Analysis 2*; **Fig. S2**). Results indicated significant rs-fMRI activity differences in bilateral intermediate sub-regions of the hippocampus, left dorsoanterior insula, and multiple bilateral sub-regions of the striatum (**Table S2**).

While these results are exploratory and may not be reproducible given the large number of seed regions examined, they offer insight into emerging, localized effects among ABCD youth at baseline and targets for future analyses at subsequent time points. That is, the longitudinal design of the ABCD Study provides a unique opportunity to continue following these at-risk Hispanic/Latinx youth, with the aim of more fully understanding divergent trajectories sensitive to stressful family dynamics that arise during adolescence when Hispanic/Latinx youth are developing their own cultural values, beliefs, and practices (28,75). Finally, we note that while differences in rs-fMRI activity (i.e., fALFF and ReHo) were observed, significant effects were not found for long-range connectivity differences, either for pairwise functional connectivity between self and affiliation regions or for whole-brain, seed-to-voxel functional connectivity in corticolimbic regions. Future work will examine neurodevelopmental changes across adolescence to determine if localized, corticolimbic brain effects among Hispanic/Latinx youth at ABCD baseline are ultimately translated into long-range connectivity differences. The current work was based on caregiver-reported VIA and CBCL measures and thus potentially provides a limited assessment of youth acculturation and mental health; future analyses of subsequent ABCD time points should incorporate youth-reported measures.

In conclusion, these outcomes indicate that acculturation is an important factor relevant to ABCD Hispanic/Latinx caregivers' mental health, as well as the mental health and rs-fMRI activity of their children. This work demonstrates that the ABCD multisite design and demographically diverse sample offer an opportunity to study participant groups that have been historically underrepresented in neuroimaging research. Further, the current work intentionally does not compare Hispanic vs. non-Hispanic participants, which can implicitly provide support for a deficits-based framework. Instead, we emphasize the diversity of Hispanic/Latinx families in the US who have diverse family dynamics, life experiences, and health-related outcomes. Moreover, analysis of a subset of the ABCD sample creates a space to focus on Hispanic/Latinx culture in a way that is not centered around non-Hispanic, majority experiences. ABCD's robust culture and environment protocol was thoughtfully developed and provided the measures that made this work feasible. Additional population-based, neuroimaging studies incorporating other culturally-relevant measures of the social and structural determinants of health are urgently needed. Such work will allow for a more complete understanding of neurobiological processes of risk and resilience among individuals from underrepresented, minoritized groups that experience health-related disparities as a consequence of their racial, ethnic, sexual, or gender identity.

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Data Availability

Data used in the preparation of this article were obtained from the Adolescent Brain Cognitive Development℠ (ABCD) Study (https://abcdstudy.org), held in the NIMH Data Archive (NDA). This is a multisite, longitudinal study designed to recruit more than 10,000 children age 9-10 and follow them over 10 years into early adulthood. The ABCD Study® is supported by the National Institutes of Health and additional federal partners under award numbers U01DA041048, U01DA050989, U01DA051016, U01DA041022, U01DA051018, U01DA051037, U01DA050987, U01DA041174, U01DA041106, U01DA041117, U01DA041028, U01DA041134, U01DA050988, U01DA051039, U01DA041156, U01DA041025, U01DA041120, U01DA051038, U01DA041148, U01DA041093, U01DA041089, U24DA041123, U24DA041147. A full list of supporters is available at https://abcdstudy.org/federal-partners.html. A listing of participating sites and a complete listing of the study investigators can be found at https://abcdstudy.org/consortium_members/. ABCD consortium investigators designed and implemented the study and/or provided data but did not necessarily participate in the analysis or writing of this report. This manuscript reflects the views of the authors and may not reflect the opinions or views of the NIH or ABCD consortium investigators.

The ABCD data repository grows and changes over time. The ABCD data used in this report came from NDA ABCD Release 3.0 (DOI: 10.15154/1520591). An NDA Study was created to associate the analyses reported in this study with the underlying ABCD Study data (DOI: 10.15154/1527751).

Code and Materials Availability

Additional information and resources are available on a project page for this study at the Open Science Framework (OSF) (https://osf.io/mkdw3/). The code is available in two GitHub repositories, including one for analysis of the VIA data (https://github.com/NBCLab/abcd-hispanic-via) and one for the fMRI preprocessing and analyses (https://github.com/NBCLab/abcd_fmriprep-analysis). ROI and connectivity maps are available in NeuroVault (https://neurovault.org/collections/SMQUTHLQ/). High-resolution figures are available via FigShare (https://figshare.com/account/home#/projects/143997).

Competing Interests

The authors declare no competing interests.

Author Contributions

AM and ARL conceived and designed the project. AM, MCR, JAP, and ARL analyzed data. MCR, JAP, TS, JSF, KLB contributed scripts and pipelines. ASD and MTS provided statistical support and LMU, CAG, SWH, MS, MRG, RG provided support on analysis and interpretation of ABCD measures. AM, MCR, JAP, and ARL wrote the paper and all authors contributed to the revisions and approved the final version.

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