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## Review article

## Assessment of acculturation in minority health research

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## ABSTRACT

Acculturation represents an important construct in the context of health disparities. Although several studies have reported relationships between various aspects of acculturation and health in minority populations, crucial inconsistencies remain. One likely reason for these inconsistencies may relate to limitations in the conceptualization and operationalization of acculturation, particularly in the context of health research. The acculturation construct underwent major conceptual and operational change when it was adapted from anthropology to psychology, and we argue another major shift is now required for use of this construct in health research. Issues include determining whether acculturation measures should focus on an individual's internal attitudes or overt behaviors; whether they should characterize cultural orientation status at a given point in time or change over time; whether measures should be culture-specific or more global in nature; how the issue of multiculturalism should be addressed; how measures can optimally incorporate multiple dimensions of acculturation; and whether proxy measures should be used. These issues are important in the context of health research because of their implications for determining the direct and indirect effects of cultural change on health-related biological and behavioral processes. We elaborate on and address each of these issues from a perspective that spans multiple disciplines across the biological and social sciences, and offer concrete recommendations with the ultimate goal of achieving a better understanding of the role of acculturation in minority health and health disparities.

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## 1. Introduction

A range of academic disciplines are interested in the question of how post-migration and post-colonization cultural adjustment, or 'acculturation,' affects health in minority migrant and indigenous populations, respectively. A multitude of theory and evidence suggests that acculturation can affect health (Berry, 1998; Chun et al., 2003; Organista et al., 2003), yet, crucial inconsistencies exist in the literature regarding the nature of the relationship between acculturation and health outcomes (Lara et al., 2005; Ra et al., 2013; Salant and Lauderdale, 2003; Smith et al., 2012; Yoon

et al., 2013). These inconsistencies undermine our ability to determine the precise mechanisms by which an individual's acculturation experiences affect health and disease risk, as well as the role of acculturation in explaining epidemiological trends in minority health. A major impediment to the application of acculturation in health research is that, when applied to health, the construct has been inappropriately and inconsistently conceptualized and operationalized (Abraído-Lanza et al., 2006; Comer, 2003; Hunt et al., 2004; Lopez-Class et al., 2011; Thomson and Hoffman-Goetz, 2009; Wallace et al., 2010).

Here, we address key limitations in how the construct of acculturation has been defined, measured, and interpreted in the context of health research. We integrate rigorous theoretical and methodological approaches to understanding culture (D'Andrade, 1984; Dressler, 2005) with the requirements of health research, both of which have been insufficiently attended to (Abraído-Lanza

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et al., 2016; Dressler, 1995, 2005; Hunt et al., 2004; Kagawa Singer et al., 2016; Salant and Lauderdale, 2003). Our goal is to provide a coherent perspective that incorporates concepts from social, biomedical, and computational sciences towards offering concrete suggestions to enhance the quality and efficacy of studies in this field.

We highlight concerns related to the conceptualization of the construct of acculturation, particularly, whether it should measure an individual's internal feelings or overt behaviors; whether it should characterize cultural orientation status at a given point in time or change over time; whether measures should be culture-specific or more global in nature; how the issue of multiculturalism should be addressed; how measures should optimally incorporate multiple dimensions of acculturation; and whether proxy measures should be used. Furthermore, we discuss concerns related to operationalization, specially, how different domains of acculturation may exert independent and/or interactive effects on health outcomes, and how some of the commonly-used proxy measures of acculturation may capture non-acculturative causes of health disparities. Each of these issues is addressed with recommendations for measurement techniques and/or statistical analysis methods.

### 1.1. Acculturation conceptualized in different academic disciplines

Acculturation is a construct with roots in the fields of anthropology (Boas, 1888) and archaeology (Powell, 1880). It was initially used to describe the cultural and linguistic changes that occur when two groups come into contact (Rudmin, 2003). Early anthropological methods included direct observation of contact between cultural groups, interviews with individuals, reading historic testimonies, and deductions based on analysis of history (Redfield et al., 1936). There was emphasis on the ways in which history was crucial for understanding the process of acculturation in order to recognize elements of the origin culture when they are expressed (Herskovits, 1937). Observations of acculturation were also considered useful for better understanding the dynamics and structure of culture itself, as conflicting traditions and changes in certain aspects of culture allows each piece to be more clearly visible (Herskovits, 1937).

The construct was subsequently adopted by psychology alongside major changes in operationalization (Graves, 1967; Thurnwald, 1932), and re-conceptualized to focus on an individual's experience of changes in identity, values and behaviors, rather than as a group-level phenomenon. In psychology, the most widely-accepted conceptualization is Berry's model of acculturation strategies, assessed by two independent, orthogonal measures of acquisition of host culture and retention of heritage culture (Berry, 1997, 2003).

Acculturation has become a construct of considerable interest in medicine and public health (Abraído-Lanza et al., 2006; Berry, 1998). However, this disciplinary transition occurred without refining the construct and methodologies to be more appropriate for health research (Hunt et al., 2004; Lopez-Class et al., 2011). We argue that new considerations and modifications are necessary to improve research into acculturation's health consequences.

### 1.2. Acculturation and epidemiology

Epidemiologists have frequently observed trends in minority population health that seem to reflect changes in "cultural orientations," or the degree to which individuals espouse the culture (values; identity; preferences; behaviors; traditions) of their heritage (ethnic; racial; religious; national) group. Consequently, a large number of studies have investigated the relationship between various aspects of acculturation and health, particularly in Hispanic

Americans (reviews: (Abraído-Lanza et al., 2016; Lara et al., 2005; Thomson and Hoffman-Goetz, 2009)), Asian Americans (reviews: (Salant and Lauderdale, 2003; Suinn, 2010)), ethnic minority immigrants to Canada (reviews: (Sanou et al., 2013; Urquia et al., 2012)), and Native Americans (Duncan et al., 2014; Garrett et al., 2012). Notable inconsistencies have emerged in the relationship between acculturation and health (Castro, 2007). For example, among Hispanic Americans, acculturation has been associated with higher (Moscicki et al., 1989), lower (González et al., 2001), and no difference (Cuéllar and Roberts, 1997) in depression risk, and higher (West et al., 2002), lower (Hazuda et al., 1988a), and no difference (Harris, 1991) in diabetes risk. For another example, among Asian Americans, acculturation has been associated with better (Chou et al., 2010; Dey and Lucas, 2006), worse (Acevedo-Garcia et al., 2010), and no difference (John et al., 2012) in self-rated health. These kinds of inconsistencies call into question how acculturation, including its various components and domains, affects health-related biological and behavioral processes. We argue that shortcomings in the conceptualization and operationalization of acculturation likely account for the many contradictory findings in this area of research. Widely-used methodologies to characterize acculturation in the context of studies of both physical (Abraído-Lanza et al., 2006; Berry, 1998; Comer, 2003; Hunt et al., 2004; Lopez-Class et al., 2011; Schwartz et al., 2010) and mental health outcomes (Berry, 2009; Chirkov, 2009; Gonzales et al., 2002; Tardif-Williams and Fisher, 2009; Ward, 2008) have been criticized. We build upon those previous critiques, summarize major inadequacies from past studies, and suggest alternative approaches that would enhance the quality of research in this area (Table 1).

## 2. Conceptualization of acculturation

### 2.1. Does acculturation reflect internal state (attitudes/preferences/feelings), external state (behaviors), or both?

Internal state is comprised of attitudes, preferences, and feelings, while external state is comprised of behaviors. Previous authors have disagreed about whether the construct of acculturation should reflect internal or external state (Ward and Kus, 2012). Internal state (e.g., low mood) may be reflected in external state (e.g., avoidant behavior), and thus internality and externality can be strongly correlated. However, the internal and external aspects of acculturation do not necessarily parallel one another. In a Native American cohort, internalized negative attitudes about Native cultural identity were associated with less adoption of Anglo cultural behaviors (Walters, 1999). Thus, despite the expectation that internal rejection of Native identity should be associated with a shift towards an Anglo cultural status, the opposite was observed.

Acculturation affects health at the point at which acculturation becomes directly or indirectly (i.e., via behavior) "biologically embedded" in an individual. Life experiences, such as social interactions, behaviors, and events, can affect human biology (Fox et al., 2015; Hertzman, 1999). The supposition that life experiences shape human biology was proposed and theoretically developed in the field of medical anthropology, i.e., the study of "cultural embodiment" (Csordas, 1994; Fabrega, 1992). The frameworks of "embodiment" in anthropology and "biological embedding" in developmental sciences converge in their mutual interest addressing the social origins of epidemiological inequalities (Gravlee, 2009; Krieger and Smith, 2004). Because people in different sectors of society (e.g., based on socio-economic status, ethnicity, geography) have systematic differences in experiences, when those experiences become biologically embedded they can result in systematic differences in health status (Hertzman, 2012). We emphasize that certain external aspects of cultural orientation

**Table 1**

Summary of issues and considerations that need to be addressed for accurately measuring the relationship between acculturation health outcomes, with proposed solutions.

	Issues to address	Solutions
Conceptualization of acculturation for health research	Internality vs. externality	<ul style="list-style-type: none"> <li>• Subscales</li> <li>• Ridge regression</li> <li>• Indirect effects modeling</li> <li>• An instrument can assess either internality or externality only</li> </ul>
	Direct vs. indirect effects	<ul style="list-style-type: none"> <li>• Moderator analysis</li> <li>• Multi-level modeling</li> </ul>
	Cultural orientation status vs. change	<ul style="list-style-type: none"> <li>• Instruments should assess either change or status</li> <li>• Status assessments should not be interpreted as reflecting change</li> <li>• Status assessments should focus on current and recent traits and experiences</li> <li>• Instruments could be developed that directly ascertain cultural orientation at a past timepoint or change over a specific timeframe</li> <li>• Adjust for recall bias</li> <li>• Anchoring methods</li> </ul>
Operationalization of acculturation for health research	Cultural specificity	<ul style="list-style-type: none"> <li>• Select study population based on epidemiological groupings</li> <li>• Culturally global instrument for insufficiently-characterized cultures and comparison studies</li> <li>• Culturally specific instrument for causal analysis</li> </ul>
	Proxies	<ul style="list-style-type: none"> <li>• Should be avoided</li> <li>• Nativity/generation status conflates acculturation's intergenerational versus individual health effects</li> </ul>
	Dimensionality	<ul style="list-style-type: none"> <li>• Bi-dimensional instruments</li> <li>• Models with interaction terms</li> <li>• Categories based on threshold scores or cluster analysis</li> </ul>
	Multiculturalism	<ul style="list-style-type: none"> <li>• Structural equation modeling</li> <li>• Distinct scales for all cultures involved</li> </ul>
Measuring health	Biomedical indicators	<ul style="list-style-type: none"> <li>• Anchoring subjective measures of health</li> <li>• Medical records</li> <li>• Medical procedures or assessments</li> <li>• Collecting and analyzing biosamples</li> </ul>

may affect health *directly*, for example, via use of culturally-favored products that contain heavy metals (Lin et al., 2010; Schwarcz et al., 2013). Other external aspects of culture may affect health *indirectly*, i.e., the external manifestation of culture may affect another factor that results in biological change. For example, lacking the ability to speak English is an external manifestation of culture that does not directly affect human biology, but may affect access to healthcare resources (Flores, 2006) and thereby indirectly affect biology. Internal aspects of culture can affect health *only indirectly*, often mediated by behavior or psychological stress. For example, low degree of internal adherence to traditional religiosity does not directly change human biology, but may have an indirect influence by affecting whether an individual engages in illicit drug use (Engs and Mullen, 1999), which affects biology.

Deciding whether acculturation should reflect internal or external states determines which items are appropriate to include in assessment instruments, and thereby changes our understanding of how acculturation affects health. The health effects of a preference may be substantially different depending on whether or not that preference is reflected in actual behavior. For example, a preference for origin-culture food may or may not be related to the behavior of eating a diet composed of origin-culture foods, because this behavior would be affected by other factors including availability, cost, health concerns, family preferences, and desire to conform. Therefore, analyses based on the Mexican American Acculturation Scale (Montgomery, 1992) with item "How much do you enjoy eating Mexican food?" could produce a different description of the relationship between acculturation and health than an instrument like the African American Acculturation Scale (Landrine and Klonoff, 1994) with item "I eat a lot of fried food." Other scales have items that are ambiguous in whether they capture preference or behavior, such as the Acculturation Rating Scale for Mexican Americans-II (Cuellar et al., 1995) with item "My family cooks Mexican foods" and the Bicultural Acculturation Scale (Cortés et al., 1994) with item "How many days a week would you like to eat Puerto Rican food?" A small number of specific behavioral

acculturation scales have been developed, such as the Cuban Behavioral Identity Questionnaire (Garcia and Lega, 1979) and the Ethnocultural Identity Behavior Index (Yamada et al., 1997).

Acculturation assessment instruments that inappropriately combine internality and externality have only limited ability to reveal the mechanisms by which acculturation affects health. The problem presents itself when investigators using scales with ambiguous assortments of internal and external items correlate scores with behavioral constructs that are themselves also measured in the score. For example, the 8-item AHIMSA acculturation scale contains the item "The food I eat at home is from ..." with answer choices "United States," "Country my family is from," "Both," and "Neither" (Unger et al., 2002). A study demonstrated that AHIMSA scores were correlated with frequency of eating fast-food (Unger et al., 2004). We suggest that the food consumption item from the AHIMSA qualifies as a surrogate measure of fast-food consumption, and therefore computing this correlation exemplifies a statistical fallacy based on the principles of surrogate variables. An approach that may be more useful is to use instruments that explicitly include internal and external sub-scales, such as the separate behavioral and value acculturation scales for Cuban Americans (Szapocznik et al., 1978) or the Internal-External Ethnic Identity Measure (Kwan, 2000). We suggest two approaches for statistically modelling how acculturation's internal and external components correlate with a particular health outcome. A multiple regression model that includes internal and external sub-scales as predictors will likely violate the assumption of noncollinearity, so ridge regression may be a better option, which alleviates this problem by centering, scaling, and attaching a penalty term to the predictive variables (Marquardt and Snee, 1975). Another option is indirect effects modeling (Hayes, 2009), which may be useful in determining whether the correlation between internal acculturation and a health outcome is reduced in magnitude or rendered null when the intervening effect of external acculturation has been controlled. Different from 'control' variables in multivariate regression, which are not part of the hypothesized causal pathway,

indirect effects are operationalized as mediators that transmit the influence of independent variable to dependent variable. Mediation models are designed based on hypothesized causal pathways (Preacher and Hayes, 2008). Thereby, indirect effects modeling could examine whether internal acculturation's relation to a health outcome is transmitted, entirely or partially, via external expression of acculturation. In the case of partial mediation, indirect effects modeling could help discern what proportion of internal acculturation's relationship with health outcomes is explained by external acculturation.

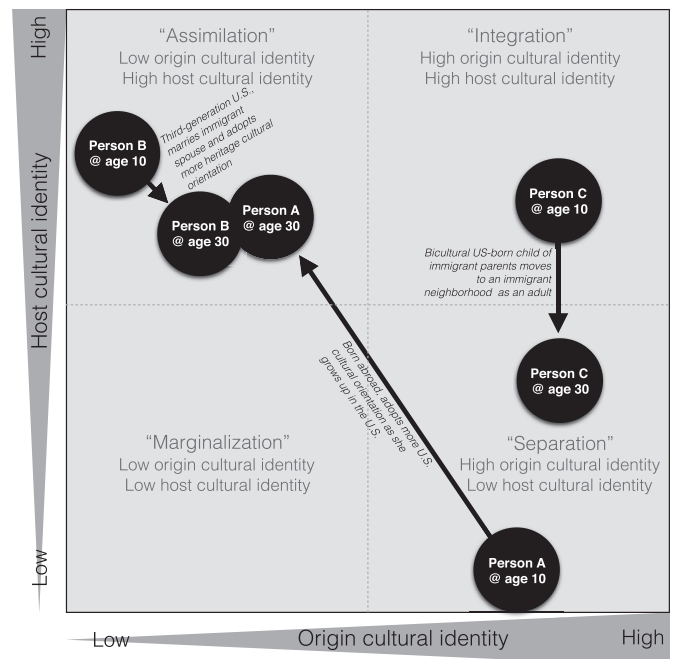
Discordance between internal and external aspects of acculturation could potentially be a source of psychological stress for an individual, thereby adversely affecting health. For example, an individual may experience stress if her/his preference is for traditional foods but ingredients are not locally available, or if s/he would prefer to speak English but lacks the ability. This idea is distinct from the related concept of cultural competence (the degree to which an individual's cultural knowledge reflects the overall model of her/his group's shared culture (Dressler and Bindon, 2000; Romney et al., 1986)) and is more specific than the related concept of acculturative stress (physiological or psychological detriment caused by stressors of acculturation (Berry et al., 1987)). In addition, discordance in an individual's rates of changes in different domains of cultural orientation (e.g., identity versus language ability) could be a previously-unrecognized source of stress.

The effect of discordance on health could be explored using statistical approaches that include a term modeling the interaction between internal and external acculturation subscales. Another strategy would be to classify each item in an acculturation assessment instrument as internal versus external, as well as whether the hypothesized effect on human biology is direct versus indirect. Researchers could then perform multi-level modeling to investigate not only the relationship between acculturation scores and health outcomes, but also whether that observed relationship is attributable to internal or external aspects of acculturation, and whether direct or indirect relationships with biology should be explored as mechanisms.

## 2.2. Should acculturation score indicate current status or change over time?

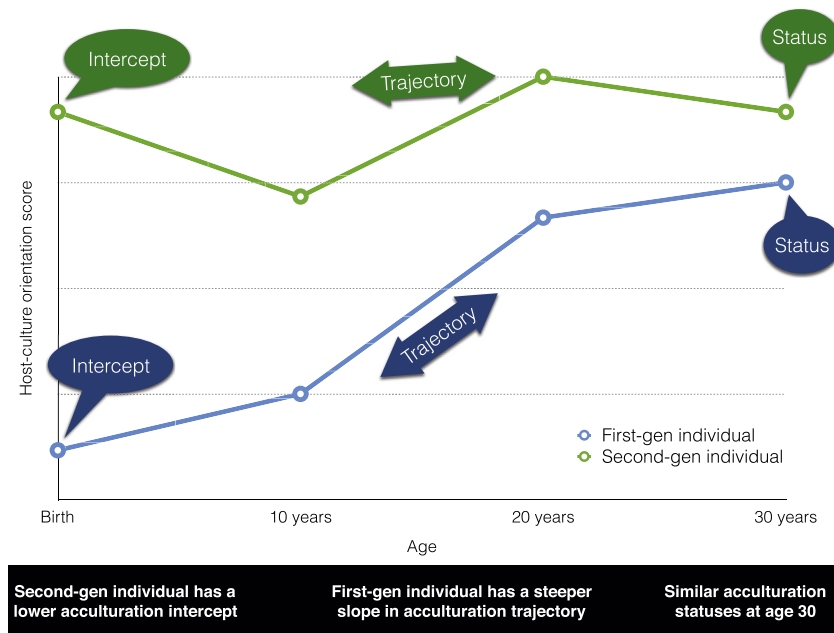
Previous authors have been inconsistent in whether the concept of acculturation reflects an individual's current cultural orientation or the span of cultural change experienced over time. In other words, does an acculturation score describe the extent to which an individual's status can be described as oriented towards heritage and host cultures, or how different an individual's orientation is compared to before contact with the host culture (Fig. 1)? While literature focusing on characterizing acculturation (without regards to its relationship with health) is fairly consistent in describing acculturation score as reflective of current cultural orientation (Berry, 2003), studies of acculturation's relationship with health often take a different perspective.

A common interpretation in health research is that acculturation score is a measurement of how much cultural change the individual has experienced, and therefore unfavorable outcomes associated with greater degree of acculturation are attributed to the stresses of cultural change (Abraído-Lanza et al., 2006; Rudmin, 2009). This interpretation is often held regardless of whether the study cohort is of mixed nativity, which is problematic because immigrants and native-born descendants of immigrants usually have different cultural orientation starting points (Fig. 2). These starting points have been referred to as "acculturation intercepts," based on the mathematical concept of an axis intercept as the starting point of one attribute at the point of origin of another



**Fig. 1. Changes in cultural orientation.** This plot represents a bi-dimensional acculturation model. X-axis reflects the degree to which an individual endorses origin cultural identity, and Y-axis reflects the same for host culture. Berry's 4-category acculturation model is superimposed for reference. This plot describes changes in acculturation status that can occur across an individual's lifetime. The example depicted describes three individuals, each measured for origin and U.S. cultural orientation at two timepoints. Assessments at age 30 would find that Persons A and B exhibit similar acculturation statuses, and yet Person A has undergone a more substantial change in cultural orientation over her lifetime. This exemplifies the importance of resolving whether 'acculturation' refers to status (location of points) or change (distance between points). The cultural change experienced by Person C demonstrates that change in one dimension does not necessitate change in another.

attribute. This nomenclature comes from a literal use of the term (Castro et al., 2010b), subsequently described by Lopez-Class et al. as a theoretical construct (Lopez-Class et al., 2011). Building off these conceptual frameworks, we argue that nativity is typically associated with differential acculturation intercepts, conceptualized as the cultural orientation status at the point of origin at birth (Fig. 2). We recognize the liability in assigning cultural orientation at birth, but because there is no specific moment at which an individual becomes culturally cognizant we use birth as an expression of the earliest point in the lifespan at which an individual's cultural orientation exists. How early-life cultural starting points vary by nativity is exemplified in a survey of >5000 U.S. ethnic-minority children in which 75% of foreign-born but only 26% of U.S.-born respondents self-identified their ethnicity as belonging to their heritage nation, and 8% of foreign-born and 92% of U.S.-born respondents self-identified their ethnicity as American (Rumbaut, 2005). While among some immigrants, acculturation score may reveal the change in cultural orientation that transpired, native-born individuals often have traversed far less cultural distance to achieve the same score. The importance of considering acculturation intercepts and trajectories in order to fully appreciate the cultural changes that underlie acculturation status is diagrammed in Fig. 2, which depicts hypothetical data from first-generation and second-generation individuals who exhibit similar acculturation statuses when assessed at age 30. The first-generation individual underwent very little change across the lifespan while the second-generation individual exhibits a much steeper trajectory of change across the lifespan ultimately resulting in that same status.



**Fig. 2. Acculturation intercept and trajectory.** Individuals may arrive at similar acculturation status despite different intercepts and trajectories. X-axis represents an individual's age, i.e., timeline. Y-axis represents one domain of acculturation, host culture orientation. The "acculturation intercept" is the value on one scale (e.g., host culture orientation) at the point at which another scale (e.g., age) is zero. This plot also depicts the change in host-culture orientation across time ("trajectory"), which is steeper for the first-generation individual. At age 30 years, there is only a small difference in host-culture orientation scores. A similar plot could be drawn with X-axis representing years-since-immigration, in which the acculturation intercept would reflect acculturation status at the time-of-arrival. First-gen: first-generation; Second-gen: second-generation.

An instrument that captures current acculturation status may be of interest to health researchers only insofar as current status is a proxy for status over a longer span of time. The relative influence upon health of acculturation status at one moment of a person's life compared to any other moment is difficult to argue. Furthermore, acculturation status changes over time and, potentially, at different rates within an individual's lifespan (Fig. 2). Researchers are faced with the challenges of assessing a snapshot of a dynamic process whose stability varies across time and across individuals, and assessing the cumulative effect on health of all previous acculturation statuses an individual embodied across the course of her/his lifetime. To address the first challenge, acculturation assessment instruments should focus on current traits and experiences, and avoid items inquiring about traits or experiences from earlier phases in a person's life except for how they relate directly to current acculturation status (Table 1). To address the second challenge, researchers must assess not only current status but also change over time, ideally by repeated assessments.

For studies that aim to measure change-over-time in cultural orientation but limited research resources prohibit longitudinal studies, instruments could be developed that ascertain subjects' cultural orientation at a past timepoint or change over a specific timeframe. It should be noted that subjective reporting of past experiences risks introducing retrospective recall biases (Coughlin, 1990) and response shifts (Howard and Dailey, 1979), which previous authors have addressed by statistically adjusting for participants' recall bias on known items (McPhail and Haines, 2010). We suggest that clinical health research provides a methodological framework for measuring retrospective change over time that can be applied to the development of acculturative change instruments. The 2009 Food and Drug Administration Guidance for Industry Patient-Reported Outcomes (PRO) Measures report (Food and Drug Administration, 2009) suggests that an individual's reconstructed memory of symptoms can be "anchored" by measuring the correlation between an individual's rating of the

target item to the same or closely related concept measured by an independent anchor (Wyrwich et al., 2013). Anchor-based methods can be used in medicine by correlating PRO for change in a symptom with clinical assessment of change (e.g., joint swelling (Kosinski et al., 2000)), or by anchoring individuals' rating of change in a symptom on a linear (e.g., 7-point) scale to their own assessment of whether that symptom over time became "better," "worse," or "about the same" (Jaeschke et al., 1989). This methodology could be applied to acculturative change, for instance, measuring an individual's perception of her/his cultural change on a linear scale, and anchoring with categorical assessments (e.g., *Have your values become more British over the past five years? Select a number from 1 (no change) to 7 (much more). Would you say your values changed (a) none, (b) somewhat, or (c) very much?*) Other anchoring options could include an informant's assessment of the target individual, or the researcher's assessment of a quantitatively observable domain (e.g., score on a language fluency test; income; neighborhood ethnic composition).

### 3. Operationalization of acculturation

The second step in evaluating current approaches for determining the effects of acculturation on health is that the construct of acculturation needs to be operationalized in an optimal manner. We describe operationalization-related issues and approaches towards addressing them (Table 1).

#### 3.1. Cultural specificity

An important question relates to what populations acculturation instruments should represent. Should groups be distinguished by geography or another demographic factor? For example, is it most appropriate to examine how acculturation relates to health among all immigrants to the U.S. (Popkin and Udry, 1998), Hispanics (Gordon-Larsen et al., 2003), Mexicans (Hovey, 2000), or

immigrants from a particular region in Mexico? Or perhaps Mexican immigrants of low-SES (Rasmussen et al., 1997), or female Mexican Americans (Castillo et al., 2004)? Previous studies of the relationship between acculturation and health have been criticized for using culturally heterogeneous populations (Borrell and Dallo, 2008; Chun et al., 2003).

First, we address study population selection. No matter the level at which population partitioning is conducted, the population under study will likely exhibit heterogeneity in both culture and demography (Salant and Lauderdale, 2003), and so concerns about over-generalization will always be justified. The onus upon researchers is to select a population that has both cultural coherence and practical meaning. For cultural coherence, cultural models define the world in an arbitrary way, but what gives these definitions causal force is that people agree about them (Berger and Luckman, 1967; D'Andrade, 1984). Cultural models have genuine meaning and utility insofar as people agree that the cultural model reflects their perception of the way things are (Dressler et al., 2005). For practical meaning in health disparities research, the impetus for investigating acculturation is to determine whether shared experiences within a particular group explain trends in health outcomes among that group. The observation of inter-group health disparities and intra-group trends in disease prevalence have thus far been the primary justification for research into the relationship between acculturation and health. Therefore, the study population should be selected primarily based on epidemiological groupings, and secondarily based on cultural groupings. For example, the observation that a particular disease disproportionately afflicts individuals of a particular national origin, indigenous community, ethnicity, religion, or migration route justifies investigation into how cultural changes might play a role in disease risk. Subsequent efforts can determine whether the whether the epidemiological group can be defined as a culturally coherent group with which one can study acculturation.

Second, we address how culturally specific the content of acculturation-assessment instruments should be. An “etic” approach is more generalized than based on local meaning, while an “emic” approach is based principally on local meaning (Berry, 1999). Both approaches are valuable in different circumstances. Etic approaches represent a vital first-step in researching a population in which local meaning has yet to be sufficiently characterized, and are essential for comparative studies. Emic approaches are better able to capture the details of individuals' daily lives, and provide a secondary step in the process of determining specific causal pathways and relationships (Berry, 1999; Kagawa Singer et al., 2016). Summarily, studies of the relationship between acculturation and health should be conducted on populations that are epidemiologically distinct, with etic measurement of acculturation in preliminary and comparative studies, and emic measurements in secondary studies investigating specific causality.

### 3.2. Proxies

Certain aspects of acculturation have been over-emphasized for ease of ascertainment and analysis at the expense of incorporating the range of behaviors, beliefs, and identity aspects of acculturation (Alegria et al., 2007; Allen et al., 2008). Language, duration of residence in host country, and nativity (first versus later generation status) have been widely utilized as proxies for acculturation (Lommel and Chen, 2016; Thomson and Hoffman-Goetz, 2009). Many studies of Hispanic Americans have relied on these proxies for assessing acculturation in its relation to overall health (DuBard and Gizlice, 2008; Marin et al., 1987), chronic disease (Eamranond et al., 2009; Mainous et al., 2006), and health-related behaviors (Ahluwalia et al., 2007; Heck et al., 2008).

In many instances proxies may fail to adequately capture the aspects of acculturation that affect human biology. One issue is that duration of exposure to host culture is not necessarily associated with cultural incorporation. Another issue is that nativity/generation status conflate inherited and intergenerational effects on health with the effects of an individual's own life experience (Fox et al., 2015). Many traits that determine health, such as metabolism, brain structure/function, stress responsiveness, and cardiovascular function, are influenced by biochemical “cues” in the intrauterine environment during critical periods of prenatal development (Godfrey and Barker, 2001). These traits influence disease etiology directly and indirectly by affecting how an individual physiologically responds to environmental exposures. Thereby the life experiences and exposures of a mother can influence her child's responses to the environment it encounters in its life, affecting the child's disease propensity. Consequently, individuals' immigration and acculturation experiences can affect health in the *next* generation through this process. The practice of using nativity as a proxy for acculturation presumes that differences in health outcomes between first- and later-generation individuals are attributable to differences in cultural phenomena experienced by each nativity subset, when in reality, the cultural experiences of one generation may manifest in health outcomes in the subsequent generation.

This issue also relates to cohort selection and the design of acculturation instruments. Interpretation of acculturation's health consequences in a mixed cohort of first-generation and later-generation individuals, or using an acculturation assessment instrument that includes nativity or generation status as items, invites the risk of confounding intergenerational effects on health with the effects of individual acculturation experience.

### 3.3. Dimensionality

Questionnaire-based instruments typically quantify degree of acculturation on a numeric scale. Acculturation was initially conceptualized by anthropologists as a uni-dimensional continuum or series of steps (e.g., Spindler's *native-oriented*, *transitional*, *lower- and upper-status acculturated* (Spindler, 1955)) by which origin culture was lost and host culture concurrently adopted (McFee, 1968). Similarly, among psychologists, early instruments operationalized acculturation as a uni-dimensional, linear scale in which adoption of host culture is *necessarily* characterized by loss of heritage culture (Barona and Miller, 1994; Cuéllar et al., 1995; Marin et al., 1987; Yoon et al., 2013).

McFee pioneered the argument that acculturation (among Native Americans) may be more accurately conceptualized as a bi-dimensional process in which Indian and White cultural orientations should be measured independent of one another, and demonstrated that individuals assessed separately on Indian and White orientation scales do not follow the previously-dominant expectation of cultural replacement (McFee, 1968). This bi-dimensional model was implemented among psychologists decades later, as researchers recognized that acculturation may occur independently in different domains (Cuéllar et al., 1995; Hazuda et al., 1988b; Marin et al., 1987; Szapocznik et al., 1980), and adoption of host cultural identity and retention of heritage cultural identity may be independent or orthogonal to one another (Berry, 1997; Marin and Gamba, 1996; Marin et al., 1987; Oetting and Beauvais, 1991). The need to recognize dimensionality for accurately measuring acculturation is reflected in Fig. 1, which compares three hypothetical individuals, each measured at two timepoints (ages 10 and 30), on a bi-dimensional representation of acculturation. Person A represents the previously-prevailing expectation of acculturation trajectories that might be typical of first-generation

individuals. Contrastingly, Person B exemplifies how a person may exhibit the opposite trajectory, becoming less host and more origin culturally oriented. Persons A and B exhibit similar acculturation status at age 30 despite dramatic differences at age 10 (see Fig. 2 for further exploration of this issue). Person C demonstrates how change in one acculturation domain does not necessitate change in other domains, highlighting the need to measure different aspects of acculturation separately.

Many health researchers continue to employ overly simplistic instruments (proxy and uni-dimensional) for ease of use and interpretation. Some authors have suggested mixed qualitative-quantitative methods would better capture acculturation's multifaceted effect on health (Castro et al., 2010a; Castro and Coe, 2007; Edwards and Lopez, 2006; Kagawa Singer et al., 2016; Sussner et al., 2008); however, these methods are incompatible with the conventional biomedical research paradigm. Better options include the use of bi-dimensional instruments analyzed as two continuous predictive variables, or administering a questionnaire and categorizing individuals based on threshold scores or as naturally-occurring groups based on cluster analysis. Previous studies have used cluster analysis to determine acculturation categories, such as Lee et al.'s two-step method imposed in a cohort of Asian Americans, in which tentative groupings were subsequently clustered using agglomerative hierarchical clustering methods (Lee et al., 2013). Multi-dimensional instruments can be used in analyses that allow for multiple predictors, e.g. multiple regression or generalized linear modeling.

Converging evidence supports the use of multi- or bi-dimensional measurements of acculturation to yield more detailed, accurate information about acculturation's relationship with health. Previous studies using bi-dimensional instruments that independently measure adoption of host culture and retention of heritage culture have observed the two dimensions to exhibit different relationships with outcomes, such as the observation from a cohort of Korean Americans that positive affect was significantly related to degree of American cultural orientation, but exhibited no relation with degree of Korean cultural orientation (Kim et al., 2010). In a cohort of Mexican American pregnant women, subscales of the Multidimensional Acculturation Scale (González et al., 2011) were differentially related to psychological risk profiles (based on assessments of depression, mastery and coping), such that English proficiency, Spanish proficiency, and American cultural identity subscales were significantly related to psychological risk profiles, but Mexican cultural identity was not, and significant differences existed between the low and moderate psychological risk groups for English proficiency, Spanish proficiency, and Mexican cultural identity, but not American cultural identity (Ruiz et al., 2015). These results exemplify how studies using dimensional assessments of acculturation yield informative information that would be otherwise unrecognized.

### 3.4. Multiculturalism

When either the origin or receiving society is itself a multicultural setting, bi-dimensional acculturation instruments are insufficient. A three-dimensional conceptualization has been proposed for assessing acculturation among Russian Jewish immigrants to the U.S. (Birman et al., 2010), Black Caribbean immigrants acculturating towards European- and African-American cultures of the U.S. (Ferguson and Bornstein, 2014), and ethnic minority immigrants acculturating towards French and English-Canadian cultures of Montreal (Doucerain et al., 2013). Another consideration is that rather than acculturating towards the surrounding culture, an alternative pathway can involve the construction of a hybrid, fusion culture (Arends-Tóth and van de Vijver, 2004). In these instances,

bi-dimensional conceptualization of acculturation is insufficient. Birman et al. navigate this challenge in a cohort of Russian-Jewish-Americans by using structural equation modeling, nesting three models: a bi-cultural model linking Russian and American identities with outcomes of interest, a model that added to the prior model Jewish identity and linked it to all outcomes, and a model with non-significant paths removed (Birman et al., 2010). Inclusion of Jewish identity in the model rendered links between Russian identity and two outcomes of interest non-significant, demonstrating the improved clarity that can result from modeling together independent measures of multiple cultural identities.

In the Birman et al. study, the model including all three identities was a superior fit to the data and a better predictor of psychological adjustment than the bicultural model (Birman et al., 2010). We speculate that biological indicators of health may similarly exhibit differential relations with different aspects of multicultural identity. Using multiple or multi-dimensional predictive variables may be crucial for accurately measuring the relationship between acculturation and health in cases of multiculturalism. Biological indicators of health may relate differentially to the distinct cultural orientations a person inhabits in a multicultural setting.

## 4. Measuring health

It would expand our understanding of the relationship between acculturation and health for more studies to measure health outcomes by using objective measures rather than relying on self-reported measures of health. Self-reported health is affected by cultural values and notions of health and wellness (Kandula et al., 2007), and so the possibility that cultural orientation is reflected in both predictor and outcome confounds results. We recommend that future studies use biological or clinical criteria for determining health status, or employ anchoring techniques for improving the objectivity of otherwise subjective measures (Wyrwich et al., 2013).

A relatively objective method for assessing how acculturation affects health is to assess biomedical indicators. This approach involves accessing medical records, conducting medical procedures or assessments, or analyzing biosamples (e.g. blood, urine, saliva, hair). Neuroimaging studies assessing how brain activity relates to culture exemplify investigation based on medical procedures or assessments (Han and Northoff, 2008; Han et al., 2013). Studies assessing how BMI or birth outcomes are related to acculturation exemplify assessments based on medical records (Callister and Birkhead, 2002; Delavari et al., 2013).

Biological sample collection offers unique benefits for investigating the relationship between acculturation and health. Biological samples can be obtained in population research using low-risk, minimally-invasive methods such as collection of saliva, urine, stool, breastmilk, hair, and blood spots. These relatively easy to collect biological samples offer researchers the ability to assess 'biomarkers,' or biological indicators of physiology and health, such as hormones, cytokines, antibodies, metabolites, nucleic acids, and microbes. For example, hormones related to psychosocial stress, reproductive function, and metabolism, as well as many other biomarkers, can be measured from small quantities of saliva (Granger et al., 2012). Of the myriad advantages of biomarkers in this area of research, firstly, biomarkers can provide information on disease risk and etiology before symptom onset. The overt expression of diseases associated with acculturation, such as type-2 diabetes, cardiovascular disease, and other non-communicable chronic diseases (Coonrod et al., 1999; Stern et al., 1992; Sundquist and Winkleby, 1999; West et al., 2002), is typically preceded by many years of pre-clinical biological changes in the index individual (Chen et al., 2012). Studies that assess health based only



on self-reported symptomology may fail to detect physiological changes that have not yet been perceived or felt by the individual but nonetheless influence risk and development of disease states (McDade et al., 2007). Secondly, biomarkers reveal the physiological mechanisms by which socio-cultural conditions affect health. Studies that relate acculturation to self-reported health can only speculate about physiological pathways, while biomarkers can uncover key steps in the causal pathway by which socio-cultural experiences affect health. Thirdly, biomarkers offer the unique ability to assess physiological processes in populations incapable of providing self-reported health information, such as infants or cognitively incapacitated adults, as well as opportunity for cross-linguistic and cross-cultural comparisons of health and disease-related information (McDade et al., 2007). Fourthly, combinations or panels of biomarkers may provide insight into shared physiological pathways that lead to a variety of health problems (Juster et al., 2010). The multifaceted experience of acculturation may biologically embed across multiple physiological systems, leading to a diversity of combinations of ways that health may erode over time. Across the lifespan, repeated exposure to stressors can cause repeated stimulation of the sympathetic–adrenal–medullary and hypothalamic–pituitary–adrenal (HPA) axes (Juster et al., 2010), and the chronic stimulation of these stress pathways may damage one or more of many interconnected physiological systems, eventually leading to chronic disease (Seeman et al., 2001). Studies involving panels of biomarkers, therefore, have the unique ability to demonstrate shared biological pathways by which socio-cultural stressors influence risk for a wide range of chronic diseases (Seeman et al., 2008).

A small number of studies have investigated how acculturation is related to health biomarkers measured in body fluids or tissues (e.g. (D'Anna-Hernandez et al., 2012; Peek et al., 2010; Ruiz et al., 2006)). Many of these studies used proxies (Crimmins et al., 2007; Ruiz et al., 2012) or language-only questionnaires (Ruiz et al., 2007, 2013) for measuring acculturation. Future studies should employ the most efficacious, rigorous measurement of acculturation (e.g., bi-dimensional or multi-dimensional scales that account for internality/externality) alongside efficacious, rigorous measurement of health (e.g., multiple biomarkers).

In summary, improvements are recommended for conceptualization and operationalization of the construct of acculturation to render it more appropriate and effective for use in health research. Investigation of both subjective and objective indicators of health will yield a fuller picture of the causal pathways that link acculturation and health outcomes. A better understanding of how acculturation, context, and biology interact to affect health in minority groups would enable more effective public policy interventions aimed at improving health and well-being in socially disadvantaged populations.

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