An Exploration of Ethnic Identity and Social Reorientation among Youth

by

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Dedication

Para la gente del barrio. Para los padres de familia que luchan dia y dia.

Acknowledgments

To my parents, Orlando and Liliana Constante, thanks for your love and providing a home for your children to grow. To my siblings, Anthony and Julianna Constante, thanks for your support and our special bond. Each time I visit you both, it feels as if I never left for grad school. I am proud of both of you for who you are and will always love you.

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Abstract

Youths' sense of connection to their ethnicity, or their ethnic identity, has been considered a culture asset in that this identification with one's culture is thought to be protective and promotive for youth development, especially ethnic minority youth in the U.S. (Perez-Brena et al., 2018). Youths' ethnic identity have been linked with lessened engagement in health compromising behaviors and behaviors that support their academic success (Rivas-Drake et al., 2014). However, the field continues to ask how ethnic identity serves as a cultural asset. This dissertation considered how ethnic identity translates into the cognitive and behavioral processes that support adjustment. This dissertation bridged ethnic identity developmental theories with other identity-relevant frameworks for adolescence that emphasize the neuroscience aspects that supports social reorientation and identity development (Dahl, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer et al., 2018) as well as the role of social identities in decision-making (Berkman et al., 2017; Oyserman, 2007).

In study 1, ethnic identity development was examined in relation to two important facets of adolescent adjustment; resisting peer influence and future orientation (Miller & Byrnes, 2001; Steinberg & Monahan, 2007; Steinberg et al., 2009). It was expected that youth who had explored their ethnicity and had greater clarity about their ethnic group membership would demonstrate greater resistance to peer influence and demonstrate tendencies to weigh decisions and their consequences with the future in mind. The findings showed that ethnic identity resolution was positively associated with resisting peer influence, relying more on their own

perspective than that of their peers. This suggests the importance of resolution development in how youth appraise and discern socially salient information.

In study 2 considered how, if at all, ethnic identity development is implicated in the brain. Despite burgeoning research demonstrating consequential associations of youth ethnic identity with cognition, behavior, and adjustment (Rivas-Drake et al., 2014), little is known about how ethnic identity may be reflected in the brain. I considered large-scale brain networks that are known to support human social interactions, social cognition, mentalizing, processing social norms, motivation, and self-referential thinking (Feng et al., 2021). These large-scale brain networks, from a domain-general perspective, are viewed as important for making sense of social interactions and relating such experiences into one's self-concept (Buckner & DiNicola, 2019). It was hypothesized that ethnic identity exploration and resolution would be positively associated with the functional organization of the default mode network and the frontoparietal network (Andrews-Hanna et al., 2010; Vincent et al., 2008). A person-specific modeling approach (GIMME) was used to characterize brain connectivity amongst these networks (Beltz & Gates, 2017). Clarity about one's ethnic group membership (e.g., resolution) was associated with greater frontoparietal network density (e.g., number of brain connections that comprised one's personalized brain connectivity model) -- the network that supports cognitive control.

Altogether, this dissertation offers a novel perspective for how ethnic identity functions as a cultural asset. These studies found that ethnic identity resolution development may be one way youths' connection to their ethnicity translate to how they cognitively appraise socially salient information. This mechanism could be at work when youth navigate their social environments in ways that promote their adjustment. At the brain level, resolution was linked with connectivity within the cognitive control network during the resting state, potentially reflecting the everyday ways resolution supports behavioral adjustment.

Chapter I

Introduction

Ethnic Identity: An Important Cultural Asset

Recent reformulations of Bronfenbrenner's ecological model have placed culture at the center of environmental influences, reflecting a renewed theoretical engagement with how we view culture in developmental science (Vélez-Agosto et al., 2017). Culture influences daily interactions, shaping children's thoughts and behaviors. The field of developmental science has learned much about the adaptive role of culture in children's development, or how cultural connections manifest in positive outcomes (Perez-Brena et al., 2018).

Researchers have studied the role of culture in development is through the lens of ethnic identity. Ethnic identity refers to an individual's sense of connection to their ethnic group (Umaña-Taylor et al., 2004). Varied theoretical formulations and psychometric evaluations have enabled the field to capture the multi-dimensionality of ethnic identity, which can be conceptualized in terms of its content and process (Douglass & Umaña-Taylor, 2015; Galliher et al.,2017; Phinney & Ong, 2007; Umaña-Taylor, 2011; Umaña-Taylor et al., 2014). The content of ethnic identity includes attitudes and beliefs individuals have about their ethnic group. This includes, for example, how individuals view their own group and believe others view their group (Sellers et al., 1998; Umaña-Taylor et al., 2014). The process component of ethnic identity refers to how individuals develop their sense of connection to their ethnic group. This involves exploration, which refers to seeking out and gaining knowledge about one's ethnicity, and resolution, which refers to having clarity about what it means to belong to one's ethnic group

(Umaña-Taylor, 2011). Although beliefs and attitudes regarding one's ethnic group may be contingent on the group's societal standing (i.e., minority status is often reflective of a country's sociopolitical history), the process of developing connections to an ethnic group is thought to occur universally across populations and has been studied in myriad groups, including White, Latinx, Black, Asian American and other youth of color (e.g., Martinez-Fuentes et al., 2020). In addition, within any ethnic group, individual variation in such connections is expected. That is, two individuals who identify with the same ethnic group may have explored their ethnicity and have developed clarity about what it means to belong to their ethnic group to differing extents.

Children's interactions with family members and their broader community inform their awareness of their ethnic group. As they grow up, children develop ideas about what constitutes their ethnicity and who comprises their ethnic group. They may also embrace the cultural values and practices representative of their ethnic group (Quintana et al., 1999). As children progress into adolescence, their increased cognitive abilities and sensitivity to social environmental cues enable youth to entertain more complex interpretations of their interactions with their ethnic group (Neblett et al., 2012; Umaña-Taylor et al., 2004; Umaña-Taylor, 2011). The way youth understand their ethnic group membership has implications for how they view and navigate their world (Umaña-Taylor et al., 2014). As a critical period for identity development, adolescence is an important period to study the different ways in which youth are connected to their ethnic group and its implications for their well-being.

Empirical work suggests that there are promotive and protective benefits associated with youths' ethnic identity (Neblett et al., 2012; Rivas-Drake et al., 2014a). Broadly, among ethnic minority youth, a more positive sense of their ethnic identity has been associated with better psychosocial adjustment, such as fewer mental health problems and better coping with stress; better academic adjustment, such as more academic achievement and more school engagement; and less engagement in health risk behaviors, such as substance use (Brittian et al., 2015; Cavanaugh et al., 2017; Rivas-Drake et al., 2014a; Rivas-Drake et al., 2014b; Zimmerman et al., 2013). In general, ethnic minority youths' ethnic identity is important for their adaptive adjustment, which may allow them to thrive in myriad domains.

This cumulative work evidencing the role of ethnic identity has established it as a cultural asset. Cultural assets are ways individuals benefit in their well-being and development from connections to their heritage culture (Perez-Brena et al., 2018). Ethnic identity emphasizes a complementary focus on social ties—a sense of belonging or identification with one's ethnic group (Umaña-Taylor, 2011). Ethnic group connections allow individuals to develop within a social system characterized by goals, values, practices, and attitudes that may or may not differ from the dominant culture. Although navigating multiple sociocultural environments (e.g., mainstream and heritage cultures) may be pose challenges for adolescents, we have learned that some form of heritage connection allow youth to thrive in mainstream society (Schwartz et al., 2015). Growing up in a sociocultural environment that differ from the dominant culture is thought to help instill in children skills for navigating their own ethnic group as well as social institutions, like schools (Coll et al., 1996). Much work has supported the notion that when individuals feel positively connected to their ethnic group, they experience promotive and protective benefits to their well-being and adjustment—serving as cultural asset (Perez-Brena et al., 2018). Ongoing research is still asking how youths' connections to their ethnicity translate into enjoying positive outcomes. This dissertation proposes novel ways to consider how youths' ethnic identity development may translate into adaptive adjustment.

Considering Other Possible Mechanisms

Although extant research tells us much about the main effects associated with having a positive sense of ethnic identity, we know less about the mechanisms by why this might be the case. To be clear, a "positive" ethnic identity has been defined in several ways in the literature, such as the pride one feels toward one's ethnic group or achieving a state of commitment and/or resolution about one's ethnic identity (Galliher et al., 2017; Phinney & Ong, 2007; Umaña-Taylor, 2011). It has been hypothesized that having a more positive ethnic identity entails having a more positive sense of self and hence better self-esteem, enabling better adjustment in general (Neblett et al., 2012; Smith & Silva, 2011). This positive self-esteem is thought to come from having a secure sense of belonging to one's ethnic group that can be manifested in pride and positive affect for one's ethnic group (Rivas-Drake et al., 2014b). Indeed, there is a good deal of evidence to support this hypothesis (Piña-Watson et al., 2017; Romero & Roberts, 2003; Fisher et al., 2017).

However, it is also possible that other mechanisms are at work. The positive outcomes evident when youth have a positive sense of their ethnic identities may relate to how they adaptively make decisions that are beneficial as opposed to detrimental to their adjustment. This begs the essential question of how developing ethnic group connections may inform the values, motivation, and priorities that underlie how one navigate their everyday world. For example, individuals with a positive sense of their ethnic identity show better academic adjustment, such as more school engagement, better academic efficacy, and more academic achievement (Constante et al., 2018; Miller-Cotto & Byrnes, 2016; Rivas-Drake, 2011). Students with positive connections with their ethnic group may be prioritizing school, effectively engaging in academic tasks and school behaviors, and negotiating and overcoming obstacles to their academic success. Another example is reflected in youths' involvement in health risk behaviors. Having a positive sense of one's ethnic identity has been associated with less engagement with deviant peers as well as less involvement in substance use and other health compromising behaviors (Grindal, & Nieri, 2016; Derlan & Umaña-Taylor, 2015; Zapolski et al., 2018; Brook et al., 2010). As a cultural asset, focusing on the way in which youth develop and formulate their ethnic identity (e.g., ethnic identity development) may uncover other mechanisms that help explain how ethnic identity is informing how they navigate their world. For example, as a cultural asset, how does ethnic identity development translate into the cognitive and behavioral processes that underlie adjustment such as the way youth appraise socially salient information

To conceptualize how ethnic identity development functions as a cultural asset to support adjustment, I draw from three theoretical frameworks, ethnic identity development theory (Umaña-Taylor et al., 2004; Umaña-Taylor, 2011), a social reorientation perspective of adolescence (Dahl, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer et al., 2018), and the identity-value model of decision-making (Berkman et al., 2017; Osyermen, 2007). Through a social reorientation perspective of adolescence, the heightened sensitivity to social environmental cues and increased cognitive abilities set the stage for youth to constantly negotiate the beliefs, values, and ideas of salient social others in regard to their own sense of self (Dahl, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer et al., 2018). This process occurs in various social contexts, such as with peers and parents, and I argue that it may also occur with ethnic group members, and which implicates ethnic identity development perspectives. An identity-value model of decision-making also considers how social identities, such as one's ethnic identity, are thought to inform values, priorities, and motivations, which may inform how youth make decisions involved in everyday adjustment (Berkman et al., 2017; Osyermen, 2007).

Integrating these identity-relevant frameworks helps provide a more comprehensive picture of ethnic identity in adolescence that allows to ask how identity may inform behaviors during this period. Specifically, this multi-theoretical grounding helps to shed light on how ethnic identity processes might be pertinent to the cognitive and behavioral processes that support adjustment.

I bridge these frameworks to help identify ways that ethnic identity supports adjustment. Navigating one's social environment, such as refusing to go along with friends even though it will make friends unhappy (e.g., resisting peer influence) may be contingent on how youth see themselves (e.g., identities) (Berkman et al., 2017). Similarly, being able to make decisions based on longer term benefits versus immediate gratification (e.g., future orientation) may be also depend on identity. This dissertation will contribute new knowledge to the field by considering how ethnic identity may be implicated in resisting peers and being future-oriented—two factors thought to be involved in everyday adolescent adjustment (Johnson et al., 2014; Steinberg et al., 2009).

Similarly, by drawing from these integrated frameworks this dissertation also considers how looking inward at brain processes may reveal insights as to how ethnic identity helps promote adaptive outcomes. Although every thought and behavior studied in psychology is processed, organized, and executed by the brain, little is known about how ethnic identity is implicated at this level. One's ethnic group connection and its influence on thought and behavior are complex social cognitive and behavioral processes that are not easily understood neurocognitively. Yet, recent developments in neuroimaging methodology make it possible to describe characteristics of the brain's functional organization with complex psychological processes and psychological profiles (e.g., Beltz et al., 2016). That is, we can ask how do people's lived experiences, whether it be maltreatment, clinical diagnoses, aging, positive social interactions, and so on, inform how the brain is shaped and organized? Taking this approach is a way for researchers to explore how a sense of ethnic connections embedded within the self (e.g., ethnic identity development) is implicated in the brain's functional organization.

As an initial step, it is important to begin conceptualizing how ethnic identity is associated with the brain organization and functionality that may underlie youths' positive adjustment. I argue that the default mode and the frontoparietal networks, two large-scale brain networks thought to support human social interactions (Barrett & Satpute, 2013; Feng et al., 2021), are potentially implicated in ethnic identity development. The default mode network is involved in self-referential thinking (i.e., thinking about one's sense of self), autobiographical thinking, and mentalizing (i.e., thinking about another person's perspective) (Buckner & DiNicola, 2019; Spreng & Andrews-Hanna, 2015). I propose that this brain network may be exercised, and hence shaped and organized, when individuals have engaged in ethnic identity development processes: exploring, participating, and learning more about one's ethnicity and developing a sense of clarity about what it means to belong to one's ethnic group. The default mode network and its connection to the frontoparietal network, a network underlying cognitive control, is thought to support better planning and adjustment (Scolari et al., 2015; Spreng et al., 2013). I propose that exploring the interconnections between these two networks as it relates to ethnic identity may contribute foundational knowledge that can ultimately be used to better understand the ethnic identity-adjustment links commonly observed in behavioral studies.

Statement of the Problem

Although we have learned much about the role of ethnic identity in positive adjustment in the past two decades (Umaña-Taylor et al., 2014), we know less about the potential mechanisms by which these associations manifest. While self-esteem had been previous explored as a mechanism, it has yielded mix support. There is little conceptual and methodological work regarding how ethnic identity informs adolescents' day to day decisions that underlie their positive adjustment in a myriad of developmental domains. Integrating identity relevant frameworks into current perspective of ethnic identity development may help expand the scope of how we understand ethnic identity as a cultural asset. Being able to navigate, resist, and manage social influences, and being able to adaptively make decisions, may be at partly contingent on one's identity. In this dissertation, I consider ethnic identity among ethnic minority youth in the United States. Further, despite the burgeoning evidence regarding how ethnic identity is implicated in healthy functioning, there is less knowledge about how ethnic identity is implicated in the brain. Integrating knowledge of how ethnic connections are embedded within the self with knowledge of brain functionality may reveal a more comprehensive understanding of how and for whom ethnic identity may function as a cultural asset. It is important to begin formulating how ethnic identity may be implicated in brain functionality to understand potential mechanisms at multiple levels. Doing so will help elucidate the conditions under which ethnic identity is linked to positive adjustment.

Significance

The proposed dissertation is significant for multiple theoretical and methodological reasons. First, the proposed research will contribute new knowledge of how one's ethnic identity is associated with positive adjustment and therefore clarify the conditions under which it may function as cultural asset. Second, this dissertation involves the integration of developmental science, cultural psychology, and neuroscience to formulate a more comprehensive picture of how one cultural asset (ethnic identity) can be understood within the brain to inform behavior.

Third, from a conceptual standpoint, I propose to expand the scope of potential mechanisms that may be involved in the link between ethnic identity and positive adjustment beyond those studied previously by considering other identity relevant frameworks into current ethnic identity developmental perspective. I draw conceptual links between how individuals view themselves in terms of their ethnic group membership and how this may inform the way they make decisions and navigate social influences. Individuals with a positive sense of self, more generally, may be better able to adaptively resist social influences that may compromise themselves (Miller & Byrnes, 2001). For example, adolescents with less self-concept clarity are more suspectable to the influence from their peers to engage in delinquent behaviors (Levey et al., 2018). Similarly, individuals with a positive sense of self may be better equipped at thinking about their future and engaging in adaptive decision-making that may be most beneficial, or least harmful, to their well-being (Hoyle & Sherill, 2006; Johnson et al., 2014). This dissertation extends previous knowledge by exploring the sense of self that is derived from social connections and experiences with one’s ethnic group, which is a salient context for self-concept among ethnic minority youth in the U.S.

I consider cognitive-behavioral processes that are ecologically reflective of how youth adjust in their everyday context in relation to ethnic identity development. Resisting maladaptive social influences and making decisions for one’s concurrent and future well-being are two facets involved in promoting outcomes that are beneficial for youth. Examining the links between ethnic identity and these ecologically representative forms of adjustment is an important steppingstone that may then open new avenues for linking ethnic identity with more precise experimental measures of cognition and behavior, as has been done with other cultural processes (e.g., familism; Telzer et al., 2016).

Fourth, I will assess two distinct aspects of ethnic identity: exploration and resolution. Earlier conceptualizations of ethnic identity involved composite measures, but more recent theoretical formulations and psychometric evaluations have led to reliable measures of the multiple dimensions of ethnic identity (Douglass & Umaña-Taylor, 2015; Phinney & Ong, 2007; Galliher et al., 2017; Umaña-Taylor, 2011). This approach provides three advantages over previous research. It provides better insight as to what it is about connection to one's ethnic group that is associated with adaptive outcomes, not just overall "more" or "less" ethnic identity (Cokley, 2007; Umaña-Taylor et al., 2004). In addition, measuring exploration and resolution may reveal individual differences in the relationship between ethnic identity and adaptive outcomes within an ethnic group, but may also reveal something universal about being connected to an ethnic group. Finally, assessing specific dimensions of ethnic identity allows researchers to draw more precise conceptual links to potential cognitive, affective, behavioral, and physiological mechanisms.

Fifth, this dissertation aims to advance knowledge of ethnic identity through the proposed, novel methodological approaches that have not been employed in this field. Although we know much about the adaptive role of ethnic identity in psychosocial and behavioral outcomes, we know little about how it is implicated in the brain. As the field of developmental science continues to learn more about ethnic identity from a behavioral and psychosocial perspective, the burgeoning of empirical evidence suggesting the promotive and protective role of ethnic identity in healthy adjustment merits basic research on how ethnic identity is associated to brain networks wired to enable such healthy adjustment. Looking at the brain is one way to learn more about mechanisms. For example, individuals with strong connections to their ethnicity may have healthy brain functionally that may help explain everyday healthy adjustment, such as coping with stress. The question for the field, is how? Just as rearing experience within the home is thought to shape the brain (e.g., Smith, & Pollak, 2021), the adaptive role of ethnic connections also merits consideration. There are virtually no neuroimaging studies on ethnic identity and brain functionality, and only a few studies consider a cultural developmental perspective. Using an integrated framework, researchers can begin to assess how sociocultural contexts shape the brain using a developmental perspective.

In doing so, I draw insights from the field of cultural neuroscience. A common methodological approach in cultural neuroscience is to study two populations that were brought up in different sociocultural environments and compare and contrast their brains through neuroimaging (Lin & Telzer, 2018). However, this approach is limited in advancing our knowledge of how differences in the brain emerges as a function of culture. As a nascent field, most studies have used cross-sectional approaches to compare adult populations. Studying populations over time may help determine how differences in the brain emerge as a function of culture. In addition, culture is often operationalized as simplified categorical definitions (e.g., East vs. West; Western vs. Asian; United States vs. Japan) for the purpose of group comparisons (Seligman et al., 2016). These simplistic definitions of culture make it difficult to learn what it is about culture that might contribute to neural differences. Although growing up in a particular sociocultural environment over time may shape the architecture of the brain, these categorical operationalizations are noisy measures of culture. To learn about the role of culture in the brain, the field of cultural neuroscience should adapt a developmental perspective (Qu & Telzer, 2018). This perspective compels us to more precisely articulate what aspects of cultural experience may be important at different developmental periods.

Similarly, this dissertation considers the recommendations above to study culturally salient processes and the brain. Reliable measures that have been well vetted within developmental science will be used to assess the role of one culturally salient process—i.e., ethnic identity development—that is known to be salient during the periods of adolescence and young adulthood. Measures of ethnic identity are a step toward more precisely identifying what it is about one's connection to one's ethnicity that influences the outcome of interest. This makes studying ethnic identity in the brain somewhat distinct from studying culture in the brain. While it is possible to investigate how engaging in specific cultural practices or experiences may shape a single neural structure (e.g., Kitayama & Uskul, 2011), the nature of ethnic identity makes it very likely not implicated within a *single* brain region. Rather, ethnic identity concerns developing connections to one's ethnic group, which involves complex social-cognitive processes.

Ultimately, developing these ethnic connections and formulating one's identity is likely reflected through brain *networks*, or systems of brain regions that are known to work together. More recently, it has become increasingly acknowledged that human social interactions rely on large-scale brain networks such as the default mode, central executive, and salience networks (Feng et al., 2021). The question is, are these large networks also relevant for ethnic group interactions (e.g., through identity processes)? In this dissertation, I consider potential brain networks implicated in ethnic identity, which reflects a novel methodological approach in this field. Studying how a system of brain regions work together may be more representative of complex social cognitive processes in human thought and behavior as opposed to studying one brain region. Rather than examining how select brain regions are modulated by psychological or behavioral measures, I instead propose to look at how brain networks are modulated by such psychological and behavioral characteristics (e.g., ethnic identity exploration and resolution).

Given the heterogeneity in how individuals develop their ethnic identities, a modeling approach that can recognize this at the brain level is also needed. That is, two individuals who grow up in the same sociocultural context may develop connections to their ethnicity in different ways as measured by their ethnic identity exploration and resolutions. These lived experiences may also inform the brain's functional organization in unique ways. Therefore, as a starting point to assess how ethnic identity processes are implicated in the brain, I utilized group iterative multiple model estimation (GIMME), a person-specific modeling approach. GIMME allows me to model brain network connections uniquely for each individual in a way the accounts for brain network connections that are present across all individuals (Gates & Molenaar, 2012). This approach has several critical advantages over traditional neuroimaging approaches. This allows me to better capture the heterogeneity in how individuals' brains work as well as potential homogeneity of the brain's functional organization across individuals (e.g., Beltz et al., 2016; Beltz et al., 2018). More importantly, it is suited for linking variations in brain networks with variations in psychological characteristics. A person-specific approach is methodologically appropriate for studying ethnic identity, defined as variable psychological characteristics (e.g., exploration and resolution), and the brain.

Research Questions

The integration of culture and neuroscience with a developmental perspective may provide a more comprehensive picture of how ethnic connections shape thought and behavior and how it is manifested in adaptive outcomes. To contribute new knowledge to the field, the proposed dissertation comprises two studies that address distinct but related questions. The first part of this dissertation aims to expand the scope of potential mechanisms for how ethnic identity development promote adjustment. Two facets involved in youth positive adjustment are resisting peer influence and making decisions that are most beneficial and least harmful to oneself concurrently and in the long run (i.e., future orientation) (Johnson et al., 2014; Steinberg et al., 2009). Accordingly, Research Question 1 is: *Is more ethnic identity exploration and resolution associated with greater resistance to peers and more future orientation?*

The second part of this dissertation details theoretical and methodological considerations to begin investigating how ethnic identity may be implicated in the brain, relying on the same set of integrated frameworks. I propose that the default mode and frontoparietal network are two potential candidate brain networks that may be pertinent to ethnic identity development, as well as to how it relates to adjustment. The default mode network is a set of brain regions that work together to underlie self-referential and autobiographical thinking, as well as mentalizing (i.e., thinking about another person's thoughts). The default mode network may have been exercised, hence organized and shaped, when individuals have explored their ethnicity and thought about what it means to belong to their ethnic group. The frontoparietal network is a set of brain regions thought to underlie cognitive and behavioral control. The relationship between the default mode and frontoparietal network may provide insight into the brain-level facets of how ethnic identity can translate into better adjustment. Accordingly, Research Question 2 is: *Do individuals with more ethnic identity exploration and resolution have more functional connections within the default mode and frontoparietal network?* Finally, Research Question 3 is: *Do individuals with more ethnic identity exploration and resolution have more functional connections across the default mode and frontoparietal networks?*

Organization of Proposed Dissertation

This dissertation consists of two studies. Chapter 1 provides a background on the state of developmental science and its knowledge on the adaptive role of ethnic identity in positive adjustment and discusses the significance of the dissertation studies. Chapter 2 is organized in an APA style-like manuscript with an Introduction, Method, Results, and Discussion section. I provide a literature review for study one and hypothesize how ethnic identity would be associated with resistance to peer influence and future orientation. Chapter 3 is similarly organized as Chapter 2, in an APA style-like manuscript. I provide a literature review for study two and hypothesize how ethnic identity would be implicated in brain networks involved in self-related processes, mentalizing, and cognitive control. In Chapters 2 and 3, I delineate the methodological approach, summarize the results, and discusses the findings for each respective study. Chapter 4 provides an integrated discussion of the overall dissertation findings, limitations, future directions, and implications for the field.

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Chapter II

Study 1: Ethnic Identity through a Social Reorientation Lens: Conceptualizing links with Resisting Peer Influences and Future Orientation

Ethnic identity development refers to the process of exploring and gaining knowledge about one's ethnicity (i.e., exploration), as well as how one develops a clear understanding about what it means to belong to one's ethnic group (i.e., resolution) (Umaña-Taylor, et al., 2004). There is a great deal of research demonstrating that youth who have a positive sense of connection to their ethnic group enjoy better psychosocial adjustment (e.g., Rivas-Drake et al., 2014; Smith & Silva, 2011). Broadly, among ethnic minority youth, a more positive ethnic identity has been associated with better psychosocial and academic adjustment as well as less engagement in health risk behaviors (Brittian et al., 2015; Cavanaugh et al., 2017; Rivas-Drake et al., 2014a; Rivas-Drake et al., 2014b; Zimmerman et al., 2013). Further, recent work has shown that youth with positive ethnic identities are more likely to engage and interact with people outside of their ethnic group, suggesting better social competency (Knifsend & Juvonen, 2013). Moreover, these promotive and protective effects have been supported through experimental interventions that foster ethnic identity development among in diverse samples, including White youth (Umaña-Taylor et al., 2018).

In contrast to knowledge about main effects evident when youth have engaged in ethnic identity development, less is known about the potential mechanisms that could help explain these associations. To be clear, some potential mechanisms have been explored. For example, self-esteem has been considered as an important mediator that helps explain how ethnic group connections manifest in adaptive outcomes. A positive sense of self, derived from the positive social ties and sense of belonging with one's ethnic group, has been found to promote self-esteem that enables youth to thrive in their environments, such as developing fewer depressive symptoms and engage in less substance use (Fisher et al., 2017; Piña-Watson et al., 2017; Romero & Roberts, 2003).

Adolescence is an important period to understand the mechanisms by which ethnic identity relates to positive adjustment. Compared to childhood, advanced cognitive abilities and heightened sensitivity to social-environmental cues allow youth to evaluate interactions with ethnic group members and develop complex meaning about their own ethnic group membership (Quintana, et al., 1999). Interacting with ethnic group members and developing a sense of identity helps youth have a sense of belonging, which has a direct influence on youths' behaviors and well-being (e.g., Umaña-Taylor et al., 2014). From a cultural ecological perspective, sociocultural contexts, including ethnic group connections, play a central rather than peripheral role in development (Coll et al., 1996; Perez-Brena et al., 2018; Vélez-Agosto et al., 2017). The integrative model of developmental competencies in ethnic minority child development (Coll et al., 1996), in particular, underscores how interacting with ethnic group members helps youth of color foster competency for navigating their ethnicity as well as social institutions such as schools. Yet, despite burgeoning evidence supporting the importance of ethnic connections as a cultural asset, research is still needed to understand the mechanisms by which these cultural processes may or may not manifest in adaptive outcomes.

Further, adjustment during a period of heightened social saliency requires adaptive decision-making in ways that promote less detrimental outcomes. Successfully navigating social influences and making decisions that serve promotive goals may depend on one's social identities. For example, individuals with a more positive sense of their ethnic identity show better academic adjustment, such as more school engagement, better academic efficacy, and more academic achievement (e.g., Constante et al., 2018; Rivas-Drake, 2011). A recent meta-analysis by Miller-Cotto and Byrnes (2016) demonstrates the broad array of academic benefits of having a more positive ethnic identity for diverse youth across 47 studies. Students with positive connections to their ethnic group tend to prioritize school, effectively engaging in academic tasks and school behaviors, and negotiating and overcoming obstacles to academic success. Another example is reflected in youths' involvement in health risk behaviors. Having a positive ethnic identity has been associated with less engagement with deviant peers as well as less involvement in substance use and other health compromising behaviors (Brook et al., 2010; Derlan & Umaña-Taylor, 2015; Grindal, & Nieri, 2016; Rivas-Drake et al., 2014b; Zapolski et al., 2018). Yet, the links between ethnic identity and these underlying facets of everyday adjustment, such as navigating social influences and being future oriented, have been underexplored.

Integrating a social reorientation (e.g., Dahl, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer et al., 2018) and an identity-value model of decision-making (Berkman et al., 2017; Osyermen, 2007) into current knowledge of ethnic identity development in adolescence (Umaña-Taylor et al., 2004; Umaña-Taylor, 2011), the present study links ethnic identity development and two underlying facets of everyday adjustment. These frameworks overlap in their attention to how identity development in social context is thought to occur and to how social identities inform a behavior in myriad contexts. Drawing on these frameworks helps to shed light on whether developing one's ethnic identity specifically may contribute to what one values in oneself, and thus informs how one navigates social environments and social influences.

Bridging Social Reorientation and Identity-Value Frameworks

A social reorientation perspective of adolescence addresses a range of developmental processes that support identity development in general as well as adaptive adjustment and which are likely relevant to particular social identities such as ethnic identity. A social reorientation perspective of adolescence helps explain how salient social groups become embedded in one's sense of self. This perspective emphasizes that the developing brain may underlie the heightened social reorientation and engagement in exploration that contributes to youth's developing identities (Dahl, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer et al., 2018). Youth take into account ideas, beliefs, and practices of salient others, such as peers, and family, and they incorporate others' perspectives into their own self-concept; this is part of the process of how individuals are influenced by salient others (Telzer et al., 2018). Social orientation also occurs in ethnic identity development. Negotiating the perspectives of others in relation to one's sense of self may be an underlying mechanism for adaptive outcomes; that is, having negotiated whether and how beliefs and perspectives of salient others matter for their own identity may prepare youth to better disregard social pressures to engage in deviant behavior, for example.

In a complementary manner, identity-value models of decision-making consider how the self is integral in how one interacts with one's environment (Berkman et al., 2017; Pfeifer & Berkman, 2018). This framework acknowledges that different aspects of identity may contribute to one's values and motivation that underlie behaviors. Of the pieces of information that contributes to making decisions, engaging in a particular behavior may be valued more when it is relevant to one's identity. For example, when deciding whether to study or hang out with friends, if one's self-view is of a high achieving student and grades are valued, then this aspect of their identity will have more weight on their decision (Pfeifer & Berkman, 2018). An identity-value model allows us to consider the "self" in decision making in everyday context as one that is informed by social identities (Oyserman, 2007). Although this study will not explicitly examine how different contexts on a moment-to-moment basis make certain aspects of one's identity more salient to inform behaviors, the identity-value framework is useful because it supports the notion that social identity informs values and motivations over time and thus informs how one interacts with one's environments. Having a clear sense of self may reflect greater self-assuredness and self-competency that may be vital for adaptively navigating one's environments, in particular during adolescence (e.g., Rivas-Drake & Umaña-Taylor, 2019). Drawing from an identity-value model of decision-making in general, a sense of self derived from exploring and developing meaning from ethnic group interactions informs youths' values, motivations, and priorities, thus potentially inform how they navigate their environment.

Linking Ethnic Identity to Future Orientation

There are several conceptualizations of future orientation (Johnson et al., 2014). Earlier conceptualizations focus on the tendency to think about the future, in terms of goals, hopes, and expectations (Nurmi, 1991). Some of these earlier conceptualizations assessed how optimistic individuals were about their future, while more recent conceptualizations assess how individuals weigh decisions with the future in mind. For example, it is possible to measure future orientation regarding one's educational and career outlook, in addition to delayed gratification or planning tendencies (Robben & Bryan, 2004; Seginer, 2009). Across these conceptualizations, individuals who are more future-oriented are more likely to think and behave in ways that are promotive to their adjustment and development. For adolescents, future orientation is thought to hold promotive and protective value for academic behaviors as well as for refraining from health risk behaviors (Johnson et al., 2014).

Youth who are more future-oriented perceive greater consequences from engaging in risk-taking behaviors (Robbins & Bryan, 2004). For example, youth with a greater future orientation have been shown to be less likely to use marijuana, drugs, alcohol, and engage sexually risky behaviors as well as have improved educational outcomes (Chen & Vazsonyi, 2013; Johnson et al., 2014). In a longitudinal study of ethnic and racially diverse youth, future orientation predicted less engagement in health risk-taking behaviors (Jackman & MacPhee, 2017). In another study of low-income African American youth, future orientation was associated with less delinquency involvement, lower likelihood to engage in risky sex, and higher levels of school bonding and positive student-teach relationships (So et al., 2016).

In the present study, future orientation is conceptualized as how individuals weigh decisions with the future in mind. This operationalization reflects the cognitive and motivational components of future orientation. Being more future-oriented reflects having better planning ability, delayed gratification, and stronger ability to overcome obstacles, which are informed by perceived values in future domains (Seginer, 2009; Johnson et al., 2014; Steinberg et al., 2009). This operationalization more closely represents how youth make decisions on a daily basis, such as in their academically related decisions, whereas other conceptualizations focus on affective components, such as optimism and hopefulness toward the future. Here, future orientation reflects one's ability to make decisions that would be most beneficial and least maladaptive to oneself, both concurrently and in the long run (Steinberg et al., 2009).

Part of being future-oriented is engaging in self-evaluation to plan thoughtfully for one's future and also acknowledge the immediate or long-term consequences of one's actions. These self-evaluative processes may be contingent on one's self-understanding (Hoyle & Sherrill, 2006). For example, one study found that youth who engaged in more identity defining experiences were more future-oriented, in that they held clarity, optimism, and goals and plans about their future (Sharp & Coatsworth, 2012). However, few studies have evaluated the link between identity and future orientation, much less considered ethnic identity. Among first year college students, one study found that students with more clarity about their ethnic group membership also showed more career decisiveness and career clarity (Duffy & Klingaman, 2009). In a separate study of African American youth, future orientation (i.e., planning tendency) and ethnic identity were each independently and positively associated with higher academic achievement; however, their interactive effects were not examined (Adelabu, 2008). Based on theoretical frameworks discussed above, identity informs values, motivations, and priorities, having implications in how they weigh and make decisions. Therefore, it is hypothesized that youths' sense of identity derived from developing connections to their ethnicity (exploration and resolution) will be associated with being more future orientated, specifically in how they weigh decisions with the future in mind.

Resistance to Peer Influence

Being able to navigate, resist, and manage social influences is considered another facet of adolescent adjustment (Miller & Byrnes, 2001). During a period of heightened exploration and sensitivity to social environmental cues, adolescents are consistently tasked with navigating social (e.g., peer) influences (Steinberg et al., 2008; Dahl et al., 2016). Although youth are thought to be vulnerable to maladaptive outcomes due to their social reorientation, youth are also presented with opportunities to gain positive experiences driven by their social reorientations that ultimately contribute to their identity development. Youths' affiliations with peers is commonly modeled as a mediator that helps explain both youths' adaptive and maladaptive outcomes (e.g., positive academic-related outcomes and health compromising behaviors; Lee et al., 2017; Quimby et al., 2017). Successfully navigating peer contexts may be contingent on identity. The identity-value model of decision-making suggests that values and motivations to engage in certain behaviors is shaped by peers (Berkman et al., 2017).

Empirically, there are two related but distinct lines of research regarding ethnic identity and peer relationships. One line of inquiry concerns how youth influence one another in their ethnic identity formation (e.g., Rivas-Drake et al., 2017). The other line of work concerns how youths' ethnic identity informs behaviors in peer contexts, such has formation of friendships and engagement in prosocial or maladaptive behaviors (Derlan & Umaña-Taylor, 2015). In the first line of work, evidence is emerging that youth can influence each other in their beliefs and attitudes about their ethnic identity. For example, in a longitudinal social network study, peers influenced each other's engagement in ethnic exploration and resolution as well as their ideas about what society thought of their ethnic-racial group (Rivas-Drake et al., 2017; Santos et al., 2017). From a social reorientation perspective, these findings illustrate how youth negotiate the ideas and beliefs of salient social others—such as ideas regarding race and ethnicity—and incorporate them into their self-concept.

In a second line of inquiry, studies find that ethnic identity may inform youth behaviors in peer contexts. For example, youth who had a clearer understanding of their ethnic group membership were more likely to have ethnic-racially diverse friend groups over time (Rivas-Drake et al., 2017). This illustrates the prosocial benefits of having a positive ethnic identity, suggesting that having a positive sense of self regarding one's ethnic group membership may give youth confidence to develop positive interpersonal relationships. Regarding how youth navigate peer relationships, African American youth with more positive connections to their ethnicity were less likely to associate with deviant peers (Derlan & Umaña-Taylor, 2015). In a separate longitudinal study of African American and Latinx youths' transition from adolescence to adulthood, youth with lower ethnic identity affirmation (positive affect toward their ethnic group) were more likely to associate with substance using peers, which in turn was associated later adult substance use (Brook et al., 2010). These authors suggest that youth who feel a sense of belonging to their ethnic group may resist peer pressure to engage in problem behaviors in order to preserve a positive ethnic identity. To date, however, no research has specifically examined the role of ethnic identity development and youths' tendency to resist peer influence, as opposed to simply avoiding or associating with deviant peers.

Identity development may allow youth to navigate their social environment by selectively adopting adaptive behaviors (e.g., studying more) and rejecting negative ones (e.g., substance use experimentation). Negotiating the influence of salient social others (in developing identity) may contribute to values and motivations that may underlie youth behaviors in context. Further, social identity, and related self-assurance, may lead to more cognitive appraisals of peer messages (Neblett et al., 2012). Youth may be less susceptible to peers, more generally, if they have a more internally directed decision-making orientation that is inform by their self-concept. In this manner, ethnic identity development may be relevant in how individuals develop an adaptive future orientation and navigate social influence.

The Current Study

Ethnic identity development is thought to convey promotive and protective benefits for youth (Brittian et al., 2015; Cavanaugh et al., 2017; Neblett et al., 2012; Rivas-Drake et al., 2014a; Rivas-Drake et al., 2014b; Zimmerman et al., 2013). However, there is less knowledge as to *how* ethnic identity may function to promote such adaptive outcomes. The current study examines the relations between ethnic identity development and two underlying facets of everyday adolescent adjustment: future orientation and resistance to peer influence. Future orientation and resistance to peer influence are linked to many of the adaptive outcomes evident when youth have positive ethnic identities, such as more positive school outcomes and less involvement in health risk behaviors. Future orientation reflects being able to make decisions that are most beneficial and least maladaptive for oneself concurrently and in the long run. Resisting peer influence reflects one's ability to rely more on one own's self-view, perspective, attitudes, and ideals and less so of that of their peers (e.g., one's ability to adaptively navigate social influence).

Integrating a social reorientation perspective of adolescence and an identity-value model of decision making into current knowledge of ethnic identity development (Berkman et al., 2017; Osyermen, 2007; Steinberg, 2008; Telzer et al., 2018; Umaña-Taylor et al., 2004; Umaña-Taylor, 2011), it is proposed that part of ethnic identity development involves negotiating the views, ideas, and beliefs from salient ethnic group interactions that may contribute to the values and motivations of individuals, thus informing how one interacts with their environments and ultimately underlying adaptive adjustment. A sense identity that is derived from ethnic group connections may support one's capacities to make adaptive decisions in that they are more internally driven. It is hypothesized that more ethnic identity exploration and resolution will be associated with greater future orientation and resistance to peers. Given the saliency of ethnic identity developmental processes for ethnic-racial minority status youth (e.g., youth of color) as well as the likelihood that processes may also occur among White youth in ethnic-racially diverse school contexts (e.g., Brown et al., 2014; Feitosa et al., 2016; Fisher et al., 2020), we explored whether the hypothesized associations were moderated by youth of color status.

Method

Participants

Data were retrieved from Wave 2 of the Adolescent Health Risk Behavior (AHRB) study (UM IRBMED Approval #: HUM00097653; PI: Daniel Keating), which is a longitudinal (3-wave) study of adolescents' health risk behaviors. A total of 913 participants who ranged from 16 to 21 years of age were surveyed in wave 2 (42% of the wave 1 sample). About 16% (n = 143) were 16 years old, 28% (n = 251) were 17 years old, 20% (n = 176) were 18 years old, 9% (n = 83) were 20 years old, and less than 1% (n = 4) were 21 years old. Nine participants did not report their age. Four hundred and thirty participants were attending high school. Two hundred and ninety-seven participants were attending a 4-year college or university, 83 participants were attending community college, 10 participants were attending vocational/technical school, and 72 participants were not attending school. Twenty-one participants did not report their current education status. Three hundred and thirty-six participants self-identified their sex as male (40%), and 492 self-identified as female (60%). Five hundred sixty-eight participants self-identified as White, 167 as Black or African American, 54 as Hispanic or Latino, and 39 as Asian. Eighty-five identified as mixed-race and were excluded from the final analytic sample of 828 participants.

Procedure

Approximately one year prior to Wave 2, participants in the present analytic sample completed surveys in their high schools as part of Wave 1 of the AHRB study. The parent AHRB study sample was recruited across 12 school districts at Wave 1 (see Table S2.1 for school demographics). Given that many participants would have exited high school by the next wave of data collection, participants were mailed a newsletter and a $2 bill as follow up and were notified about an upcoming opportunity to participate in Wave 2 of the AHRB study. They were informed that they would receive an email with their log-in information. For participants who were under the age of 18, parents were sent mail to opt out of the study. Participants who did not respond to the mailing or the email were sent two to three reminder emails. Participants who continued to not respond were called, and if they could not be reached, contactvia Facebook was attempted. A final reminder was sent to everyone to inform that the opportunity to complete the survey was about to end.

Participants who responded to the email and accessed the survey portal via the internet completed informed consent upon entering their log-in information. The survey was self-administered at the location and time of their choosing. They were informed that the AHRB study was similar to what they completed at Wave 1 in their high schools. The survey consisted of a series of questionnaires and a set of cognitive-behavioral tasks. Participants were also informed that they would be compensated for their participation in the AHRB study if they completed both the questionnaires and the cognitive-behavioral tasks. Participants were instructed that they could pause and return to the questionnaire portion of the study. However, they could only take breaks between cognitive-behavioral tasks, not during. Upon completing the study, participants were thanked for their time and reminded that they would receive $50 through mail within a week.

Measures

Ethnic identity. Exploration and resolution were assessed with the Ethnic Identity Scale (Umaña-Taylor et al., 2004; see Table S2.2). A sample item for exploration is, “I have experienced things that reflect my ethnicity, such as eating food, listening to music, and watching movies" (7 items; α = .85). A sample item for resolution is, "I have a clear sense of what my ethnicity means to me" (4 items; α = .85). Response options ranged from 1 (*Does not describe me at all*) to 4 (*Describes me very well*). All items were scored such that higher values indicated more exploration and resolution, respectively.

Resistance to peer influence. The Resistance to Peer Influence Scale (Steinberg & Monahan, 2007) comprised 10 items; α =. 77 (see Table S2.3). The scale is designed to minimize social desirability by presenting respondents with a series of statement pairs separated by the word *BUT*, with respondents instructed to choose the best descriptor followed by instructions to indicate the extent to which the descriptor is true. A sample statement is: "For some people, it's pretty easy for their friends to get them to change their mind" BUT "For some people, it's pretty hard for their friends to get them to change their mind". Response options range from 1 to 4, such that 1 and 4 represent that statement A or B is really true of them, respectively, and 2 and 3 represent that statement A or B is sort true of them, respectively. Items are scored so that higher scores indicate a stronger resistance to peer influence. An unweighted average of all items is calculated such that higher values indicate more resistance to peers.

Future orientation. The Future Orientation Scale (FOS; Steinberg et al., 2009) included 15 items; α =.75 (see Table S2.4). The items are designed to minimize social desirability by presenting respondents with a series of statement pairs separated by the word *BUT* with respondents instructed to choose the best descriptor followed by instructions to indicate the extent to which the descriptor is true. The scale includes three subscales. The first is time perspective (e.g., "Some people spend very little time thinking about how things might be in the future" BUT "Other people spend a lot of time thinking about how things might be in the future"; 5 items, α=. 58). The second subscale is anticipation of future consequences (e.g., "Some people usually think about the consequences before they do something" BUT "Other people just act – they don't waste time thinking about the consequences"; 5 items, α=. 60). The third subscale is planning (e.g., "Some people like to plan things out one step at a time" BUT "Other people like to jump right into things without planning them out beforehand"; 5 items, α=. 68). Response options range from 1 to 4, such that 1 and 4 represent that statement A or B is really true of them, respectively, and 2 and 3 represent that statement A or B is sort true of them, respectively. Items are scored so that higher scores indicate more time perspective, anticipation of future consequences, and planning. A confirmatory factor analysis indicated that a model with the three intercorrelated 5-item subscales provided a satisfactory and better fit to the data than a single 15-item factor (CFI =.935; TLI =.921; RMSEA (CI 90%) = .043 (.04, .05); SRMR =.040).

Demographic information. Race and ethnicity were self-reported by identifying as one or more of the following: American Indian/Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Black or African American, and White. Participants also self-reported if they identified as Hispanic or Latino. Participants identified their sex as male or female. School demographic information were retrieved from the State of Michigan Department of Education, including gender and race/ethnicity composition.

Analysis Plan

Structural equation modeling (SEM) framework was used to examine the associations among ethnic identity development, resistance to peer influence, and future orientation. Specifically, ethnic identity exploration and resolution were expected to predict resistance to peers and future orientation within a single model. Sex (1 = male, 2 = female) and age were included as covariates. Given the psychometric properties of the future orientation measure, future orientation was modeled as a latent variable comprised of three intercorrelated 5-item subscales. The proposed hypothesized model is drawn in Figure 1. After examining patterns of missingness, full information maximum likelihood (FIML) in Mplus 8.1 (Muthén & Muthén, 1998-2019) was used to handle missing data.

Measurement invariance assessment was conducted to determine the extent to which the predictor variables, ethnic identity exploration and resolution, demonstrated comparable psychometric properties across White youth and youth of color. This helps ensure that comparisons of path estimates between predictor and outcome variables across groups are not biased by potentially different psychometric properties of exploration and resolution in each group. Configural invariance indicates equivalence in factor structure of a latent variable across groups. Metric invariance indicates equivalence in the factor loadings of a latent variable across groups. Scalar invariance suggests equivalence in the factor intercepts of a latent variable across groups. A series of model constraints were applied to determine whether each feature of the model (structure, factor loadings, factor intercepts) could be held equal across groups. Chi-square difference tests between invariance models was used to determine whether model fit was compromised as features of the model were constrained. A non-significant Chi-square test indicates that the equality constrains are tenable and features of the model do not differ across groups. Achieving metric invariance was deemed acceptable, as the aim of the study was to compare the beta estimates between the latent predictor variables and the outcome variables across groups (Putnick & Bornstein, 2016). Achieving scalar invariance would be optimal but only necessary if comparing the means of the latent variables across groups, which was not an aim of the study.

Given the saliency of ethnic-racial membership for ethnic minority youth in the United States, the multigroup analysis serves to explore whether the associations between ethnic identity and resistance to peers and future orientation are similar among White youth and youth of color. Multigroup SEM proceeded as follows: Associations of exploration and resolution with resisting peer influence and future orientation were first examined in the whole sample. Initially, school district was added as a clustering variable to determine whether the result of the model was sensitive to school district. However, this yielded model non-identification and thus was not included in the final models (single group and multiple group path models) to maintain model parsimony.

After testing the hypothesized associations for the entire sample (N=828), multigroup tests of the same model were evaluated (Figure 2.1), where estimated paths were allowed to vary between White youth (N=568) and youth of color (N=260). A Chi-square difference test was used to compare the fit of the model in which paths are constrained to be equal with that in which paths are free to vary between the two groups. A significant chi-square difference test indicates that equality constraints are untenable. Therefore, if there was a significant change in chi-square, models with sequentially constrained paths were then tested to determine which paths in the final model can be constrained to be equal and which should be allowed to vary freely. For such paths that were allowed to vary freely, the standardized estimated coefficient for each group would be examined to determine if the path was significant for a particular group, or if the effect is greater for one group versus the other. Recommended thresholds to assess the fit of the models to the data were followed, including a comparative fit index (CFI) and Tucker-Lewis index (TLI) of greater than .90, a root mean square error of approximation (RMSEA) of less than .05 with a

90% confidence interval less than .08, and a standardized root mean square residual (SRMR) of less than .08 (Hu & Bentler, 1999; Kline, 2010).

Results

Preliminary Analyses

Means, standard deviations, and correlations among key variables are presented in Table 2.1. There was a positive and significant correlation among all of the key variables; exploration, resolution, resistance to peer influence, and future orientation (see Table S2.5 for mean, standard deviations, and correlations for White youth and youth of color). None of the key variables was missing more than 3% of data. Each key variable was not substantially skewed (exploration skewness = .42, exploration kurtosis = -.60, resolution skewness = -.19, resolution kurtosis =-.84, resistances to peer influence skewness = -.30, resistances to peer influence kurtosis = -.52, future orientation skewness = -.42, future orientation kurtosis = -.39).

The measurement invariance assessment demonstrated that ethnic identity exploration and resolution as latent variables achieved configural and metric invariance among White youth and youth of color (see Table 2.2). This suggest that for White youth and youth of color, ethnic identity items supported exploration and resolution as latent variables in structurally similar ways and had similar factor loadings across groups. Scalar invariance was not achieved, suggesting that one or more factor intercept(s) varied across group. In the multigroup path models, ethnic identity exploration and resolution were defined as latent variables for White youth and youth of color in accordance with the measurement invariance assessment. Factor structure and factor loading were constrained as equal, as the measurement invariance assessment indicated no difference across groups. Factor intercepts were freely estimated across groups. These specification in ethnic identity exploration and resolution as latent variables reflect the metric invariance that was deem accepted to proceed with comparing beta path estimates across groups in the multigroup path models.

Primary Analyses

The single group path model had good fit, CFI = .947, TLI = .931, RMSEA (CI 90%) = .06 (.05, .07), SRMR = .04). Factor loadings for latent variables are presented on Table 2.4. All indicators of latent variables were significant. There was a positive and significant association between ethnic identity resolution and resisting peer influence (b= .184, $p < .001$) (see Figure 2.2 for standardized estimates). There was also a positive and significant association between sex and resistance to peer influence (b = .144, $p < .001$) and future orientation (b = .076, $p = .027$).

To determine whether any paths in the single-group path model differed between White youth (n = 568) and youth of color (n = 260), a multigroup path model was tested. Ethnic identity exploration and resolution were specified in accordance with the measurement invariance assessment, i.e., constrained factor structure and loadings and freely estimated factor intercepts across groups. Path estimates between predictor variables (exploration and resolution) and outcome variables (resistance to peer influence and future orientation) were freely estimated across groups. This multigroup path model had good fit, CFI = .921, TLI = .904, RMSEA (CI 90%) = .07 (.06, .07), SRMR = .06. Factor loadings for latent variables are presented on Table 2.4. There was a positive and significant association between ethnic identity resolution and resisting peer influence among White youth ($b = .164$, SE = .05, $p < .001$) and youth of color ($b = .284$, SE = .13, $p = .023$) (see Figure 2.3 for standardized estimates). Among White youth, there was a positive and signification association between sex and resistance to peer influence ($b = .121$, SE = .05, $p = .008$) and future orientation ($b = .082$, SE = .04, $p = .047$). Among youth of color, sex was positively and significantly associated with resistance to peer influence (b = .191, SE = .07, p = .010).

To determine whether the association between ethnic identity resolution and resisting peer influence differed in magnitude (e.g., group moderation) between White youth and youth of color, the freely estimated multigroup path model was compared to a fully constrained nested multigroup path model. Table 2.3 summarizes comparisons of model fit between the freely estimated and fully constrained multigroup models. There was a non-significant difference in Chi-Square ($\chi^2(4) = 5.702$, p = .223) between models, indicating that the constraints were tenable – model fit did not worsen by constraining model paths. Therefore, path estimates across groups could be held equal, suggesting that the association between ethnic identity resolution and resisting peer influence did not differ across groups. Given that there were no paths that differed across groups, sequentially constrained nested models were not necessary to identify any moderated paths.

Discussion

A social reorientation lens (Dahl, 2016; Steinberg 2008; Telzer et al., 2018) was used to conceptualize how youths' ethnic identity development might translate into thoughts and behaviors that facilitate adjustment. Ethnic identity exploration and resolution reflect gaining knowledge about one's ethnicity and developing meaning about one's group membership (Umaña-Taylor et al., 2004). Drawing from an identity-value model of decision making (Berkman et al., 2017), ethnic identity may inform one's values, motivations, and priorities that may underlie adjustment (Pfeifer & Berkman, 2018). Future orientation and resistance to peer influence are both facets involved in adolescent adjustment—tendencies to plan and weigh decisions with the future in mind, as well as tendencies to adaptively navigate social influences.

We hypothesized that youth ethnic identity development would be associated with greater future orientation and more resistance to peer influence. The present results suggest that having more clarity about one's ethnic group membership was associated with more resistance to peer influence.

Resolution Development as a Mechanism

The main finding expands our current knowledge of ethnic identity resolution as a cultural asset. Having a clear sense about one's ethnic group membership (e.g., resolution) was associated with better resisting peer influences. This finding was supported in both White youth and youth of color, and to similar extents. Not only has resolution shown importance for distancing away from deviant peers (Derlan & Umaña-Taylor, 2015), but as evidenced in the present study, is also important for dealing with peers in general. One reason for this may be that youth with more ethnic identity resolution may cognitively appraise messages and perspectives from their peers in ways that resist shifting their perspective to go along with their peers and instead rely on their own perspectives. The conceptual overlaps between ethnic identity development, social reorientation, and identity-value models of decision-making are consistent with this finding. To reiterate, the social reorientation evident during adolescence is likely also implicated in the way youth are motivationally attuned to salient ethnic group interactions during ethnic identity development. This means that processes involved in negotiating the perspectives, ideas, and beliefs of salient social others may inform values, motivations, and priorities—facets of the self that may be at work when individuals decide whether to engage a particular behavior. In this manner, ethnic identity resolution development may function as a mechanism to support adjustment.

As others have previously reasoned, youth may be less suspectable to peers if they have a more internally directed decision-making orientation (e.g., Neblett et al., 2012). Youth with a positive sense of who they are may be better positioned to evaluate information from peers in light of their own values and priorities and determine whether to enact in peer-driven behaviors. One's ethnic identity could have implications for navigating one's social environment by promoting the adoption of positive influences (e.g., studying more) and rejecting negative ones (e.g., substance use experimentation).While previous studies have proposed that the reason youth avoid engaging in maladaptive behaviors like substance from peer influences is to preserve their sense of selves and maintain one's ethnic identity (Brook et al., 2010), the present study posits that identity developmental processes themselves may as a way serve to promote adjustment. Thus, it may be the case that having negotiated whether and how beliefs and perspectives of salient others matter for their own identity (e.g., ethnic identity development) may prepare youth to disregard social pressures to engage in deviant behaviors (e.g., resisting peer influences).

It is important to acknowledge that ethnic identity development was not associated with how youth think about, plan, and make decisions with the future in mind. Despite the fact that ethnic identity is a cultural asset in other ways, neither exploration nor resolution evinced a direct association with how individuals weigh decisions as was hypothesized. This was surprising given the conceptual overlaps between self-view and future orientation (Hoyle, & Sherrill, 2006) and the extent that cognitive, behavioral, and motivation processes involved in future orientation is thought to support adjustment (Jackman & MacPhee, 2017; Johnson et al., 2014). The null findings regarding future orientation may also suggest a limitation in the measure itself. Conceptually, it may be the case that ethnic identity development is more relevant to the aspects of future orientation that concern optimism and hopefulness toward the future as opposed to those concerning delayed gratification (Seginer, 2009).

Exploration and Resolution in Context

The goal of the present study was to evaluate the association between exploration and resolution, and future orientation and resistance to peer influences. In evaluating these associations in a diverse sample, we assessed measurement invariance between youth of color and their White counterparts. The current psychometric findings regarding exploration and resolution corroborate prior measurement invariance assessments. For example, it has been demonstrated that a reduced version of the ethnic identity scale, as similarly used in the present study, showed strong (scalar) measurement invariance across White, Latinx, East Asian, Black, South Asian, and Middle Eastern adult samples (Douglas & Umaña-Taylor, 2015). In a separate study, similar patterns were observed using the ethnic identity scale among White, Latinx, Black, and Asian adolescents, achieving metric invariance (Sladek et al., 2020).

Yet, recent calls have emphasized the importance of providing as much environmental information as possible to help interpret ethnically and racially salient measures such as ethnic-racial identity development (Syed et al., 2018). For example, accounting for school-and neighborhood-level information could help explain inter-group dynamics in ethnic-racially diverse samples. In the present study, our sample came from 12 school districts. Supplemental Table S2.1 shows the various demographic characteristics across these schools. It is important to highlight that the ethnic-racial diversity in most of these schools likely makes race and ethnicity salient not only for youth of color but also White youth. Thus, it was expected that White youth would also engage in ethnic identity development processes to a greater extent than if the majority of schools were predominantly White. Such contexts are important to consider as it may influence the way youth responds to ethnic identity development questions, and ultimately, for the kinds of processes examined in the present study. In the present study and as shown by others, although White youth responded to the ethnic identity measures in largely similar ways compared to youth of color, we do not know whether their responses are driven by similar experiences, motivations, or perspectives. Our interpretation of their responses is limited to the phrasing of items. For example, ethnic identity resolution items such as "I am clear about what my ethnicity means to me" indicate extent of clarity and we can infer that the respondent has given thought about their ethnic group membership, but we are limited in inferring the actual meaning they ascribe to their ethnic group membership.

While the present study focused on ethnic identity development (e.g., processes) specifically, ethnic identity content should also be considered for understanding the potential link between ethnic identity and future orientation as well as resistance to peer influence in studies with diverse youth samples. Ethnic identity content refers to the idea, beliefs, and perceptions about one's group as well as how one believes others view that group (Galliher et al., 2017). Ethnic identity content is likely to differ across ethnic-racial groups because of the social implications race and social stratification in the U.S. It remains an open question, too, whether the current national dialogue about racial issues will affect how the field of developmental science thinks about ethnic identity development (Marks et al., 2020; Martinez-Fuentes et al., 2020). For example, ethnic identity resolution may also involve an understanding of the current and socio-historical implications of their group membership. There may be developmentally grounded universal processes that reflect the extent and complexity that individuals think about issues of race, and hence group membership. However, these processes likely depend on experiences (both negative and positive, e.g., family cultural socialization and ethnic-racial discrimination) that are tied to group membership. The inherent link between ethnic identity resolution development and ethnic identity content may have implications for the way youth cognitively appraise social information and what they decide to do with this information.

Limitations and Future Directions

The White youth sample in the present study was larger than the youth of color sample, comprised of Black, Latinx, and Asian youth. A larger youth of color sample would have provided an opportunity to test the hypothesized among multiple ethnic and racial groups. This may help further address the extent and different ways that ethnic identity functions as a cultural asset among diverse youth. Drawing from contextual information, such as neighborhood and school level information, may help interpret salient ethnic-racial processes in a given sample (Syed et al., 2018). School demographics were reported; however, this information was not possible to include in the tested model. There were too few students represented in each school to determine whether the present findings were sensitive to school district. In addition, there was no public demographic information for one of the schools. As discussed above, there are limiting assumptions that come with school level demographic information such as assuming that diversity translates to inclusivity and inter-ethnic-racial group interactions (Syed et al., 2018). This may have implications for the hypothesized model as it was interested in peer interactions. Gathering more information about participants peers, such as peers' ethnic-racial background could have provided additional insight into how ethnic identity functions as a cultural asset. For example, future studies should ask whether the relations of ethnic identity resolution and resisting peer influence depend on the ethnic-racial composition of the individual's peer network. Finally, regarding limitations of the present sample, having a wider age range could help reveal whether the present finding is unique to late adolescence or manifest differently in earlier adolescence (Williams et al., 2020).

Future studies can also consider the extent to which alternative operationalizations of future orientation and resistance to peer influence capture aspects of social reorientation in ways that are more relevant to youths' ethnic identity development processes (Farrell et al., 2017; Seginer, 2009). The present study did not directly assess decision-making in social context, as is sometimes directly observed in experimental tasks with peers present. Instead, the measure of resistance to peer influence employed in the present study is an assessment of how youth cognitively appraise social information and whether or not they are inclined to adopt the same perspective of their peers or retain their own point of view (Steinberg, & Monahan, 2007). Establishing a link between ethnic identity and youths' appraisal of peer messages is an important step to effectively evaluate how ethnic identity is involved in behaviors, such as studying or risk-taking, that may be driven by peers. Future studies should examine whether the link between ethnic identity and cognitive appraisal of peer influences actually have direct implications on youths' behaviors.

Conclusion

The study findings support a potential mechanism for adolescents' adjustment that involves ethnic identity resolution. We found that developing clarity about what it means to belong to one's ethnic group may be mechanism that supports youth to resist peer influences in ways that could potentially result in positive adjustment. Youths' ethnic identity developmental processes, however, were not linked with how they think, plan, and weigh decisions with the future in mind (i.e., future orientation). A sense of identity, connection, or belongingness to salient social groups fulfills a basic need for belonging and thus serves an adaptive role. Ethnic group connections allow individuals to develop within a social system characterized by goals, values, and practices that inform their social identities which may inform how they navigate their environments. This study demonstrates how a social reorientation lens could be used to help make sense of how ethnic connections may translate into positive adjustment.

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Table 2.1

Means, Standard Deviation, and Correlations of Key Variables

		M (*SD*)	1	2	3	4
1.	Exploration	2.31 (.79)	-			
2.	Resolution	2.64 (.89)	.60***	-		
3.	Resistance to Peer Influence	3.01 (.56)	.13***	.19***	-	
4.	Future Orientation	3.06 (.47)	.10**	.11**	.24***	-

Note. N = 828. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 2.2

Multigroup Measurement Invariance Assessment of Ethnic Identity Exploration and Resolution

Model	CFI	TLI	χ^2 (df)	Model Comparison	$\Delta\chi^2$ (Δdf)
M1. Configural	.993	.902	247.041 (49)	-	-
M2. Metric	.933	.912	282.226 (55)	M1 vs M2	8.185 (6), $p = .225$
M3. Scalar	.925	.913	313.278 (62)	M2 vs M3	31.052 (7), $p < .001$

Table 2.3

Multigroup Path Model Fit Summaries

Model	CFI	TLI	RMSEA (CI 90%)	SRMR	χ^2 (df)
M1. Single Group	.947	.931	.06 (.05, .07)	.04	317.366 (80), $p < .001$
M2. Multi-Group	.921	.904	.07 (.06, .07)	.06	477.044 (171), $p < .001$
M3. Multi-Group Constrained	.921	.906	.07 (.06, .07)	.06	482.746 (175), $p < .001$
M3 vs. M2	-	-	-	-	5.702 (4), $p =.223$

Note. M1. Single Group N = 828. M2 and M3, Multigroup; White youth N = 568, youth of color N = 260.

Table 2.4

Factor loadings for latent variables in Single and Multigroup models

	Single Group			Multigroup		
	Exploration *b* (SE)	Resolution *b* (SE)	Future Orientation *b* (SE)	Exploration *b* (SE)	Resolution *b* (SE)	Future Orientation *b* (SE)
EIS 2	1.00 (.00)	-	-	1.00 (.00)	-	-
EIS 4	1.93 (.23)	-	-	2.11 (.30)	-	-
EIS 5	2.45 (.27)	-	-	2.55 (.34)	-	-
EIS6	2.44 (.27)	-	-	2.75 (.37)	-	-
EIS 8	2.34 (.26)	-	-	2.61 (.35)	-	-
EIS 11	2.20 (.25)	-	-	2.34 (.32)	-	-
EIS 3	-	1.00 (.00)	-	-	1.00 (.00)	-
EIS 12	-	0.84 (.05)	-	-	0.84 (.06)	-
EIS 17	-	1.00 (.05)	-	-	1.02 (.06)	-
Planning	-	-	1.00 (.00)	-	-	1.00 (.00)
Time	-	-	0.94 (.09)	-	-	0.98 (.09)
Anticipation	-	-	1.19 (.12)	-	-	1.21 (.12)

Note. Unstandardized beta coefficients and standardized errors are shown.

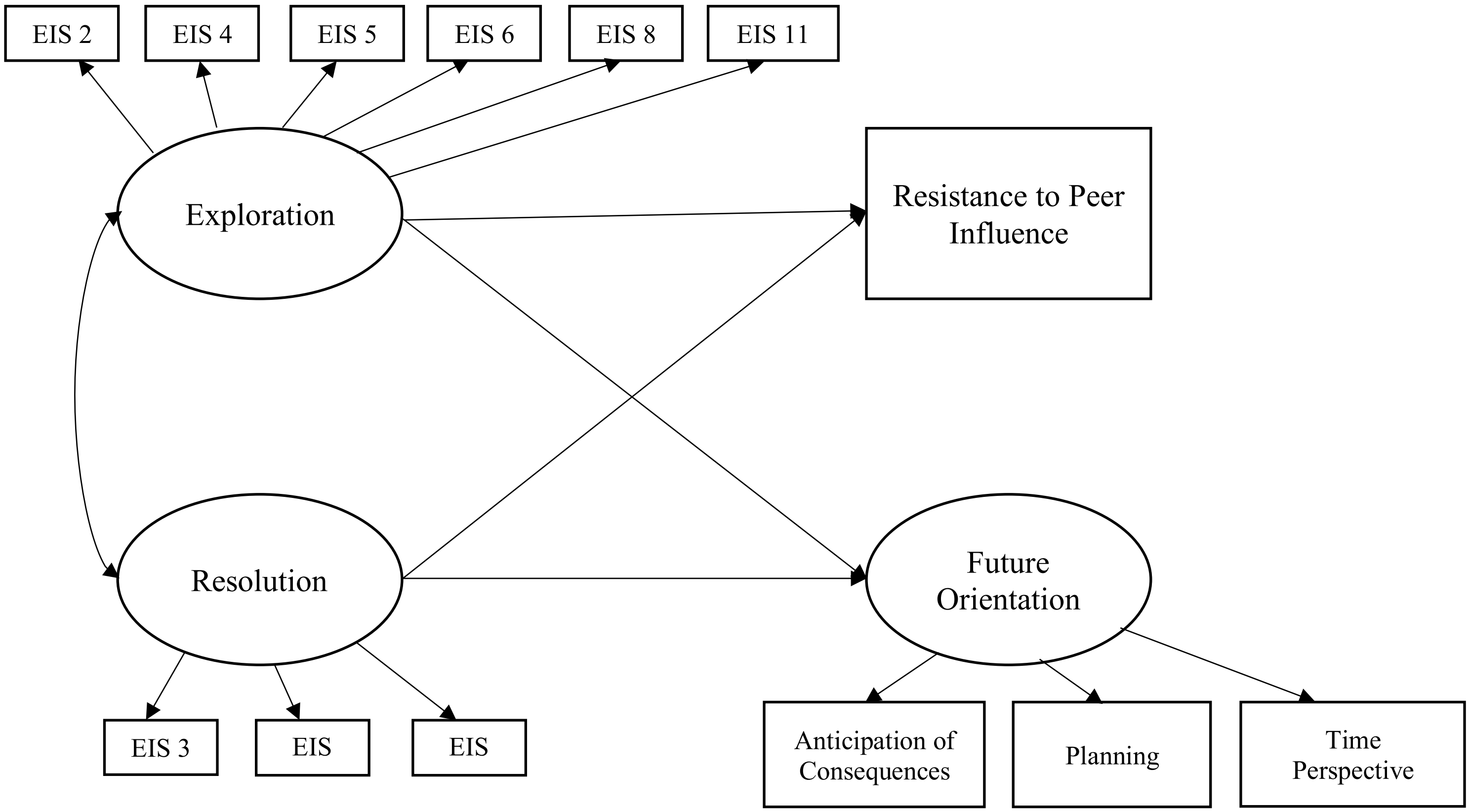

Figure 2.1. Hypothesized Path Model

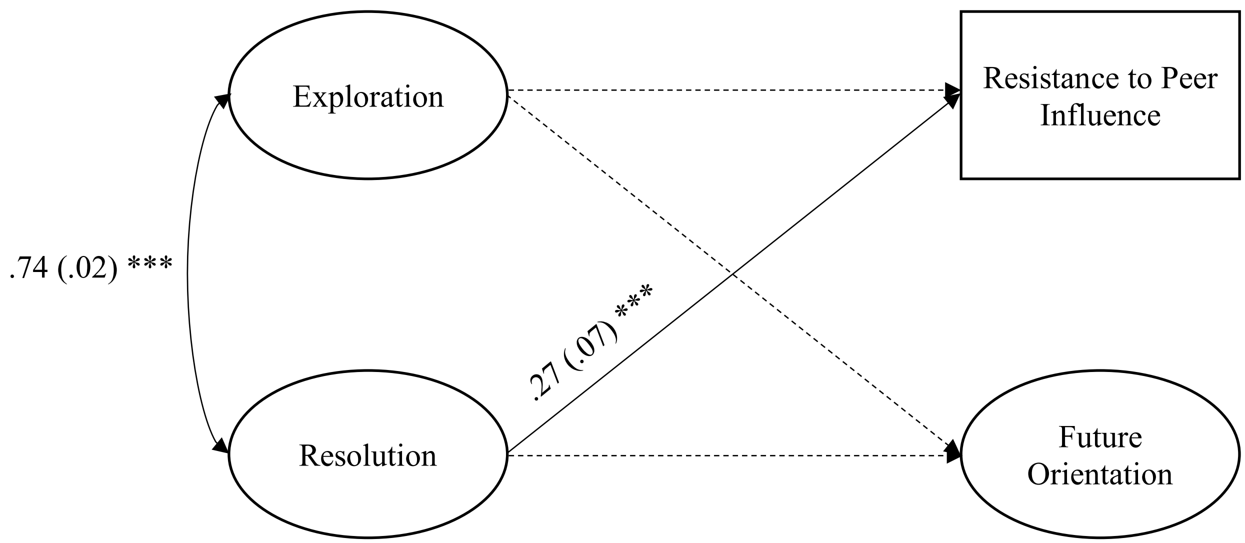

Figure 2.2. Single group path model of the associations of ethnic identity exploration and resolution with resistance to peer influence and future orientation. Standardized beta estimates and standard errors are shown. Covariates include age and sex. Model fit indices shown in Table 2.3 (M2). Factor loadings of latent variables are presented in Table 2.4. *$p < .05$. **$p < .01$. ***$p < .001$.

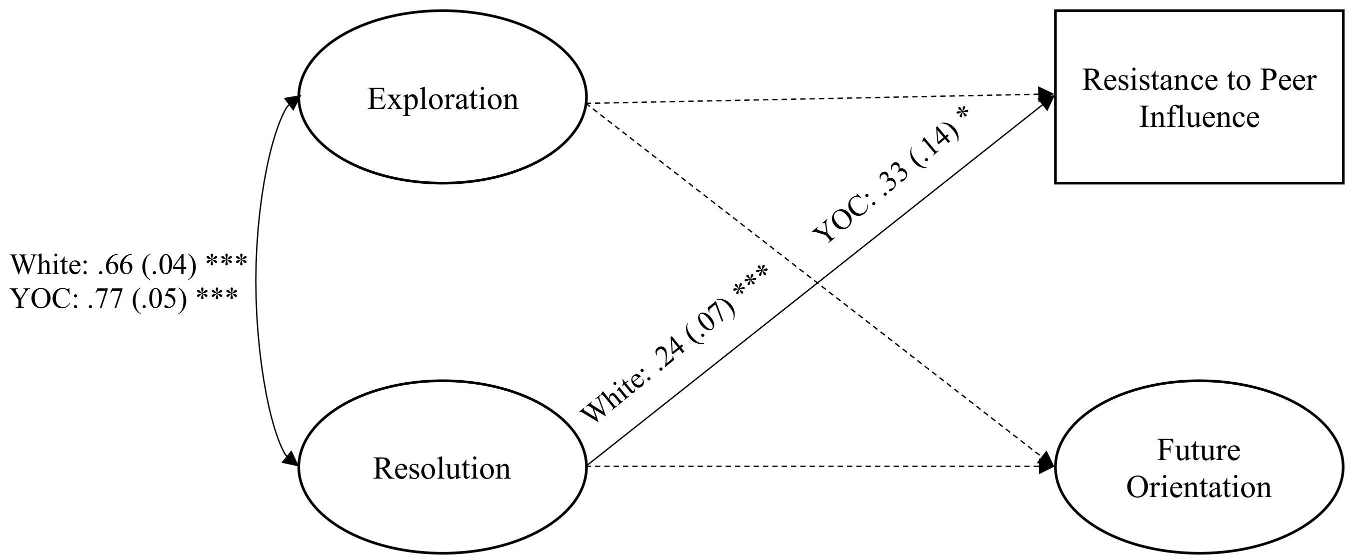

Figure 2.3. Multigroup path model of the associations of ethnic identity exploration and resolution with resistance to peer influence and future orientation. Standardized beta estimates and standard errors are shown White youth and youth of color (YOC). Covariates include age and sex. Model fit indices shown in Table 2.3 (M2). Factor loadings of latent variables are presented in Table 2.4. $^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table S2.1

School Gender and Race-Ethnicity Composition

School	% Female	% American Indian	% Asian	% African American	% Hispanic	% Hawaiian	% White	% Two or More Races
1	53.11	0.59	1.88	4.35	29.61	0.24	58.28	5.05
2	49.84	0.24	0.32	8.01	2.16	0	88.94	0.32
3	50.20	0.23	1.49	37.29	5.24	0.08	53.09	2.58
4	47.54	0.27	0.27	1.09	3.01	0	94.26	1.09
5	49.17	0.23	4.15	1.76	2.05	0.23	90.04	1.54
6	50.14	0.34	1.35	46.47	2.09	0.11	48.05	1.58
7	49.94	0.18	9.53	28.82	1.94	0.12	57	2.41
8	52.35	0	0.23	0.47	1.17	0.23	94.37	3.52
9	48.36	0.58	1.16	75.53	6.74	0.58	13.29	2.12
10	40.00	0	1.38	57.24	8.28	0	31.72	1.38
11	-	-	-	-	-	-	-	-
12	46.50	0	0.32	59.55	7.96	0	27.07	5.10

Note. School demographic information were retrieved from the State of Michigan Department of Education. School # 11 is a private school.

Table S2.2.

Ethnic Identity Scale items

Item	Description
Exploration	
1. (eis2r)	I have not participated in any activities that would teach me about my ethnicity.
2. (eis4)	I have experienced things that reflect my ethnicity, such as eating food, listening to music, and watching movies.
3. (eis5)	I have attended events that have helped me learn more about my ethnicity.
4. (eis6)	I have read books/magazines/newspaper or other material that have taught me about my ethnicity.
5. (eis8)	I have participated in activities that have exposed me to my ethnicity.
6. (eis11)	I have learned about my ethnicity by doing things such as reading (books, magazines, newspaper), searching the internet, or keeping up with current events.
7. (eis15)	I have participated in activities that have taught me about my ethnicity.
Resolution	
8. (eis3)	I am clear about what my ethnicity means to me.
9. (eis12)	I understand how I feel about my ethnicity.
10. (eis14)	I know what my ethnicity means to me.
11. (eis17)	I have a clear sense of what my ethnicity means to me.

Note: Item 2 is reverse coded.

Table S2.3

Resistance to Peer Influence Scale items

1.	Some people go along with their go along with their friends just to keep their friends happy.	Other people refuse to go along with what their friends want to do, even though they know it will make their friends unhappy.
2.	Some people think it's more important to be an individual than to fit in with the crowd.	Other people think it's more important to fit in with the crowd than to stand out as an individual
3.	For some people, it's pretty easy for their friends to get them to change their mind.	For other people, it's pretty hard for their friends to get them to change their mind.
4.	Some people would do something that they knew was wrong just to stay on their friends' good side.	Other people would not do something that they knew was wrong just to stay on their friends' good side.
5.	Some people hide their true opinion from their friends if they think their friends will make fun of them because of it.	Other people will say their true opinion in front of their friends, even if they know their friends will make fun of them because of it.
6.	Some people will not break the law just because their friends say they would.	Other people would break the law if their friends say they would break it.
7	Some people change the way they act so much when they are with their friends that they wonder who they "really are".	Other people act the same way when they are alone as they do when they are with their friends
8.	Some people take more risks when they are with their friends than they do when they are alone.	Other people act just as risky when they are alone as when they are with their friends.

9.	Some people say things they don't really believe because they think it will make their friends respect them more.	Other people would not say things they didn't really believe just to get their friends to respect them more.
10.	Some people think it's better to be an individual even if people will be angry at you for going against the crowd.	Other people think it's better to go along with the crowd than make people angry at you.

Table S2.4

Future Orientation Scale items

Planning		
1.	Some people like to plan things out one step at a time	Other people like to jump right into things without planning them out beforehand
2.	Some people are always making lists of things to do	Other people find making lists of things to do a waste of time
3.	Some people make decisions and then act without making a plan	Other people usually make plans before going ahead with their decisions
4.	Some people think that planning things out in advance is a waste of time	Other people think that things work out better if they are planned out in advance
5.	Some people like to take big projects and break them down into small steps before starting to work on them	Other people find that breaking big projects down into small steps isn't really necessary
Time Perspective		
6.	Some people spend very little time thinking about how things might be in the future	Other people spend a lot of time thinking about how things might be in the future
7.	Some people would rather be happy today than take their chances on what might happen in the future	Other people will give up their happiness now so that they can get what they want in the future
8.	Some people would rather save their money for a rainy day than spend it right away on something fun	Other people would rather spend their money right away on something fun than save it for a rainy day
9.	Some people often think that life will be like 10 years from now	Other people don't even try to imagine what their life will be like in 10 years
10	Some people take life one day at a time without worrying about the future	Other people are always thinking about what tomorrow will bring
Anticipation of Consequences		
11.	Some people like to think about all of the possible good and bad things that can happen before making a decision	Other people don't think it's necessary to think about every little possibility before making a decision
12.	Some people usually think about the consequences before they do something	Other people just act – they don't waste time thinking about the consequences

13.	Some people have trouble imagining how things might play out over time	Other people are usually pretty good at seeing in advance how one thing can lead to another
14.	Some people don't spend much time worrying about how their decisions will affect others	Other people link a lot about how their decisions will affect others
15.	Some people think it's better to run through all the possible outcomes of a decision in your mind before deciding what to do	Other people think it's better to make up your mind without worrying about things you can't predict

Note: Items 1, 2, 8, 9, 10, 11, and 12 are reverse-coded.

Table S2.5

Means, Standard Deviation, Correlation for White youth and youth of color

	M (SD)	Exploration	Resolution	Resistance to Peer Influence	Future Orientation
Youth of Color					
Exploration	2.85 (.77)	-			
Resolution	3.04 (.79)	.58***	-		
Resistance to Peer Influence	3.09 (.61)	.18**	-.05	-	
Future Orientation	3.08 (.45)	.15*	-.09	.36***	-
White Youth					
Exploration	2.07 (.67)	-			
Resolution	2.45 (.87)	.53***	-		
Resistance to Peer Influence	2.97 (.54)	.04	.01	-	
Future Orientation	3.06 (.48)	.07	-.06	.18***	-

**p* < .05. ***p* < .01. ****p* < .001

Chapter III

Study 2: Personalized neural networks underlie ethnic identity exploration and resolution

Introduction

Ethnic identity refers to one's sense of self regarding one's ethnic/racial group connection. Youth who feel connected to their ethnic group enjoy better psychosocial adjustment, benefit in their academic outcomes, and engage in fewer health compromising behaviors such as substance use (Rivas-Drake et al., 2014; Umaña-Taylor et al., 2018). The integrative model for developmental competencies (Coll et al., 1996) has been a prominent guiding framework describing the different ways in which ethnic group connections benefit youth adjustment (Perez-Brena et al., 2018). However, the potential mechanisms underlying youth ethnic identity development – and potentially contributing to adaptive adjustment – are largely unknown, perhaps because developmental frameworks centered in sociocultural contexts, specifically regarding ethnic identity development, have rarely been considered with respect to neurodevelopmental frameworks (Qu & Telzer, 2018).

Indeed, it is currently unclear how ethnic identity is reflected in the brain, let alone in novel investigations of the *functional organization* of the brain that underlies (mal)adaptive behaviors. Functional organization refers to synchronous activity among brain regions (or networks) implicated in basic and complex human cognitive, behavioral, social, and affective processes (Power et al., 2011; van den Heuvel & Pol, 2010)[1]. It has also become increasingly

[1] For more details on resting-state fMRI, see Appendix A

clear that social interactions are similarly supported by synchronous activity among brain network regions (Feng et al., 2021). Revealing the ways in which these large-scale brain networks undergird psychological processes linked to ethnic identity will not only begin to define the role of the brain in adaptive behaviors evident when youth have positive connections to their ethnic group, but it will also help consider the role of ethnicity and identity in future neuroscience research, and vice-versa in developmental science research. Accordingly, the goal of the present study is to integrate social neuroscience and methodological advances in person-specific neural network mapping with the study of ethnic identity development.

Ethnic Identity Development and Adolescent Social Reorientation

To help conceptualize ways that ethnic identity developmental processes are reflected in the brain, the current work draws on multiple frameworks that emphasize development in sociocultural context, social neuroscience, and identity. A social neuroscience perspective of adolescence posits that there is heightened neural sensitivity to social environmental cues during this period, which is thought to underlie social reorientation and support exploring and gaining experiences that inform identity development (Dahl, 2016; Galván & Tottenham, 2016; Pfeifer & Peake, 2012; Steinberg, 2008; Telzer, 2016; Telzer et al., 2018). This perspective is consistent with two different theories of identity development and identity-informed behaviors. For instance, the same social neuroscience perspective of social reorientation (sensitivity to social environmental cues and salient social others like peers and parents) may also explain the way interactions with ethnic group members support identity development. Current knowledge of ethnic identity developmental processes directly coheres with this social reorientation perspective (Umaña-Taylor et al., 2004; Umaña-Taylor et al., 2014). Ethnic identity exploration refers to gaining knowledge about one's ethnicity, and ethnic identity resolution refers to having clarity about what it means to belong to one's ethnicity. During adolescence in particular, youth interpret their ethnic group interactions with increased complexity and also negotiate the views and perspectives of ethnic group members to develop their own sense of self (Quintana et al., 1999). A fundamental process of formulating one's identity concerns integrating the perspective of others with one's own to create a unique sense of self (see e.g., Rivas-Drake et al, 2017 for how this may occur with peers). The social and motivational saliency that youth attribute to ethnic group member interactions is, in turn, likely supported by neural processes implicated in self-reflections and social cognition (Pfeifer & Berkman, 2018; Welborn et al., 2018). Mentalizing, or thinking about the thoughts and perspectives of others, is an important aspect of identity development, consistent with social neuroscience perspectives on adolescent social reorientation (Pfeifer & Peake, 2012).

The social neuroscience perspective of adolescence also aligns with the identity-value model of decision-making which emphasizes that the self is integral in how one interacts with one's environment (Berkman et al., 2017; Pfeifer & Berkman, 2018). This framework acknowledges that different aspects of one's identity, including social identities, may contribute to the values and motivations that underlie behaviors. Of the pieces of information that contribute to making decisions, engaging in a particular behavior may be valued more when it is relevant to one's identity (Oyserman, 2007). Ethnic group connections may inform values and motivations over time and may contribute to behavior in numerous contexts. The identity-value model helps to link ethnic identity with thought and behavior and facilitates the consideration of aspects of the brain's functional organization (i.e., networks) that may reflect this relationship.

Integrating social neuroscience and identity development frameworks reveals brain networks that likely underlie self-reflection, social cognition, and cognitive control: The default mode and frontoparietal networks are potential candidate networks implicated in ethnic identity development. Furthermore, these frameworks do not diverge from, but actually converge with the integrative model of developmental competencies that emphasizes the role of ethnic group connection in adjustment; however, weaving these various perspectives together illuminates potential mechanisms to help explain how ethnic group connection may translate to behavioral adjustment.

Resting State Networks Underlying Adolescent Social Reorientation

Adolescent social reorientation is supported by several brain networks. Many of these networks are studied during the resting state because synchronous brain activity during an idle state can capture how network connections have been exercised, and hence, shaped and organized (Liégeois et al., 2017). The default mode network, and the mentalizing subnetwork in particular, is likely involved in the study of social identity processes because this network is thought to be involved in instances of social affiliation and interactions (Spreng & Andrews-Hanna, 2015). The default mode network (which typically includes anterior medial prefrontal cortex and posterior cingulate cortex) is involved in internal mentation and is often implicated in self-generated or self-referential thinking, such as past-future autobiographical thinking, episodic memory, self-evaluation, as well as social cognition and mentalizing (Andrews-Hanna et al., 2010; Buckner & DiNicola, 2019). The mentalizing subnetwork (which consists of the dorsal medial prefrontal cortex, temporal parietal junction, lateral temporal cortex, and temporal pole) is thought to be involved in perspective-taking, social cognition, and theory of mind (Spreng & Andrews-Hanna, 2015), whereas the core default mode system is thought to be involved in self-evaluation and self-related processes (Barrett & Satpute, 2013). A domain-general view of the default mode network suggests that remembering, thinking about the future, and taking another person's perspective, all depend on the ability to draw on stored experiences to create meaningful mental moments in the present (Barret & Satpute, 2013). This domain-general view of the default mode network aligns well with current knowledge of ethnic identity development processes, such as exploration and resolution development.

Further indication of the relations between default mode network and ethnic identity come from a meta-analysis of the brain's role in human social interactions (Feng et al., 2021). Studies that examined the neural correlates of social interactions, social norms, and social norm violation consistently point to a set of brain regions that reflect social cognition, motivation and cognitive control. In fact, the intrinsic activity among these regions was examined to identify the neurobiological system linked to the processing of common social interactions, and the system mapped onto the default mode network as well as the salience and cognitive control networks (Feng et al., 2021). Despite the known role of large-scale networks in social interactions, the specific role of ethnic group social interactions is sorely under-studied. Ethnic identity reflects how social ties contribute to one's sense of self, implicating brain networks involved in self-referential thinking and social cognition such as the default mode network.

The frontoparietal network is also important for understanding the neural basis of adolescent social reorientation. It is integral to facilitating communication across networks and helps support everyday functionality because it is a set of brain regions involved in actively (dis)engaging other networks to facilitate cognitive tasks. Brain regions that make up the frontoparietal network, such as the dorsolateral prefrontal cortex, frontal cortex, and inferior parietal lobe, are thought to underlie cognitive control and decision-making (Campbell et al., 2012; Scolari et al., 2015). The frontoparietal network can be viewed as a functional hub that balances activity between the default mode network (processing internal world) and the attentional network (processing external world) (Vincent et al., 2008). In addition, the frontoparietal network is structurally interspaced amid the default mode network (Spreng et al., 2013; Vincent et al., 2008), that is, within the prefrontal and parietal lobe. The frontoparietal network and the default mode network have been shown to coactivate during planning and goal-directed cognition (Gerlach et al., 2014; Spreng et al., 2010; Utevsky et al., 2016), such that strong functional interconnections between the networks result in better planning capability than do weak functional interconnections between the networks.

The Study of Ethnic Identity in the Brain

Ethnic identity development captures, through social ties and connections, identification with an ethnic group comprised of people who share cultural features. When considering the brain in this process, the aim is not to compare differences in brain function of people from different cultures (Qu & Telzer, 2018; Seligman et al., 2016). Ethnic identity can be informed by cultural experiences but does not necessarily reflect the embodiment of a cultural self (e.g., how behavioral norms are ingrained), and so, culture and ethnicity should not be equated. The key distinction is the identification and sense of understanding of belonging to one's ethnic group, not endorsement of cultural norms. This distinction is particularly important for studying populations comprised of diverse ethnic groups, such as in the U.S, where each person may develop connections to their ethnic group in distinct ways. Therefore, studying ethnic identity processes and the brain requires methodological approaches that acknowledge heterogeneity in such psychological processes and the brain function that underlies them.

Group iterative multiple model estimation (GIMME; Gates & Molenaar, 2012) is a person-specific network mapping approach that assumes such heterogeneity, and thus, is well-suited to the examination of the neural underpinnings of identity-linked default mode and frontoparietal resting state networks. The modeling capabilities of GIMME allow it to capture the heterogeneity as well as potential homogeneity of the brain's functional organization (e.g., Beltz et al., 2016). This is a critical advantage over traditional neuroimaging analytic approaches that average brain activity across individuals and potentially lose meaningful heterogeneity (i.e., person-specific information) about the brain that may be relevant to the psychological processes of interest (Molenaar, 2004; e.g., Beltz et al., 2018). GIMME is data-driven and uses an iterative process to estimate connections among multiple brain regions based on individual and group-level patterns of brain activity (Gates & Molenaar, 2012). The connections can be contemporaneous (occurring at the same functional volume) or lagged (occurring from one functional volume to the next). In addition, GIMME has been shown to produce fewer spurious connections and to have greater specificity compared to other network mapping approaches (Gates & Molenaar, 2012)[2,3].

The Current Study

The default mode and the frontoparietal networks are brain networks associated with adolescent social reorientation that may also underlie ethnic identity development processes, such as exploring, participating, and learning about one's ethnicity and developing a sense of clarity about what it means to belong to one's ethnic group. Youth ethnic identity development processes (e.g., exploration and resolution) may be associated with brain networks that govern self-referential thinking and mentalizing, such as the default mode network and mentalizing subsystem. As a way to examine how ethnic identity supports behavioral adjustment, the current study focuses on connectivity within and between the default mode and frontoparietal networks

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[2] For more information about GIMME, see Appendix C.

[3] For more information about how GIMME is estimated, see Appendix D.

at rest in individual youth and examines how they are related to ethnic identity development exploration and resolution. We accomplished this using the GIMME person-specific modeling framework that reflected potential heterogeneity and homogeneity in the functional organization of the brain that may be relevant for the complex, multi-dimensional, and unique ways youth develop their ethnic identities (e.g., Beltz et al., 2016; Beltz et al., 2018). Brain network organization revealed by GIMME, such as network density (number of connections within- and between-networks; Beltz & Gates, 2017), was examined in relation to ethnic identity to reveal whether connectivity within a self-reflective network or a cognitive control network (or between them) was stronger or weaker for youth with greater exploration or resolution. It was hypothesized that greater network density within the default mode network would be associated with greater ethnic identity exploration and resolution. It was also hypothesized that greater network density between the default mode and frontoparietal network would be associated with greater ethnic identity exploration and resolution.

Exploratory analyses were considered given the literature on the saliency of ethnic identity development among ethnic and racial minority status youth (e.g., youth of color). Ethnic identity exploration and resolution have been observed in White youth and these measures have demonstrated similar psychometric properties among White youth compared to youth of color (Sladek et al., 2020). However, from a phenomenological perspective, these processes may look qualitatively different for White youth and youth of color (Martinez-Fuentes et al., 2020). Therefore, we evaluated whether relations among network densities and ethnic identity exploration and resolution differed between White youth and youth of color.

Method

A subsample of the participants from the Adolescent Health Risk Behavior (AHRB) study (N=2017) were invited to participate in neuroimaging. Of the 108 youth who participated in neuroimaging, 104 (M_{age} = 19.28, *SD* = 1.31; 61 females) were included in these analyses. Three participants were excluded due to preprocessing issues (e.g., brain activity signal distorted), and one participant was excluded because of excessive motion. Seventy-four participants were White and 30 were youth of color, comprised of Black, Latinx, Asian, and mixed race-ethnicity youth. Parental education level was reported by youth and used as a proxy for socioeconomic status, ranging from 1 (*Completed grade school or less*) to 6 (*Completed graduate or professional school after college*) (*M* = 4.32, *SD* = 1.16). The neuroimaging sample did not differ from the parent AHRB sample with respect to demographic variables except for race-ethnicity, with the parent sample having a higher proportion of youth of color (45%) than the neuroimaging sample (30%) (see Supplemental Table S3.1).

Procedures

Consistent with the aims of the parent AHRB study, participants were recruited into the neuroimaging subsample based on their health risk behaviors, aiming to have a distribution of youth who displayed typical versus more frequent levels of health risks (see Demidenko et al., 2020 for a detailed description). In addition, participants were recruited on the basis of sex (58% female) and race-ethnicity (70% White, 30% youth of color), aiming to have equal proportions of males and females and significant racial-ethnic diversity.

Recruited participants were contacted and screened for MRI eligibility (e.g., hazardous metals in bodies). Eligible participants were scheduled for a scan session approximately a week after they provided in-person informed consent or assent with parental consent (if under age 18). While in the scanner, structural brain images, resting state brain activity, diffusion tensor brain images, and brain activity during two behavioral tasks were acquired. Neuroimaging sessions were one hour long, and participants were compensated up to $140 for the entire visit. Procedures of the AHRB study were approved by the University of Michigan Institutional Review Board (IRB) (IRBMED Approval #: HUM00097653; PI: Daniel P. Keating, Ph.D.).

Either the day before or the day of the scan, participants also completed a brief survey that contained the ethnic identity measures reported here. For twenty-two subjects who did not provide information about their ethnic identity exploration and resolution during the neuroimaging portion, this information was imputed from the same measures administered during the parent study. There was an average of 7.4 months (SD = 2.7) between the larger study survey and MRI scan for 20 of the 22 participants. Ethnic identity exploration and resolution scores from these 20 youth did not differ from the scores of youth who completed the measures at the time of the scan; exploration, $t(100) = 1.06$, $p = .29$; resolution, $t(100) = 1.67$, $p = .09$, nor did the youth differ on main demographic variables (see Supplemental Table S3.2).

Resting State fMRI Data Acquisition. Resting state fMRI data was acquired using a GE Discovery MR750 3.0 Tesla scanner with a standard adult-sized coil (Milwaukee, WI). During the resting state scan, participants laid in the scanner for 8 minutes with their eyes open and fixated on a cross hair '+' displayed on a presentation screen. Functional T2*-weighted BOLD images were acquired using a multiband EPI sequence (MB factor=6) of 60 contiguous axial 2.4 x 2.4 x 2.4 mm slices (TR = 800ms, TE = 30ms, flip angle = 52°, FOV = 21.6 cm, 90x90 matrix). For preprocessing, a high resolution T1-weighted anatomical (SPGR PROMO) was also acquired (TR = 7.0s, TE = 2.9s, flip angle = 8°, Field of View (FOV) = 25.6 cm, slice thickness = 1 x 1 x 1mm, 208 sagittal slices; matrix = 256 x 256). Slices in the functional and structural sequences were prescribed in the same locations.

Preprocessing. As described in Circ et al. (2017), fMRI data were reconstructed, realignment and fieldmap correction was applied in SPM12 to each T2* run to recover inhomogeneity of signal in the B0 field, and physiological noise was removed using RETROICOR (Glover, Li, & Ress, 2000). FMRI data processing was carried out using FEAT (FMRI Expert Analysis Tool) Version 6.00, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). The first eight volumes were deleted to get a more stable neural signal. Resting state functional images were then aligned onto each participant's anatomical structural image and registered onto standard MNI space using FLIRT (Jenkinson & Smith, 2001; Jenkinson, Bannister, Brady, & Smith, 2002). Data were realigned for head movement using 6 parameter frame-wise displacement (MCFLIRT; Jenkinson, Bannister, Brady, & Smith, 2002) and were spatially smoothed using a Gaussian kernel of FWHM 5mm. FSL brain extraction tool was used to extract the brain from the skull using BET (Smith 2002). Grand mean intensity normalization of the entire 4D dataset was done by single multiplicative factor.

Additional preprocessing steps were applied in order to remove motion, white matter, and cerebral spinal fluid tissue related artifacts, which are known to introduce noise and potentially bias resting state fMRI analysis (Circ et al., 2017; Satterthwaite et al., 2013). Steps were similar to Goetschius et al. (2020) for preparing resting state data for GIMME (Beltz et al., 2019). Independent components analysis-automatic removal of motion artifact (ICA-AROMA) was used to detect and regress out motion-related artifacts using FSL (Pruim et al., 2015). White matter (WM) and cerebral spinal fluid (CSF) masks were created and used to regress out tissue related artifacts from the ICA-AROMA denoised functional subject specific data through nuisance regression (Caballero-Goudes & Reynolds, 2017). A high pass-temporal filter of 100

Hz was applied to the resting state fMRI data. Frame-wise displacement values for each participant were calculated before and after motion artifact denoising.

Measures

ROI Time Series Extraction. Functional BOLD timeseries were extracted from 17 ROIs comprising the default mode and frontoparietal networks that were defined *a priori*. The ROIs and their central coordinates are listed in Table 3.1. ROIs in the default mode, and its sub mentalizing network, were taken from previous work (Andrews-Hanna et al., 2010). ROIs in the frontoparietal network were determined using the Power Atlas due to its reliable and widely-used detection of this network at rest (Power et al., 2011). Spheres with 10mm diameters were created around the central coordinate of each ROI, and then the mean BOLD signal of each ROI sphere (at each of 592 functional volumes) was extracted for each participant. These ROI timeseries were down-sampled to every other volume (296 total time points) to reduce the high temporal resolution of the multiband data, and thus, to increase power to detect cross-ROI relations characterizing connectivity within- and between-networks (e.g., Beltz & Gates, 2017; Sate et al., 2010).

Ethnic identity. The Ethnic Identity Scale (Umaña-Taylor et al., 2004) includes two subscales: exploration (e.g., "I have experienced things that reflect my ethnicity, such as eating food, listening to music, and watching movies;" 7 items; α = .85) and resolution (e.g., "I have a clear sense of what my ethnicity means to me"; 4 items; α = .85). Participants indicated their endorsement of the 11 statements on a scale from 1 (*Does not describe me at all*) to 4 (*Describes me very well*). Items of each subscale were averaged to calculate mean scores, such that higher values indicated more exploration and resolution, respectively. Among the whole sample, ethnic identity exploration (*M* = 2.28, *SD* = .85) and resolution (*M* = 2.64, *SD* = .87) were positively correlated with each other, $r(100) = .62$, $p < .001$).

Analysis Plan

ROI timeseries for each individual were entered into GIMME analyses (Gates & Molenaar, 2012) using the *gimme* package in R studio (v. 1.2.5033). In order to estimate personalized networks, GIMME begins with a "null" model that only includes autoregressive ROI connections (i.e., estimates of how much each ROI predicts itself at the next functional volume) because this is shown to improve the recovery of connections in temporally dense data (Lane et al., 2019), such as resting state fMRI. Group-level contemporaneous (i.e., same volume) or lagged (i.e., next volume) directed connections that would significantly improve network fit for the majority of participants in the sample (>75%) according to Lagrange Multiplier equivalents tests (i.e., modification indices; Sörbom, 1989) are then iteratively added to each individual's network. When no more connections would improve network fit for the majority of the sample, individual-level contemporaneous or lagged directed connections that would significantly improve network fit for an individual participant according to Lagrange Multiplier equivalents tests are then iteratively added until the network fits each participants data well. Excellent model fit is determined by meeting two of four criteria: RMSEA $\leq .05$, SRMR $\leq .05$, CFI $\geq .95$, and NNFI $\geq .95$. Thus, final person-specific models are sparse -- containing autoregressive connections as well as statistically meaningful connections that were estimated for everyone in the sample and that were estimated just for an individual; all connections have a person-specific direction (positive or negative) and magnitude. Details of model fitting and identification are described in Beltz and Gates (2017), Gates and Molenaar (2012), and Lane and Gates (2017).

Network densities were calculated from the final person-specific GIMME models in order to characterize heterogenous resting state brain function to be linked to ethnic identity. Specifically, density was calculated for each participant by dividing the number of connections within and between their default mode and frontoparietal networks by the total number of connections in their GIMME model, reflecting the extent to which connections among ROIs that constitute the default mode, for instance, contribute to the overall network function (Beltz & Gates, 2017).

These network densities were used in hierarchical linear regressions to examine associations with ethnic identity exploration and resolution. For all regressions, post-analysis framewise displacement (calculated after motion denoising) and age were covariates entered in Step 1, and exploration and resolution were entered in Step 2. Network densities (either within or between default mode and frontoparietal) were outcomes in separate models. Type I error was .05. In the exploratory analyses, youth of color status (0 = White and 1 = youth of color) and its interaction with exploration and resolution were entered as Step 3 into the primary study models.

Results

All 104 personalized GIMME models converged. Average model fit indices across all participants suggest that the networks fit the data well: RMSEA = .053 (*SD* = .005), SRMR = .045 (*SD* =.004), CFI = .949 (*SD* = .004), and NNFI = .923 (*SD* = .006). See Supplemental Table S3.3 for model fit indices for each participant.

Figure 3.1 is a visual summary of all personalized networks. Solid lines depict contemporaneous connections, and dashed lines depict lagged connections. Bold lines represent connections that were estimated for everyone in the sample (i.e., group-level connections), and gray lines depict connections that were uniquely estimated for individuals (i.e., individual-level connections). Beyond the autoregressive connection, only one data-driven group-level connection between the left Inferior Parietal Lobe and the left Temporal Parietal Junction was present. The presence of this connection is not surprising because the two brain regions are spatially close. The small number of group-level connections indicates that there is substantial heterogeneity (reflected by variation in the presence and magnitude of individual-level connections) in resting state brain network connectivity across participants.

To illustrate the heterogeneity in brain connectivity across individuals, examples of two participants' networks are depicted in Figure 3.2a and Figure 3.2b. Again, solid lines depict contemporaneous connections, and dashed lines depict lagged connections. Each connection has a corresponding beta weight reflected by line thickness, and red lines indicate positive connections and blue lines indicate negative connections. These participants clearly have diverse networks. The personalized network depicted on the left (Figure 3.2a) is relatively dense, with more negative contemporaneous connections compared to the personalized network depicted on the right (Figure 3.2b). To help characterize how personalized networks are organized, network densities were calculated. For example, the personalized network depicted on the left has about 32% of their brain network comprised of within default mode connections and 32% comprised of within frontoparietal connections. The personalized network depicted on the right has about 26% of their brain network comprised of within default mode connections and 56% comprised of within frontoparietal connections.

Across all participants, within default mode connections (M = 10.73, SD = 3.72; range = 3 – 26), within frontoparietal connections (M = 13.48, SD = 3.37; range = 6 - 23), and between network connections (M = 18.58, SD = 8.07; range = 8 – 69) were present. Across all estimated network densities (i.e., within or between connections divided by total connections), within default mode density accounted for 8% to 47% of network connections and within frontoparietal density accounted for 2% to 57% of network connections. Between-network connections ranged from 27% to 65%. This variable distribution of network densities is indicative of the substantial heterogeneity in adolescents' functional organization during the resting state.

Network Density and Ethnic Identity

A summary of hierarchical linear regression results for ethnic identity exploration and resolution as statistical predictors of within- and between-network densities, controlling for motion and age are presented in Table 3.2.

For density within the default mode network, the step 1 model of covariates was not significant. In the step 2 model that included exploration and resolution, ethnic identity exploration was positively associated with higher default mode network density (b = .02, SE = .01, p = .04), but the model did not significantly explain the variance in network density. This finding, however, was consistent with our hypotheses.

For density within the frontoparietal network, the step 1 model of covariates was significant. Motion was negatively associated with density (b = -.75, SE = .36, p = .02). The step 2 model that included exploration and resolution was also significant. Ethnic identity resolution was positively associated with higher frontoparietal network density (b = .03, SE = .01, p = .02). This finding is also consistent with our hypotheses, and inferences were similar in a model excluding the motion covariate.

For density between the default mode and frontoparietal network, the step 1 model of covariates was not significant. The step 2 model with exploration and resolution was also not significant. Neither exploration (b = -.00, SE = .01, p = .72) nor resolution (b = -.00, SE = .01, p = .98) were associated with between-network connectivity.

Exploratory Analysis. Exploratory analyses considered whether associations between ethnic identity and resting state network densities varied between White youth (n = 74) and youth of color (n = 30). In general, White youth had lower levels of ethnic identity exploration (M = 2.02, SD = .69) compared to youth of color (M = 2.95, SD = .85), t(100) = -5.79, p < .001. White youth also had lower levels of ethnic identity resolution (M = 2.35, SD = .78) compared to youth of color (M =3.36, SD = .66), t(100) = -6.20, p < .001. In the hierarchical regression analyses reported above, an indicator of youth of color status (0 = White and 1 = youth of color) and its interaction with exploration and resolution were entered in the models (see Supplemental Table S3.4). Regarding the default mode network, neither youth of color status nor its interactions statistically predicted density, and the association between exploration and default mode density was no longer significant. Regarding the frontoparietal network, neither youth of color status nor its interactions statistically predicted density, but the association between resolution and frontoparietal density remained significant (b = .03, SE = .01, p = .02). Regarding between network density, neither youth of color status nor its interactions were statistically significant predictors, and inferences about other predictors in the model were unchanged.

Discussion

Ethnic identity development refers to the process of exploring one's ethnicity and developing a sense of clarity about what it means to belong to one's ethnic group. Despite the burgeoning knowledge on the relations between ethnic identity and youth adjustment, there has remained a key conceptual gap about ways ethnic identity development processes are reflected in the brain. This work aimed to fill that knowledge gap, proposing that the default mode and frontoparietal networks that underlie self-referential thinking, social cognition, and cognitive control are relevant for ethnic identity developmental processes. GIMME, a person-specific analysis approach well-suited to the study of heterogeneity, was used to estimate personalized brain connectivity networks. It was hypothesized that ethnic identity exploration and resolution would relate to how neural network organization, such that more exploration and resolution would be associated with greater network densities (e.g., proportional connectivity within and between these networks). Findings showed that youth who reported greater clarity about their ethnic group membership demonstrated more connectivity within their frontoparietal network and suggested that youth who reported greater ethnic identity exploration evinced more connectivity within their default mode network.

Frontoparietal Network Density. Having clarity about what it means to belong to one's ethnic group was associated with having more connectivity within the frontoparietal network during the resting state. This finding supports our hypothesis and is novel, as no previous research has examined relations between ethnic identity developmental processes and the brain. Although directionality cannot be asserted, there are plausible explanations for how more resolution development is linked to denser networks. For instance, brain networks captured during the resting state are a reflection of how the brain has been shaped and organized by lived experiences, and the frontoparietal network represents a set of brain regions that work together to support cognitive control. It has been previously noted that youth with more clarity about their ethnic group membership demonstrate better behavioral adjustment, such as engaging in less substance use and circumnavigating deviant peers (Brook et al., 2010; Derlan & Umaña-Taylor, 2015; Zapolski et al., 2018). Thus, increased frontoparietal network density could be a reflection of the known links between resolution and behavioral adjustment. That is, youth with more resolution in general may use cognitive control processes (reflected by the frontoparietal network) to promote behavioral adjustment, such as resisting peer influence and engaging in behaviors that support academic achievement. This does not mean that achieving some sort of positive ethnic identity resolution state is promotive, but rather, that the developmental process of resolution (or the exercise of negotiating what one's ethnic identity means to oneself) is promotive. Moreover, the process of negotiating the perspective of salient social others, such as ethnic group members, to develop clarity about one's sense of self could exercise the frontoparietal network. This is consistent with research that has highlighted the involvement of the central executive network in a myriad of social interactions (Feng et al., 2021), especially during social influence and mentalizing processes (Moreira et al., 2017; Welborn et al 2016).

Motion also explained frontoparietal network density. Participants that moved more in the MRI scanner had less density in their frontoparietal network connections. Although this may seem to challenge the interpretation of network links with resolution, the opposite association would have been most concerning (i.e., with more motion tied to more frontoparietal network connectivity), as previous research has shown that specific characteristics of measured brain networks, such as long-distance connection strength, are sensitive to motion (Circ et al., 2017; Power et al., 2015). Moreover, significant motion would have made it harder to detect links with behavior. In fact, when the motion covariate was removed from the model, the association of resolution remained significant, making it unlikely that resolution effects were related to statistical noise. Additionally, the association of resolution remained present in the exploratory analysis (discussed below) despite adding three additional predictors, suggesting that the effect is robust.

Default Mode Network Density. Default mode network organization was expected to relate to ethnic identity exploration and resolution. Self-referential thinking and social cognition are defining features of the default mode network (Buckner, & DiNicola, 2019). This network is relevant for ethnic identity development which involves thinking about the perspectives of ethnic group members to make sense of one's ethnic group membership and one's self-concept. Exploration of one's ethnicity, participating in culturally salient events, gaining knowledge about one's heritage, and learning from other ethnic group members involve self-reflective processes and social cognition. Default mode network density was positively associated with exploration in our study, but the finding was not as robust as the finding for resolution and frontoparietal network density because the overall model was not significant, and the effect was not present in exploratory analyses that included interactions. It is nonetheless a promising finding for future research consideration.

A possible explanation for the limited scope of this finding may concern the heterogeneity in the exploration processes itself. For example, exploration reflects the process of gaining ethnic-relevant knowledge and experiences but does not necessarily equate to achieving a "positive" state of one's sense of ethnic identity. (This is actually what precipitated the conceptual disaggregation of exploration and resolution as related and interdependent, but distinct processes; Umaña-Taylor et al., 2004.) Perhaps a better approach is to examine the interaction between exploration and resolution. For example, those with more exploration and a greater sense of clarity may have more resonating implications for the default mode network functional organization.

Between-Network Density. Connections between the default mode and frontoparietal networks were also proposed to examine whether the brain supports the known relations between ethnic identity development and behavioral adjustment. However, ethnic identity exploration and resolution were not associated with between-network density. There was a wider distribution in the presence of this type of connection across personalized models compared to within-network connections. Resting state networks are best characterized (and defined) by their within-network synchronized activity (van den Heuvel & Pol, 2010; Liégeois et al., 2017). Therefore, within-network density as indicator of the brains' functional organization may be optimal for assessing during the resting state than between-network density.

The role of youth of color status. The interactions between group status (i.e., being a youth of color versus not) and ethnic identity exploration and resolution did not help explain network densities. However, this should not discard the role of race in the way that race-salient experiences are reflected in the functional organization of the brain. This analysis, as an early step for studying ethnic identity in the brain, was important, but only a first step. Although, there was no particular hypothesis for whether and how race would impact the main findings, this exploratory analysis was still merited given the differential saliency of ethnicity and race among youth of color vis-à-vis White youth in the U.S. Ethnic identity processes of exploration and resolution can be thought as universally applicable but may be qualitatively distinct for ethnic-racial minority youth in the U.S. where race- and ethnicity-salient experiences are tied to social stratification (Coll et al., 1996). Additional considerations are needed in conceptualizing how ethnic identity content, that is one's beliefs and attitudes about their group membership, relates to the brain as the nature of identity content does vary substantially by ethnic-group membership based on their unique sociohistorical contexts. Thus, an entirely different set of integrated theoretical formulations, including neural networks, would be important to consider for conceptualizing relations between ethnic identity content and the brain.

Study Considerations

This study is novel in its conceptual framing of the research question that integrates developmental and neuroscience as well as advanced quantitative methods. A fundamental aspect of social identity development is social cognition and, particularly for adolescent identity development, social reorientation (Telzer et al., 2018). We leveraged this idea to draw conceptual overlaps between knowledge about brain networks and ethnic identity development. The proposed conceptual framing should not be viewed as a mechanistic explanation of how ethnic identity development is reflected in the brain, but rather, as one potential way to link set of ideas to conceptualize how ethnic identity development is implicated in the brain (Jabareen, 2009). Thus, continued research relying on similar and other plausible conceptual framing is needed to further explore ways that ethnic identity processes are interrelated with brain and behavior. From a methodological perspective, the heterogenous and multidimensional aspects of ethnic identity development and the brain were addressed through a person-specific brain connectivity approach. This approach was vital because meaningful information about the unique ways that ethnic identity defining experiences are internalized and reflected in the brain would be lost in approaches that averaged brain activity.

The age range of the present sample was limited to 17 through 21 years, though no significant effects of age were observed in predicting network densities. From a resting state perspective, age is important to account for in predicting brain network connectivity, which has characteristics dependent on age, such as strength and detection of long and short distance connections (Fair et al., 2008; Fair et al., 2009). With respect to ethnic identity development, our limited age range of youth in later adolescence could have narrowed viable variability in exploration and resolution given that these processes are known to manifest in a developmental age-stage manner (Umaña-Taylor et al., 2014). However, it may have also been advantageous because it allowed us to capture the resting state brain after youth had gone through the majority of adolescence during which ethnic identity developmental processes are known to be salient

(Rivas-Drake & Umaña-Taylor, 2019). Ethnic identity development does not end in early-mid adolescence, though, either; it continuously formulates even among young adults when new perspectives of one's environments may emerge (Marks et al., 2020). A younger sample with a wider age range examined longitudinally would provide unique insight into how network level neural organization coincides with exploration and resolution development. For instance, it might provide some indications of the direction between ethnic identity and brain network organization; it is plausible that ethnic identity developmental experiences shape brain functional organization and vice versa.

The sample was not entirely White, which is unfortunately often the case in neuroimaging research, but a much more diverse and larger sample is important for continued research on brain network organization as it relates to ethnic identity development, specifically among youth of color. A larger sample means more personalized networks that can help to distinguish homogenous and heterogeneous ways that ethnic identity experiences relate to brain network organization. To further understand links between ethnic identity development and the brain, it must be acknowledged that ethnic identity development does not happen in a social vacuum of positive social interaction. Ethnic identity development is also formulated from negative social interactions as well, such as ethnic-racial discrimination, that should be considered in future research.

Conclusion

Although the consequential effects of ethnic identity development on thought, cognition, and behavior are known, a foundational conceptual gap concerns the ways in which ethnic identity development, if at all, is reflected in the brain. This study begins to fill that gap by considering the role of functional brain networks in how salient social group processes relate to thoughts and behaviors tied to ethnic identity using an integrative approach that relied on multiple theories. This present study revealed that youth who had more clarity about their ethnic identity had more connectivity within their frontoparietal network, consistent with what is known about ethnic identity resolution and adjustment from self-report studies. It also suggested that youth who were exploring and gaining more knowledge about their heritage may have more connectivity within their default mode network. Importantly, the procedures used in this study did not involve average group comparisons, and instead, focused on continuous, culturally salient processes and their likely heterogeneity through person-specific neural network modeling. Researchers can take this approach and apply it to other social groups and identity processes.

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Table 3.1.

Region of Interest MNI Coordinates

Region of Interest	Abbreviation	MNI Coordinate (x)	MNI Coordinate (y)	MNI Coordinate (z)
Default Mode Network				
Anterior Medial Prefrontal Cortex	aMPFC	-6	52	-2
Posterior Cingulate Cortex	PCC	-8	-56	26
Dorsal Medial Prefrontal Cortex	dmPFC	0	52	26
L Temporal Parietal Junction	L TPJ	-54	-54	28
R Temporal Parietal Junction	R TPJ	54	-54	28
L Lateral Temporal Cortex	L LTC	-60	-24	-18
R Lateral Temporal Cortex	R LTC	60	-24	-18
L Temporal Pole	L TP	-50	14	-40
R Temporal Pole	R TP	50	14	-40
Frontoparietal Network				
L Dorsolateral Prefrontal Cortex	L dlPFC	-44	27	33
R Dorsolateral Prefrontal Cortex	R dlPFC	46	28	31
L Frontal Cortex	L Frontal	-42	7	36
R Frontal Cortex	R Frontal	44	8	34
L Inferior Parietal Lobe	L IPL	-53	-50	39
R Inferior Parietal Lobe	R IPL	54	-44	43

L Intraparietal Sulcus	L IPS	-32	-58	46
R Intraparietal Sulcus	R IPS	32	-59	41

Table 3.2
Summary of regressions of ethnic identity exploration and resolution and network densities

	Default Mode Density			Frontoparietal Density			Between-Network Density		
	b	*SE*	t	*b*	*SE*	t	*b*	*SE*	t
Step 1									
Intercept	.29***	.01	46.79	.37***	.01	45.82	.48***	.01	58.89
Motion	-.34	.25	-1.38	-.75*	.33	-2.32	.59	.33	1.79
Age	.00	.00	.31	.01	.01	1.04	-.00	.01	-.57
R^2		.02			.06			.04	
Model	F = 1.08 (2,99), p =.34			F = 3.09 (2,99), p =.05			F =1.97 (2,99), p = .15		
Step 2									
Intercept	.29***	.01	46.79	.37***	.01	48.82	.48	.01	58.89
Motion	-.34	.25	-1.38	-.75*	.36	-2.38	.59	.33	1.79
Age	.00	.00	.31	.01	.01	1.04	-.00	.01	-.57
Exploration	.02*	.01	2.03	-.02	.01	-1.60	-.00	.01	-.35
Resolution	-.01	.01	-1.46	.03*	.01	2.43	-.00	.01	-.02
Model	F (4, 97) = 1.60, p = .18			F (4, 97) = 3.08, p = .02			F (4, 97) = 1.02, p = .40		
ΔR^2		.04			.05			> .01	
	F (2,97) = 2.10, p = .13			F (2,97) = 2.95, p = .06			F (2,97) = .11, p = .89		

Note. *p < .05. **p < .01. ***p < .001

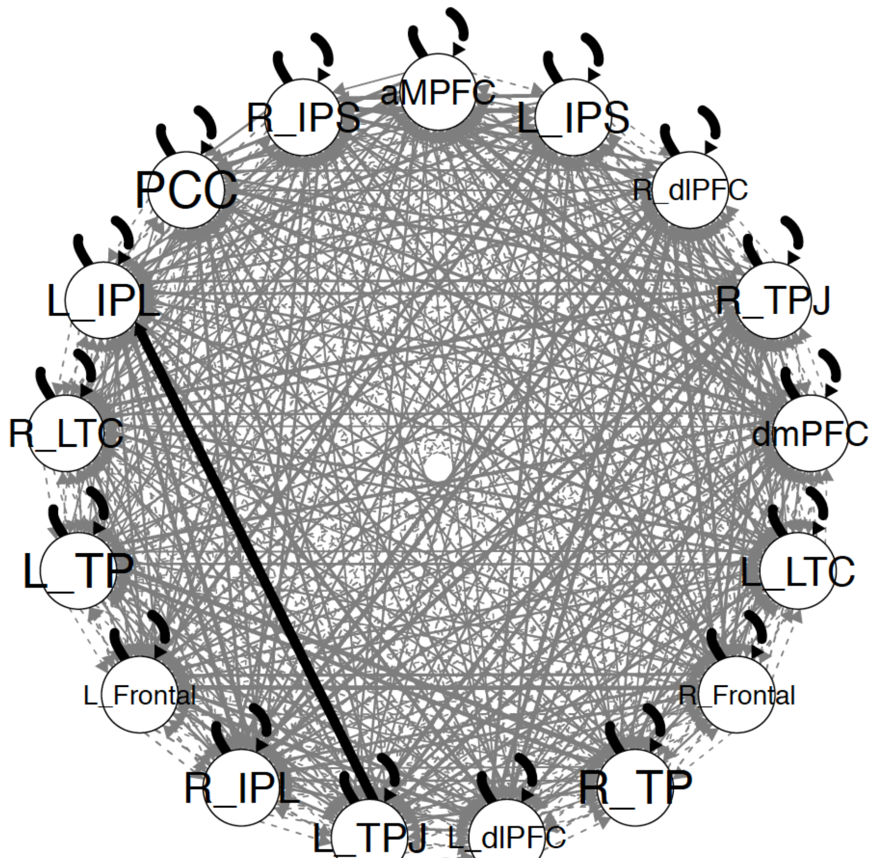

Figure 3.1. Summary of GIMME default mode and frontoparietal resting state network connectivity across participants (N = 104). Black lines represent group-level connections that were estimated for all participants. Gray lines represent individual-level connections that were estimated for some participants, with the proportion of participants reflected by line thickness. Solid lines depict contemporaneous connections, and dashed lines depict lagged connections. See Table 3.1 for ROI acronyms.

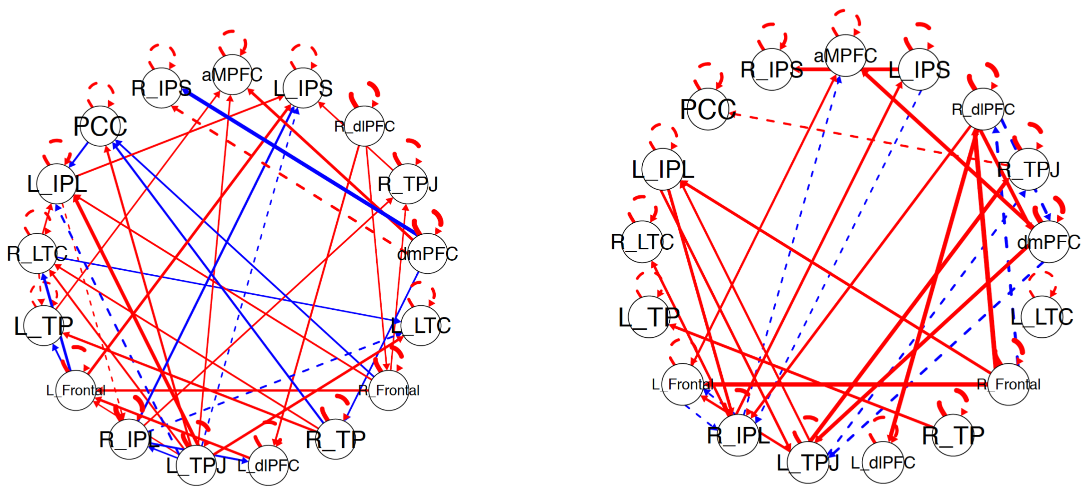

Figure 3.2. GIMME default mode and frontoparietal resting state network connectivity for two illustrative participants. Solid lines depict contemporaneous connections, and dashed lines depict lagged connections. Each connection has a corresponding beta weight reflected by line thickness, with red lines indicating positive weights and blue lines indicating negative weights. The network depicted on the left, Figure 3.2a: default mode density = 32% and frontoparietal density = 32% for a participant who had an exploration composite = 2.83 and a resolution composite = 2.66. The network depicted on the right, Figure 3.2b: default mode density = 26% and frontoparietal density = 55% for a participant who had an exploration composite = 1.66 and a resolution composite = 3.66.

Table S3.1.

Comparison of demographic variables between larger AHRB sample and neuroimaged sample

	t-test (df)	p -value	Chi-square (df)	p-value
Age	.27 (2015)	.78	-	-
SES	1.79 (1948)	.07	-	-
Sex	-	-	.74(1)	.39
YOC	-	-	11.58(1)	.00

Notes. Participants in larger AHRB survey study n= 2017; in neuroimaged sample n= 104. Parent education (1 = completed grade school or less; 6 = graduate or professional school after college.) Sex (0 = male; 1 = female). Youth of color (YOC) status ,0 = White youth; 1 = youth of color.

Table S3.2.

Comparison of demographic variables between subjects with and without ethnic identity measure at time of MRI scan

	t-test (df)	p -value	Chi-square (df)	p -value
Age	1.80 (102)	.07	-	-
Parent Education	0.27 (102)	.79	-	-
Sex	-	-	0.41 (1)	.52
YOC	-	-	0.94 (1)	.33

Notes. N = 104. Participants with ethnic identity measures at time of scan n = 84; without ethnic identity measures at time of scan n= 20. Parent education (1 = completed grade school or less; 6 = graduate or professional school after college.) Sex (0 = male; 1 = female). Youth of color (YOC) status, 0 = White youth; 1 = youth of color.

Table S3.3.

Model fit indices of 104 personalized GIMME networks

	CFI	RMSEA	SRMR	NNFI
1	0.9519	0.0505	0.05	0.926
2	0.9459	0.0496	0.05	0.9196
3	0.9503	0.0534	0.0457	0.9256
4	0.9506	0.0554	0.0413	0.9225
5	0.9508	0.0515	0.0424	0.9246
6	0.9373	0.0497	0.047	0.9085
7	0.9476	0.0493	0.0432	0.9202
8	0.951	0.0511	0.0451	0.9257
9	0.9504	0.0568	0.0435	0.9253
10	0.9361	0.0492	0.0491	0.9047
11	0.9513	0.0549	0.0498	0.9292
12	0.9508	0.0573	0.0455	0.9256
13	0.9502	0.0412	0.0519	0.9269
14	0.95	0.0497	0.042	0.9235
15	0.9506	0.0479	0.048	0.9286
16	0.9502	0.054	0.0419	0.9224
17	0.9523	0.055	0.0466	0.9295
18	0.9498	0.05	0.0478	0.925
19	0.9502	0.0521	0.0455	0.9268
20	0.946	0.0498	0.0406	0.9165
21	0.9385	0.0496	0.0492	0.9101
22	0.9527	0.0527	0.049	0.9304
23	0.9506	0.0511	0.0399	0.9228
24	0.951	0.0497	0.0465	0.9275
25	0.9515	0.0529	0.0426	0.925
26	0.9511	0.0623	0.0447	0.9172
27	0.9505	0.0468	0.0514	0.926
28	0.9504	0.0503	0.0452	0.9228
29	0.9508	0.0577	0.0378	0.9233
30	0.9476	0.0492	0.0467	0.9218

31	0.9538	0.0536	0.0483	0.9308
32	0.9462	0.0452	0.0494	0.921
33	0.9381	0.049	0.0498	0.9086
34	0.9503	0.0542	0.0434	0.9253
35	0.95	0.0607	0.0389	0.9244
36	0.9516	0.0516	0.0432	0.9272
37	0.9503	0.0564	0.0472	0.9226
38	0.9381	0.0493	0.0498	0.9079
39	0.9515	0.0563	0.0386	0.9217
40	0.9571	0.05	0.0483	0.9358
41	0.9504	0.0559	0.0438	0.9251
42	0.9504	0.0565	0.0462	0.9233
43	0.9513	0.0506	0.0423	0.9263
44	0.9507	0.0549	0.0401	0.9263
45	0.9509	0.0542	0.0439	0.9279
46	0.9512	0.0612	0.04	0.9264
47	0.9451	0.0445	0.0497	0.9179
48	0.9511	0.0532	0.0432	0.9234
49	0.9501	0.0523	0.0389	0.9217
50	0.9538	0.0503	0.0497	0.9306
51	0.9381	0.043	0.0495	0.9077
52	0.9372	0.0498	0.0497	0.9042
53	0.9513	0.0485	0.0512	0.9256
54	0.9505	0.0534	0.0418	0.9262
55	0.9513	0.0505	0.042	0.9268
56	0.9507	0.0588	0.0409	0.9248
57	0.9507	0.0577	0.0424	0.9236
58	0.948	0.0492	0.043	0.9225
59	0.9502	0.0636	0.0379	0.9219
60	0.9504	0.0446	0.0498	0.9275
61	0.9421	0.0494	0.0406	0.9105
62	0.9479	0.0497	0.0444	0.9182
63	0.9451	0.0499	0.0449	0.9165
64	0.9514	0.0515	0.0415	0.923
65	0.9514	0.051	0.0423	0.925

66	0.9504	0.0493	0.0511	0.9277
67	0.9506	0.0546	0.0484	0.9244
68	0.9496	0.0498	0.0459	0.9244
69	0.9511	0.0514	0.0416	0.927
70	0.9353	0.0498	0.0478	0.9019
71	0.9512	0.0512	0.0427	0.9251
72	0.9539	0.0527	0.0453	0.931
73	0.9502	0.0495	0.0418	0.924
74	0.9435	0.0496	0.0481	0.9159
75	0.9517	0.0535	0.0414	0.9283
76	0.9508	0.0558	0.0387	0.9238
77	0.9514	0.0525	0.0468	0.9253
78	0.9506	0.0447	0.056	0.9267
79	0.9479	0.0495	0.0492	0.9236
80	0.9512	0.0521	0.0378	0.9244
81	0.9502	0.0505	0.0442	0.9244
82	0.9416	0.0499	0.0476	0.9133
83	0.9501	0.0537	0.044	0.9253
84	0.9503	0.051	0.0414	0.9244
85	0.9506	0.0639	0.0376	0.9201
86	0.9467	0.0495	0.0449	0.9209
87	0.9505	0.0594	0.046	0.9264
88	0.9513	0.0528	0.0463	0.9272
89	0.9364	0.0469	0.0497	0.9075
90	0.951	0.0741	0.0334	0.9086
91	0.9424	0.0499	0.0454	0.9124
92	0.9516	0.0525	0.0477	0.9258
93	0.949	0.0496	0.0458	0.9255
94	0.9504	0.0525	0.0481	0.9269
95	0.9514	0.0534	0.0412	0.927
96	0.9505	0.0586	0.0461	0.9255
97	0.9515	0.0549	0.0479	0.9271
98	0.9509	0.0549	0.0404	0.9233
99	0.9503	0.053	0.0462	0.9264
100	0.9506	0.0535	0.0395	0.9251

101	0.9506	0.0769	0.0352	0.9172
102	0.9509	0.0498	0.0428	0.9271
103	0.9502	0.0587	0.0475	0.9249
104	0.9505	0.0511	0.0448	0.9259

Table S3.4

Ad Hoc summary of regressions of ethnic identity exploration and resolution on network densities

	Default Mode Density			Frontoparietal Density			Between-Network Density		
	b	*SE*	t	*b*	*SE*	t	*b*	*SE*	t
Intercept	.28***	.00	35.52	.37***	.01	34.57	.48***	.01	44.58
Motion	-.34	.25	-1.39	-.76*	.33	-2.30	.59	.34	1.76
Age	.00	.00	.08	.00	.01	0.86	-.00	.01	-.53
Exploration	.01	.01	.96	-.02	.01	-1.46	.00	.02	.02
Resolution	-.01	.01	-.82	.03*	.01	2.34	-.00	.01	-.06
YOC	.01	.02	.45	.01	.03	0.36	-.00	.03	-.19
*Exploration	.03	.02	1.398	.02	.03	0.53	-.01	.03	-.47
*Resolution	-.03	.03	-.1324	-.03	.04	-0.72	.01	.04	.28
R^2		.08			.12			.04	
Model	*F* (7, 94) = 1.24, *p* = .29			*F* (7,94) = 1.80, *p* = .05			*F* (7,94) = 0.60, *p* =.75		
ΔR^2		.02			.01			>.01	
	F (3,94) = .78, *p* =.51			*F* (3,94) = .18, *p* =.91			*F* (3,94) = .09, *p* = .96		

Notes. YOC = Youth of color, coded as White Youth = 0, youth of color = 1. Youth of color status and its interaction with exploration and resolution were entered to the final models of the primary analysis. Change in R^2 compared to final model in Table 3.2. **p* < .05. ***p* < .01. ****p* < .001.

Chapter IV

Conclusion

This dissertation set out to examine underexplored ways that ethnic identity development translates into adaptive outcomes for youth. In study one, I considered the role of youths' ethnic identity development in how they navigate social influences as well as the way they think about, plan, and weigh decisions with the future in mind (e.g., future orientation), two aspects that are important for navigating adolescence (Miller & Byrnes, 2001; Steinberg & Monahan, 2007; Steinberg et al., 2009). In study two, I considered whether and how ethnic identity development is implicated in the functional organization of the brain, specifically in large-scale brain networks that underlie human social interactions, social cognition, and self-referential thinking (Feng et al., 2021; Spreng & Andrews-Hanna, 2015). Together, these studies aimed to expand the way we view ethnic identity to function as a cultural asset by acknowledging that in the process of developing social ties and connections with one's ethnicity, identity is relevant for how one navigates many contexts (Neblett et al., 2012; Umaña-Taylor et al., 2014). Across both studies, one aspect of ethnic identity development—resolution—contributed to filling the gap about how ethnic identity functions as a cultural asset.

In study one, we learned that having clarity about one's ethnic group membership was associated with more resistance to peer influence. In study two, we learned that more ethnic identity resolution was associated with greater connectivity within the brain network that supports cognitive control (e.g., frontoparietal network; Vincent et al., 2008). These findings complement each other and help tell a story about the promotive value in ethnic identity resolution development. The association between resolution and frontoparietal network organization captured during rest may reflect the commonly known associations between ethnic identity resolution and behavioral adjustment evident in self report studies, like the findings in study 1. However, the partially supported hypothesis regarding exploration across studies contributes to discussions in the field that uncovered the distinct implications of the exploration process in relation to youth outcomes (Yip, 2018).

The following is a synthesis of the dissertation findings. I address how effective the proposed studies were at answering the research questions. I discuss how these studies complement one another in our understanding of ethnic identity development. Based on the study approaches and overall findings, I provide recommendations to the field for continued research about how ethnic identity development functions as a mechanism to support youth outcomes. Finally, I conclude by emphasizing the overall contributions of this dissertation to the field.

Summary of study findings

Study 1

The relations between ethnic identity development, resistance to peer influence, and future orientation were examined in Study 1. The use of the resistance to peer influence and future orientation measures were meant to capture underlying facets that are involved in adolescent adjustment (Steinberg & Monahan, 2007; Steinberg et al., 2009). It was expected that more exploration and resolution would be positively associated with more resistance to peer influence and greater future orientation. These relations were examined cross-sectionally in an ethnic-racial diverse youth sample through a Structural Equation Modeling (SEM) framework. A strength of the study was the measurement invariance assessment of ethnic identity exploration and resolution that reveal that these latent variables had similar psychometric properties among White youth and youth of color (i.e., ethnic minority status youth).

There were no associations between ethnic identity and the way youth think about and weigh decisions with the future in mind (i.e., future orientation). This was surprising given much research demonstrating associations between ethnic identity and behavioral outcomes for which delayed gratification may be involved. Alternatively, the null finding may indicate an issue of measurement for the future orientation scale used in this dissertation. It is possible that future orientation defined in terms of optimism and outlook may be more relevant for ethnic identity constructs than operationalization of future orientation that assess delay gratification. For example, youth with greater clarity about their identities, include their ethnic identity, have demonstrated more optimism, planned goals, and clarity about their future (Duffy & Klingaman, 2009; Sharp & Coatsworth, 2012). While both types of future orientations, delay gratification and optimism, have been linked with adaptive behaviors (e.g., less engagement in substance use), future research should continue to investigate whether and how values, motivations, and priorities that emerge from ethnic identity development are tied to the way that youth approach decision-making.

The hypothesized model was supported by the positive associations between resolution and resistance to peer influence. In addition, this finding did not differ among White youth and youth of color. This underscores that ethnic identity as a cultural asset may reflect social cognitive processes that support adaptive outcomes. The study findings were consistent with the integrated set of frameworks (e.g., Umaña-Taylor, et al., 2004; Dahl, 2016; Pfeifer & Berkman, 2018; Steinberg, 2008) and supported the idea that ethnic identity resolution, as a developmental process, may be mechanism for adaptive adjustment. The process of negotiating the ideals, beliefs, and perspectives of one ethnicity in support of identity development is important for how one navigate their environment, especially social influences.

Study 2

The potential relations between ethnic identity development and the default mode and frontoparietal networks were examined in Study 2. These large-scale brain networks are implicated in social interactions, social cognition, self-referential processes, and cognitive control (Feng et al., 2021; Spreng & Andrews-Hanna, 2015). These brain networks were examined during the resting state where they are reliably detectable (Spreng et al., 2013). More importantly, the neuro-correlates of myriad types of social interactions, social cognitions, and mentalizing processes show heightened synchronized activity at rest (or in an idle state of mind) in such a way that their brain activity can be organized into distinguished and recognizable brain networks (Feng et., 2021; Andrews-Hanna et al., 2010a; Andrews-Hanna et al., 2010b). This suggest that these large-scale brain networks are commonly at work and in communication with one another in real life human social interactions and that the way that these networks have been shaped and organized can be captured in resting state fMRI. Therefore, evaluating resting state brain networks was considered important to begin examining the relations between brain network organization and ethnic identity development. Specifically, Study 2 asked whether having engaged in ethnic identity defining experiences and thinking about one's ethnic group membership relate to the default mode and frontoparietal networks organization captured at rest?

Group Iterative Multiple Model Estimation (GIMME) was used to characterize brain network connectivity from resting state fMRI (Gates et al., 2010; Gates & Molanaar, 2012). This person-specific modeling framework was called upon because of the multidimensional and heterogenous ways that ethnic identity development manifests across people and its potential implication on brain network organization (e.g., Beltz et al., 2018). Indeed, much heterogeneity was evident in the default mode and frontoparietal brain connectivity across the estimated personalized network models. These meaningful person-specific connections in the brain would have been lost had resting state brain activity been averaged across individuals (Molenaar, 2004). Instead, network density served to make sense of the heterogeneity of default mode and frontoparietal brain connectivity, revealing the extent that these types of connections are present in one's personalized brain network model. This approach was successful in testing the hypothesized relations between ethnic identity development and brain connectivity.

The predicted relations between ethnic identity and brain network connectivity were not fully supported. One of the hypotheses was supported and in the expected direction: More ethnic identity resolution was associated with greater frontoparietal network density. Greater ethnic identity exploration was initially associated with greater default mode network density; however, this finding was not robust. This limited finding provides some merit for futures studies to continue to investigate. Participating and exploring one's ethnicity may involve brain networks engaged in social interactions and social cognition in ways that were not identified in this research. I also found no evidence to indicate that ethnic-racial minority status moderated the associations between ethnic identity development and network density. However, these relations should be further examined in larger and more diverse youth samples.

Integrative Synthesis

This dissertation incorporated a social reorientation perspective of adolescence and an identity-value model of decision-making into ethnic identity developmental theories. These integrated frameworks help to generate the research question and help to make sense of the findings. In Study 1, we can see how developing clarity about one's ethnic group membership might support the way youth navigate social influences by relying more on their own perspective than that of their peers. In this manner, ethnic identity development could be understood as a process whereby youth develop their own sets of idea and perspective from ethnic group interactions that help them navigate other salient social environments in adaptive ways. This underscores the idea that just as youth look toward salient social others, such as peers, for their identity development and navigation of adolescence in general, the same social reorientation may support the way that youth look towards ethnic group members for their identity development that help them in the way they socially appraise information (Quintana et al., 1999)—an important asset for navigating adolescence.

Similarly, the same set of theoretical frameworks were also applied to conceptualize Study 2's research question. In this case, the underlying neuroscience of social reorientation in adolescence was emphasized to identify brain networks that would be relevant for ethnic identity developmental processes (Pfeifer & Berkman, 2018; Dahl, 2016; Telzer et al., 2018). The identity-value model of decision-making was used to help make sense of the way that identity processes such as ethnic identity development could inform behavioral adjustments and the ways that this could be supported at the brain level (Oyserman, 2007; Berkman et al., 2017). More ethnic identity resolution was associated with more connectivity within the frontoparietal network, a network that underlies cognitive control. This finding suggests that clarity about one's ethnic group membership is associated with a brain network that supports behavioral adjustment.

The findings from my dissertation help tell a story about ethnic identity resolution. It expands our view of how ethnic identity development, especially resolution, functions as a cultural asset. The process of negotiating the perspective of salient social others, such as ethnic group members and what it means for one's of self, may inform the way one navigates their social environment. We saw that more clarity about ethnic group membership was associated with more adaptive ways of discerning and appraising information from peers. This may be one possible mechanism at work when we see adaptive adjustment among youth with a positive sense of connections with their ethnicity (e.g., academic promotive behavior, health compromising behaviors, and peer social interactions; Brook et al., 2010; Fisher et al., 2017; Miller-Cotto & Brynes, 2016).

The findings from Study 2 may reflect this phenomenon, or mechanism. We saw that more clarity about one's ethnic group membership was associated with more connectivity within the brain network that underlies cognitive control. The association between resolution and frontoparietal connectivity (during the resting state) may reflect the known links between ethnic identity and behavioral adjustment. For example, youth with more resolution in general may engage in aspects of cognitive control that promote behavioral adjustment such as resisting peer influence and engaging in behaviors that promote academic achievement. It must be emphasized that it is the process of developing clarity about ethnic group membership, not the state of resolution itself, that should be viewed as a cultural asset.

Across the two studies, the main findings with respect to resolution did not differ between White youth and youth of color. This raises an important point of discussion regarding the tradeoffs of combining youth of color samples, which was done in both studies. The main predictor variables in both studies, ethnic identity exploration and resolution, have demonstrated strong measurement invariance across multiple ethnic-racial groups, observed in both adolescent and adult samples (Douglas & Umaña-Taylor, 2015; Sladek et al., 2020). When ethnic-racial groups are not represented in large quantities to be examined in their own models, and it is the case that the predictor variable measures are reliable across groups, then merging participants across groups provide more statistical power. In Study 1, this yielded a larger sample of comparable size to the White youth group and allowed for multigroup testing of the hypothesized model. However, it is plausible that the hypothesized relations of interest could still differ across subgroupings but would be underpower to statistically test. For example, one implication could be that the effects observed in a pooled sample of youth of color could be masked by the fact that the observed effect is more robust for one subgroup than the others. One way to remedy this alternative explanation is by having larger multi-ethnic group samples to conduct multigroup testing.

The similar pattern observed in this dissertation among White youth and youth of color with respect to resolution reveal several things that are consistent with previous research. The first is an indication of that the ethnic identity resolution scale psychometrically functions in similar ways for diverse youth. This has been evident via measurement invariance assessment in multiple studies (Douglas & Umaña-Taylor, 2015; Sladek et al., 2020) and was observed in Study 1. Second, the consequential effects of resolution development are observed similarly across ethnic-racial diverse youth. This has also been evident in other research, especially in recent experimental intervention studies that foster resolution development in youth and observed promotive benefits among White youth (Umaña-Taylor et al., 2018). However, the ethnic identity resolution scale itself allows to infer the extent of clarity one has about their ethnic group membership and is limited for inferring the meaning youth ascribed to belonging to their ethnic group. Generally, this poses a limitation of knowing the ways in which resolution as a cultural asset functions. For this dissertation, this implies the theoretical limits for describing how resolution development functions as a cultural asset for multiethnic-racial samples because of the phenomenologically different ways youth make sense of experiences tied to their ethnic-racial group membership in a society that has been historically stratified on the basis of race. We can only infer, however, that undergoing resolution development, that is entertaining what it means to belong to one's ethnic group holds promotive value for adjustment.

Associations regarding ethnic identity exploration were not fully supported in Study 1 and were supported to limited extent in Study 2. This contributes to current discussions in the field about how exploration manifest and the variable implications it has for youth development. For example, the exploration processes can be viewed as a double-edge sword in that some studies observe promotive benefits, while other studies observe increase perceptions of ethnic-racial discrimination in the context of exploration (Meca et al., 2020; Yip, 2018). The exploration process for some may reflect positive learning experiences and meaningful interactions with one's ethnicity while for other it may not. The exploration measure may reflect a myriad of experiences, thus may limit its utilization in hypothesis testing or at least must be coupled with other explanatory variables. While recent research has tried to remedy this issue by examining exploration longitudinally to reveal directionality in relation to other variable, like perceived ethnic-racial discrimination and ethnic socialization (Meca et al., 2020), looking towards person-specific modeling (e.g., GIMME) of exploration may help identify which aspect of the exploration process are homogenous (universal) across individuals, and which aspect are heterogenous (person-specific).

Recommendations to the field

The overall findings of this dissertation suggest ethnic identity resolution development as a potential mechanism for supporting youth adjustment. Therefore, future research should continue to examine the various ways and the extent for which this may be so. Based on the findings from Study 1, resistance to peer influence should be examined as a potential mediator in the relations between ethnic identity resolution and behavioral adjustment outcomes, such as substance use or academic related behaviors. This may help provide more specificity as to how developing clarity about one's ethnic group membership supports the way you discern social influences and the ways in which they inform adolescent behaviors. The proposed set of integrated frameworks could be drawn upon to generate hypotheses on this matter. In addition, with some evidence that links resolution with brain functional organization, research down the line could also consider the role of the brain in explaining such ethnic identity resolution to behavioral outcome pathways. Ideally, these pathways should be examined longitudinally.

The overall findings and the novelty in methodology of Study 2 provide much potential for the field to build upon. Primarily, the associations between ethnic identity and resting state network activity should be examined in large, diverse samples to better ascertain within-group and across-group differences in the associations between resolution and network activity. Doing so may help identify the homogenous and heterogenous ways that ethnic identity exploration and resolution are linked to brain functional organization. With a larger and diverse sample, it is possible for GIMME to identify groups of people with similar personalized network patterns that could potentially be characterized by psychosocial behavioral traits or profiles reflecting ethnic identity development (e.g., Beltz et al., 2016). For example, individuals with high exploration and high resolution could have a common set of brain network connections present in their personalized networks. It could also be even more informative to examine the interaction between exploration and resolution for characterizing brain network organization. This recommendation also applies for self-report studies, such as Study 1, that examine ethnic identity developmental dimensions in relation to psychosocial or behavioral outcomes.

The salience network, that is the network that elicit affective states and guides the body's attention, has been similarly linked with processing human social interactions, like the default mode and frontoparietal networks (Barrett & Sapute, 2013; Feng et al., 2021). Regions that comprise the salient network are known to be responsive and (re)active toward the processing of external stimuli like human faces, specifically demonstrated via experimental tasks where activation of these regions are elicited. The involvement of these brain regions make sense during the active processing of human social interaction given the motivational and affective saliency of interacting with humans, especially those deem part of our social groups. Therefore, one way to study links between social identities, like ethnic identity, and the salience network would involve designing experimental task that elicit a social identity relevant process.

As an example, ethnic identity exploration, as a process, could be assessed via fMRI experimental tasks. Rather than creating an experimental task the attempts to capture exploration as a construct like is typically done with measurement scales that yield a summary score, an item of the ethnic identity scale (Umaña-Taylor et al., 2004) could be converted into a task. This could yield direct and specific neuro-correlates for a specific behavior or cognitive process that underlies a particular type of exploration. Participants could be shown images of books, magazines, or tv shows representative of their ethnicity and compare their brain activity in response to viewing comparable neutral images. As another example, participants could be shown images of people participating in activities that are representative of their ethnicity and have participants rate the extent they identify with that image and compare their brain activity to rating a comparable neutral activity. There are many ways in which other experimental tasks used in social neuroscience could be creatively adapted to develop tasks that can capture neuro-correlates of basic behavioral and cognitive processes that are implicated in a particular type of identity exploration. In addition, resting state networks could also be examined in a task-like manner by asking participants to think, or mentalize, about an ethnic identity formative experience – or about one of the ethnic identity scale items. This could provide additional foundational knowledge of what large-scale brain network activity look like when participants are primed to think about their ethnic identities directly.

Contextual information, such as school demographics, neighborhood ethnic composition, youths' family context, and youths' peer social network all play a role in how ethnic identity processes unfold and has implication for youth behavioral outcomes. For the research questions in this dissertation, and future research, this means incorporating contextual variables in our tested models as they help make sense of ethnic-racial salient processes (Galliher et al., 2017; Syed et al., 2018). For example, Study 1 attempted to incorporate school demographics in the tested model as ethnic-racial compositions of schools are known to have implications for inter-group dynamics. Geographic locations may differ in diversity of ethnic group composition and ethnic group concertation within neighborhoods, which may shape youths' sense of ethnic group connection and community. Considering such information helps to explain how sociocultural context may matter in any link between ethnic identity development and brain connectivity. Finally, with the growing ethnic-racial diversity in the youth population along with schools taking initiatives to promote inclusivity and thinking about diversity, there has been an increasing interest in how ethnic identity processes manifest among White youth. Continued quantitative (e.g., psychometric evaluations) and qualitative research is needed to help make sense of the extent and potentially different ways ethnic identity processes impact the various developmental outcomes among White youth compared to ethnic minority youth (Sladek et al., 2020).

Reflections, Contributions, and Significance

This dissertation incorporates the underlying neuroscience of social reorientation, the role of identity in decision-making, and the adaptive role of ethnic group connections to understand how ethnic identity developmental supports adjustment. Taking an approach that cuts across several identity relevant processes help create a comprehensive study of the potential relations between ethnic identity and everyday adjustment. This dissertation demonstrated that ethnic identity resolution as a process is a mechanism that may help support the way youth discerning social influence in adaptive ways. This dissertation also demonstrated that ethnic identity resolution was associated with more frontoparietal network connectivity in the resting state brain, either reflecting the commonly known association between resolution and behavioral adjustment that implicate cognitive control in real life, or, suggesting that resolution development itself may have involved cognitive control networks.

The interdisciplinary approach pursued in this dissertation allowed to gain new knowledge about resolution. More importantly, it helped me to gain new knowledge as to how ethnic identity may function as a cultural asset. This dissertation exemplified novel methodological approaches and theoretical considerations for the field of ethnic identity research to utilize. The findings add new avenues to consider when thinking of ways that ethnic identity support adjustment by expanding or complementing the idea of positive adjustment through the self-esteem that ethnic group connections can help foster. This dissertation also provides further support for intervention work that has helped to foster ethnic identity development in diverse ethnic-racial youth and has shown its promotive effects on adjustment (Umaña-Taylor, et al., 2018).

There are a few key strategies and lessons worth sharing that helped make multidisciplinary research as done in this dissertation possible. With respect to professional development, I found it helpful to first immerse oneself in one field before diving into another. Not only does this make learning about a topic more accessible compared to learning about distinct lines of research simultaneously, but it also helps in communicating what you have learned to others in another field. Having firm footing in one field and solid foundational knowledge about the other field allows to develop cross-discipline collaborations and be able to effectively communicate to develop an innovative research program. Developing the research questions for this dissertation made me realize the substantial knowledge gap at the brain level of what occurs when individuals are learning about ethnicity and developing their identities. With solid theoretical grounding, the saliency of social interactions and forming social connections- particularly during adolescence, emerged as a key common factor that allowed to bridge ethnic identity development research with social neuroscience. In other words, both fields, developmental science and social neuroscience, study humans. Basic social, cognitive, and behavioral processes are the building block of more complex psychosocial processes, like ethnic identity development – which when view through this lens help to make sense and reconcile both literatures.

Assessing the relations between ethnic identity development and brain functional organization helps fill an important gap in the literature, that is, in what ways are ethnic identity processes implicated in the brain. This dissertation provides foundational knowledge for the field to build upon in this area. I was able to identify two brain networks that are relevant for social interactions, social cognition, and self-referential processes that are potentially relevant to ethnic identity development. These large-scale brain networks should continue to be examined in larger and more ethnically and racially diverse samples. This dissertation demonstrated that person-specific modeling approaches, such as GIMME, can be used as a way study psychosocial and behavioral processes that are heterogenous and multi-dimensional, such as ethnic identity development, in the brain. This same methodological approach, the use of resting state fMRI and GIMME, can also be used to investigate how other social identities are implicated in the brains' functional organization.

In conclusion, having connections and social ties with one's ethnicity has been considered a cultural asset as it helps promote positive adjustment among ethnic minority youth.. This dissertation suggests that ethnic identity resolution, as a developmental process, can be considered as a mechanism that helps support positive adjustment. Drawing from perspectives focused on ethnic identity development, social reorientation, and an identity-value model of decision-making, we can understand that the underlying biology that contributes to youths' sensitivity to social environmental cues and salient social others, like peers and parents, may also occur with ethnic group members. Ultimately, a social reorientation lens allows us to view ethnic identity development as a process whereby youth are socially attuned to their ethnic groups and are constantly negotiating their ideas, beliefs, values, and motivations that contribute to how they view and navigate their environments. This social reorientation lens was argued to provide a comprehensive perspective of adolescence that accounts for the social and motivational saliency of interactions with ethnic group members, the underlying neuroscience of such social reorientation, and the role identity in how youth navigate their environments.

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Appendix A

Resting State Networks

The brain's functional organization can be thought of as structurally genetically guided, but highly experience dependent, and thus highly malleable during adolescence. Just as this may have implication for the brain's functional organization from chronic adverse experiences, like maltreatment, this also has implication for developmentally informative experiences, such as social group interactions. The following is a review of how brain functional organization can be captured through resting-state fMRI.

The functional organization of the brain can be captured through resting-state fMRI. Rather than engaging in an experimental task to modulate brain activity, resting-state fMRI captures brain activity fluctuations in the absence of an external stimulus or attention demanding tasks. Functional connectivity refers to the temporal dependency of neural activity of anatomically separated brain regions measured during a period of time (i.e., resting-state fMRI time series). During resting-state fMRI, brain regions that often work together for everyday functionality can be observed with high levels of ongoing correlated spontaneous neural activity when the brain is at "rest" (van der Heuvel & Pol, 2010; Liégeois et al., 2017). These highly correlated synchronized brain activities among brain regions (e.g., functional connectivity) can be organized into resting-state brain networks. Brain regions that make up a network are sometimes referred to as a node, and connections between two nodes are sometimes referred as an edge. Through resting-state fMRI, several brain networks have been reliably characterized, such as the attentional networks (e.g., set of brain regions involved in visuospatial processing; Barett & Sapute, 2013; Power et al., 2011).

Research on resting-state networks during adolescence have converge with the structural and physiological changes in adolescent brain development. After puberty, there are declines in synaptic pruning complimented with increases in axonal myelination, reflecting the increase in white matter volume across adolescence. These physiological changes are thought to partly underlie the adolescent brain functional organization and the increase efficiency and specificity of information exchange across the brain (Ernst et al., 2015). Studies on resting-state network in particular have noted that there is a decrease in functional connectivity of short-range (short-distance) connections and increase in functional connectivity of long-range connections (Fair, 2007; Fair, 2008). This reflects a developmental shift in brain organization by which large-scale networks shift from a locally oriented organization to more distributed and integrated networks (Fair, 2009). This aligns with the physiological changes in protracted myelination that is thought to efficiently improve connectivity across longer distances brain connectivity. At the same time, the smaller networks that become integrated in larger-scale networks are subject to finetuning reflecting specificity. There is also stronger connectivity between discrete brain networks with development, altogether reflecting more integrated, dynamic, flexible, and efficient brain organization.

Brain network organization continue to change beyond adolescence. With respect to network organization and aging among adults, a common finding is the decrease in connectivity within some resting-state networks, such as the default mode and salience networks, and less so among somatosensory, motor, and subcortical networks (van der Heuvel & Pol, 2010). Some studies have shown that long-range connections become weaker and short-range connections become stronger with aging (e.g., Tomasi & Volkow, 2012). When examining connectivity between and across large-scale networks, there are age-related decreases in connectivity within a network as well as increase connectivity between networks (Grady, Surrod, Saverino, & Campbell, 2016). Compared to younger adults, older adults show lower clustering values, or less network identifiability, - how well structures within a network predict one another. These features of resting-state networks, such as connectivity strength varied by distance and network identifiability, are sensitive to motion, particular for adolescents and older age groups. However, most of these patterns, especially for adolescents, are still supported even after strict motion artifact control (Satterthwaite et al., 2013; Circ et al., 2017).

Appendix B

Resting-State fMRI Processing

There are various steps to ensure that the resting-state fMRI signal reflects fluctuations in neural activity and is not confounded by other sources of noise. Early fMRI studies have been able to distinguish the low frequency oscillation signal that reflects resting-state neural activity from higher frequency cardiac and respiratory patterns (Biswal, 2012). These physiological sources of noise may introduce artificial correlations between fMRI time series, and therefore are important to account for in the resting-state fMRI signal. Acquiring resting-state fMRI requires participants to remain still for period of time in an MRI scanner. Head motion in particular has been found to affect the BOLD signal and subsequent analysis that rely on this signal. We can determine the effectiveness of different denoising approaches by assessing the extent to which a motion metric (e.g., framewise displacement) is correlated with pairwise functional connectivity between nodes. This evaluation is also known as QC-FC; an assessment of the extent that functional connections (FC) depend on quality check (QC) such as a motion metric. We can also determine the extent to which motion impacts short range verse long range functional connections, or the relationship between node distance and QC-FC (e.g., distance-dependent connections) (Power, Schlagger, & Peterson, 2015). Motion can affect resting-state network structure, modularity, or identifiability (Circ et al., 2017). Finally, a good denoising strategy would remove most noise and would not remove true signal, minimizing the consequences on detecting connectivity within distinct network. In other words, a good denoising strategy would not impact the expected connectivity properties of a brain network.

Head motion can be measured as displacement along three orthogonal axis (x, y, z) and through rotations along these axes. Most fMRI scanner are able to characterize motion along these six motion parameters in a time-series. Head movement beyond the 3-diminisional space in which brain activity is recorded (e.g., voxel) can be considered problematic. Head motion that are beyond a given threshold, for example 0.5mm, not only distorts the BOLD signal at the time of peak displacement, but also has temporal effects, affecting the BOLD signal during the volumes before and after peak displacement. In addition to the six motion parameters, temporal derivatives can be estimated from these six parameters to better account for the temporal effects of motion. In fact, it has been shown that motion produces large reduction in BOLD signal that is maximal in the volume following peak movement (Satterthwaite, et al 2013). Head motion also has non-uniform spatial effect throughout the brain on the BOLD signal, whereby the effect of motion on the BOLD signal is more evident on the outer compared to the inner parts of the brain. Nonetheless, displacement is highly correlated throughout the brain. Depending on the motion correction approach for resting-state connectivity, in some cases head motion appears to enhance short-range connections and diminish long-distance connections, have the opposite effect, and in other cases motion seems to increase connectivity globally (Satterthwaite et al., 2013).

The field of resting-state fMRI has learned more about the different ways denoising strategies, or ways in which physiological, head movement, and other sources of noise are accounted for in the data, affect the data and subsequent functional connectivity analysis (Satterthwaite et al., 2013; Circ et al., 2017; Power et al., 2015). Regarding head motion, the six head motion parameter and its temporal and quadratic derivates can be modeled as confound regressors. A range from six to up to 36 motion derived parameters can be included as confound regressors, with the higher number of parameters able to effectively remove non-linearities in the effect of motion on the BOLD signal (Satterthwaite et al., 2013). However, including higher number of motion parameters is more effective for denoising among subjects with larger amounts of motion. Of course, a downside to using many motion parameters in a model is the loss of degrees of freedom.

In addition to head motion and physiological noise, other types of brain tissue may also contribute to noise in the fMRI signal, such as white matter (WM) tissues and cerebral spinal fluid (CSF). The activity measured in these parts of the brain are sometimes referred to as signal of no interest because there is no expectation of BOLD signal of neuronal origin. One way to account for WM and CSF noise is to estimate the mean activity across the tissue structure and include it as a confound regressor. Usually, these types of confound nuisance regressors are defined prior to any spatial smoothing to avoid mixing data from different types of tissues (Caballero-Goudes & Reynolds, 2017). It should be noted that when these kinds of confound regressors are defined, they are not completely linearly independent and may exhibit shared variance with the rest of the brain. Pre-whitening is a recommended strategy where autocorrelations in the residuals are estimated and removed. Pre-whitening allows to achieve valid statistical inferences when using nuisance regressors and has been shown to reduce the number of significant voxels that contribute to removed noise (Bright et al., 2017). Similarly, nuisance regressor and the rest of the brain share similar temporal properties. Temporal filters are supposed to differentiate signal and noise frequency bands. Therefore, it is recommended that identical filters are applied to both the nuisance regressor and the rest of brain before denoising to prevent from reintroducing the filtered frequency. When WM and CSF noises is accounted for in addition to head motion-based regressors, they perform well to denoise the fMRI signal, but do not rid distant-dependent connections (Satterthwhattie et al., 2013).

Instead of using the mean WM and CSF as a confound regressor, the WM and CSF voxels can be used in a principal's components analysis that generates multiple types of orthogonal sources of noise as potentials confound nuisance regressors. Using this PCA approach works better than using mean WM and CSF as confound regressor, although it has been shown to not completely alleviate distant-dependent artifacts (Parkes et al., 2018; Power et al., 2015). Independent component analysis (ICA) however relies on grey matter tissue and examines coordinated or synchronized BOLD fluctuations throughout the brain. ICA is a way to derive nuisance signals by matrix decomposition of whole-brain data. ICA can spatially identify areas of the brain that are consistently active together and can temporally identify brain areas that most contribute to given temporal signal. This allows to identify hidden statistical independent sources of noise, such as those that arise from head motion, beyond physiological noise. These independent components can be used to denoise the resting-state signal (Prium et al., 2015). It should be noted that ICA requires that the data are spatially smooth beforehand.

One final method for denoising data, often as part of or done after the approaches listed above is censoring (e.g., despiking, scrubbing). Censoring involves identifying motion induced spikes in the resting-state fMRI time series and applying a method (via multiple regressions) of eliminating or reducing the influence of that timepoint on the data. A common way of identifying problematic brain volumes is through framewise displacement, which are estimated relative head motion from time point to time point derived from head motion parameters. A framewise displacement value criterion can range from greater than 0.2mm to 0.5mm. It has been shown that the inclusion of scrubbing helps in removing distance-dependent artifact (Power et al., 2015). However, censoring can be differentially more effective for subjects with more movement, and thus differentially also reduces degrees of freedom.

These preprocessing procedure for account for noise in the resting-state signal have been examined in clinical populations, younger and older samples, and high and low motion groups. For the purposes of capturing activity in resting-state networks, an ICA approach performs well in denoising the resting-state fMRI signal across these sample characteristics, in some cases reducing differences in resting-state connectivity properties across healthy and clinical sample as well as among adolescent populations (Circ et al., 2017; Parkes et al., 2018). ICA performs well in reducing the impact of motion and other sources of noise on resting state functional connectivity properties and exhibits greater sensitivity for accommodating higher temporal resolution acquisitions (Caballero-Gaudes & Reynolds, 2017). In particular, ICA has been shown do well compared to other denoising approaches to reduce distance-dependent artifacts and produces good network identifiability (Circ et al., 2017). Although the addition of censoring to ICA further improves QC-FC and distance-dependent connections, it has been shown to loss of data and reduced degrees of freedom (Circ et al., 2017; Parkes et al., 2018). Therefore, ICA in combination with WM and CSF nuance regressors are deem appropriate and optimal denoising strategy for preparing resting-state fMRI.

Appendix C

Group Iterative Multiple Model Estimation

Group iterative multiple model estimation (GIMME) is a person specific approach for modeling directed associations among variables of interest (ROI activity) based on individual and group-level information (Gate & Molenaar, 2012). GIMME was developed to model connectivity among brain regions but can also be used to model associations among behavioral and psychological time-series data. The main advantage GIMME over other brain connectivity modeling approaches is its capability to model brain connectivity at a person-specific level, accounting for intra-individual heterogeneity. This is different from modeling individual variations, which implies modeling deviations from a group mean and may impose a normal distribution. In GIMME, there is no mean, therefore the statistical power for GIMME comes from intense longitudinal measure to model within persons data. In other words, GIMME models brain connectivity unique to an individual in a way that acknowledges brain connectivity common across individuals, meaning it is capable capturing homogeneity in brain connectivity in the case that it may be present in a group.

The advantages of GIMME help deal with assumptions of homogeneity that may be violated when modeling brain connectivity aggregated across individuals. There might be substantial individual differences in the way ROIs are predicting activity in other ROIs during the time series. For example, in a study eating disorders, ovarian hormones, and brain connectivity in resting-state fMRI, functional connectivity was examined via an aggregated group average approach and through GIMME. GIMME was able to estimate group-level paths for each person, that is path that were meaningful across individuals. These group-level paths from GIMME were consistent with estimated paths from the aggregated group average model. However, GIMME was able to produce additional paths that were significant for some individuals, while these same paths were missing from the aggregated group average approach (Beltz et al., 2018). A closer look at the unique person-specific paths demonstrates how some ROIs have either more endogenous or exogenous directed paths, illustrating the different roles a ROI may have across individuals. This exemplifies the loss of meaningful information when group data are aggregated and modeled (Molenaar, 2004). Similarly, during a task-based fMRI study, each individual might engage in different psychological processes to execute the task, and thus the aggregated brain activity may not reflect the actual activity for any one individual. Altogether, this suggest that GIMME can be used to handle potential heterogeneity across individuals in the direction and the extent (magnitude) that ROIs are associated with each other during resting-state fMRI.

GIMME implements unified-Structural Equation Modeling (u-SEM). u-SEM allows to estimate contemporaneous and lagged associations (e.g., how one variable predicts another variable at the next time point). The special features of GIMME when implemented with u-SEM is that contemporaneous and lagged associations are modeled for each individual with a group-level structure. This means that GIMME estimates paths for each individual that are significant for a majority of the group, then estimates paths that are unique to that individual. Therefore, GIMME will result in one unique model per person characterizing associations among variables during the time series. Group-level paths are independently estimated for each person-- they are not an average path of the group. In some cases, if the relationship and temporal order between two variables is well established, this path may be freed or estimated for everyone in the group. In the end, each person will have a unique connectivity map that characterizes the patterns of connections among variables for that person, including unique paths that were estimate for that person, and paths that are estimated for everyone in the group. A group summary connectivity map can be constructed to represent contemporary and lagged connections that were present for everyone in the group.

GIMME assumes that residuals have no temporal dependency, are centered around zero, and represent white noise. However, because of the high temporal resolution in some time series data, there may be temporal dependencies in the residuals, meaning noise at one time point could influence estimation at subsequent time points. In these instances, and of particular importance with resting-state data where data tend to be collected in short time intervals, it is recommended to include a higher lag. This means that when modeling lagged associations, paths are estimated between one ROI with the activity of another ROI at two time points prior, in addition to one time point prior. It has been established that a posteriori model evaluation can help determine which lag would suit modeling the data (Beltz & Molenaar, 2015). In addition, if the time series data is of high temporal resolution, as is that case here with resting state TR= .8 seconds, lagged associations may account for a large amount of variance, limiting the explanatory power of other variables. An appropriate remedy would be to down sample, using measures (brain activity) at every other time point, which has been previously done with other high temporal resolution data like EEG (Sato et al., 2010).

GIMME represents the state of the art in modeling functional brain connectivity. Compared to other temporal connectivity approaches, GIMME has been shown to perform well among different types of datasets and with various types of heterogeneity (Gates & Molenaar, 2012). GIMME has been shown to reliability characterize directed contemporaneous and lagged association by accounting for individual-level variation, while other approaches assume homogeneity in brain connectivity and have less reliability in estimating undirected (e.g., seed-based correlations, principal components), and directed connections (e.g., Granger causality, dynamic causal modeling). In extensive large-scale simulations, GIMME has been also shown to reliably identify more true path connections and less false positive path connections compared to other connectivity approaches. While GIMME is data driven, compared to other data driven approaches like ICA which identifies sets of brain regions with synchronized activity throughout the whole brain, GIMME is also a model driven approach that needs pre-defined brain structure that are hypothesized to be functionally connected. In this study, brain structures that comprise the default mode and frontoparietal networked are hypothesized to show intra and inter network connectivity via GIMME.

The heterogeneity in brain connectivity captured through GIMME may be linked with measures that characterize behavioral and psychological processes. One way to do this would be to implement extend-unified-SEM (eu-SEM) with GIMME, which adds parameters that allow to modulate paths according to conditions as would be in an experimental design. Another way would be to model GIMME independently for each type of experimental condition. For example, in a study of substance use during the transition to college and fMRI task brain connectivity, GIMME was modeled according to task condition (Beltz et al., 2013). Similarly, GIMME may be estimated independently according to different groups that may be based on age, gender, health status, mental health diagnosis, or other psychological or behavioral groupings (Beltz et al., 2016). To illustrate how GIMME results may be assessed, in the study of substance use and brain connectivity, the number of estimated paths within and between the brain networks of interest were counted and compared across conditions, an indication of density (e.g., number of connections) of a specific type of connection. GIMME results also may be assessed by number of paths coming out of the node, also known as node centrality, to characterize the importance of particular ROI in a connectivity map (e.g., Beltz et al., 2016).

In some instances, the heterogeneity in GIMME connectivity maps across individuals, like network path counts or node centrality, may be further explained beyond experimental condition or group membership (e.g., age, gender, health status, mental health diagnosis, etc.). Instead, the strength of group level paths, paths that are estimated for all individuals, may be explained by behavioral or psychological measures. That is, the variation in the strength of a path that was estimated in everyone's connectivity map may be linked with variation in a measured behavioral or psychological characteristic. To illustrate, in the study of eating disorder, hormones, and brain connectivity, the strength of paths between default mode ROIs were associated with levels of estrogen and progesterone (Beltz et al., 2018). To summarize possible approaches to evaluate GIMME connectivity maps, when GIMME produces variable connectivity maps across individuals, GIMME results may be characterized by the patterns and frequency of particular types of path connections (e.g., density) and assessed with respect to defined groups or behavioral or psychological measures (e.g., do individuals with certain levels of a psychological measure have a higher number a specific type of brain connectivity). In the presence of homogeneity, that is path common across individuals, beta weights may be extracted to determine how psychological or behavioral measures help explain the strength of these group-level paths.

Appendix D

Estimation of GIMME

The intense, repeated data measuring patterns of blood flow at each ROIs over the course the scanning period will be enter as variables in GIMME.

$$\eta_i(t) = (A_i + A^g) + \left(\Phi_{1,i} + \Phi_1^g\right)\eta_i(t-1) + \zeta_i(t) \quad \text{Equation 1}$$

GIMME with unified-structural equation modeling can be defined as equation 1 above. $\eta_i(t)$is the p-variate ROI time series at time t = 1, 2, 3, …T. p is the number of ROIs and T is the length of the timeseries. A is the p-p dimensional matrix of contemporaneous relations among ROIs. Φ is the p-p dimensional matrix of lagged relations among ROIs. $\zeta_i(t)$is the p-variate error time series assumed to contain no temporal dependencies. Superscript g indicates group-level estimates and subscript i indicates person specific estimates.

GIMME begins with a null empty model with auto-regressive paths at each ROI. The way in which group-level paths and individual-level paths are estimated is through an iterative process involving Lagrange Multiplier equivalents test (i.e., modification indices) implemented through a LISERAL-based automatic search algorithm. At the group-level path identification, Lagrange Multiplier equivalents test determines which paths (contemporaneous and lagged) if freed (estimated) would significantly improve model fit across all individuals. Modification indices are generated for each individual independent of other individuals, and each path gets a count of how many individual models would significantly improve if the path were estimated. A group percentage criterion is established to determine what proportion of the group would an estimated path significantly improve model fit across individuals. Paths that would optimally improve fit for above the group percentage criterion are estimated. This is an iterative process that occurs until paths are no longer identified that would meet the set group percentage criterion. Then, paths that did not meet this criterion are pruned.

GIMME is a sparse modeling approach, only estimating paths that are important. The next step involves individual-level path identification. At this stage, models are estimated in semi-confirmatory manner in that the new null model begins with all paths that were estimated at the group level. Similar to the group-level path identification stage, Lagrange Multiplier equivalents test determine which paths (contemporaneous and lagged) if freed would optimally improve model fit for that specific individual. Individual level connections that do not significantly improve mode fit after the other individual level connections were estimated are pruned. In this manner, GIMME allows individual-level path estimation with group-level path structure. The final step in GIMME is confirmatory model fitting. Good model fit is determined by satisfactorily meeting two of four fit criteria: RMSEA < .05, SRMR < .05, CFI > .95, and NNFI > .95.

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