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Original Paper

Age-Related Decline in Children's Reward Sensitivity: Blacks' Diminished Returns

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Abstract

Background: *It is important to study the correlates of reward sensitivity since it predicts high-risk behaviors. While ageing reduces children's reward sensitivity and its associated risk taking, there is more to find out about racial differences in regard to the effect of age on reward sensitivity. Minorities' Diminished Returns (MDRs) suggest that resources and assets show weaker effects on Black children than White children.* ***Aim:*** *We compared White children to Black children as for the effects of age on reward sensitivity.* ***Methods:*** *This cross-sectional study included 10533 American children who participated in the baseline of the Adolescent Brain Cognitive Development (ABCD) study. The independent variable was age, while the dependent variable was reward sensitivity as captured by the behavioral approach/behavioral avoidance system (BAS-BIS). Gender, parental education, marital status, parental education, and household income were the covariates.* ***Results:*** *Higher age was associated with less reward sensitivity. A significant interaction was found between race and age when it comes to children's reward sensitivity. It suggested that age is associated with a smaller gain in terms of reduced reward sensitivity in Black children than White children.* ***Conclusion:*** *Age is more likely to reduce reward sensitivity in White children than Black children. This finding is in line with MDRs, and may be due to social racism, segregation, stratification, and discrimination.*

Keywords

age, children, adolescents, risk behaviors, emotion regulation, reward

1. Introduction

Gray and McNaughton's early (Gray, 1991) and recent (McNaughton & Gray, 2000) work has theorized the Behavioral Approach System (BAS) and the Behavioral Inhibition System (BIS) as reinforcement and reward sensitivity. According to this theory, high BAS scores, such as drive, reward responsiveness, and fun seeking reflect the individuals' sensitivity to reward, known as the psychological driver of a human to a certain behavior (Van den Berg, Franken, & Muris, 2010).

The importance of BAS-based scores and traits is that they closely predict risk taking and impulsivity (P. L. Johnson, Potts, Sanchez-Ramos, & Cimino, 2017). The BAS-based scores, like reward sensitivity, closely correlate with the use of tobacco (Barr, Pizzagalli, Culhane, Goff, & Evins, 2008; Cummings, Gearhardt, Miller, Hyde, & Lumeng, 2019; Janes et al., 2015; Pergadia et al., 2014; Powell, Dawkins, & Davis, 2002; Snuggs & Hajek, 2013), alcohol (Aloi et al., 2020; Black & Rosen, 2011; Boger et al., 2014; Enoch, Gorodetsky, Hodgkinson, Roy, & Goldman, 2011), and food (Cummings et al., 2020), which results in addiction and obesity (Carver & White, 1994). They also predict other risk behaviors such as aggression (Harmon-Jones, 2003) and sexual risk taking (Balda, Anderson, & Itzhak, 2006; Opel et al., 2015). Reward sensitivity, as a main component of approach motivations, predicts risky behaviors in both clinical (Alloy et al., 2012; Fletcher, Parker, & Manicavasagar, 2013; Keough, Wardell, Hendershot, Bagby, & Quilty, 2017) and community population (Tsypes & Gibb, 2020). These BAS-based traits correlate with children's risk behaviors (Aloi et al., 2020; Cummings et al., 2020; Kujawa et al., 2019), and are reported to be linked to psychopathologies like anxiety, depression, post-traumatic stress disorder (PTSD), and bipolar disorder (S. L. Johnson, Turner, & Iwata, 2003).

Considering that racial minority status and low socioeconomic status (SES), as the Black population and individuals living in poverty, score higher in BAS-based scores (for instance reward-sensitivity), these traits may explain why they remain at a higher risk of impulsive behaviors compared to the White population and to those with higher SES (Alloy et al., 2012). Surprisingly, recent research has shown that Black children remain at a high level of impulsivity along with poor emotion regulation and inhibitory control, at all SES levels (Assari, C. H. Caldwell, & R. Mincy, 2018a; Assari, 2020b; Assari, Akhlaghipour, Boyce, Bazargan, & Caldwell, 2020; Assari, Boyce, Akhlaghipour, Bazargan, & Caldwell, 2020).

The high impulsivity of Black children all across the SES spectrum is explained by Minorities' Diminished Returns (MDRs) (Assari, 2017b; Assari, 2018). MDRs refer to significantly weaker associations between SES indicators, such as parental education, household income, behavioral and health outcomes for any racial minority group, particularly among the Black population compared to the White population (Assari, 2018; Assari, 2018f). Similar MDRs of parental education (Assari, Caldwell, & Bazargan, 2019), family income (Assari, Caldwell, & Mincy, 2018a; Assari, Thomas, Caldwell, & Mincy, 2018), and marital status (Assari & M. Bazargan, 2019) are reported for several emotional and behavioral outcomes (Assari & Caldwell, 2018a; Assari, C. H. Caldwell, et al., 2019; Assari, Caldwell, & Mincy, 2018a; Assari, C. H. Caldwell, & R. B. Mincy, 2018b; Assari, Thomas, et al., 2018). For example, high SES Black children remain at a risk of impulsivity (Assari, Caldwell, & Mincy, 2018a), depression (Assari & Caldwell, 2018a), anxiety (Assari, Caldwell, & Zimmerman, 2018), aggression (Assari, C. H. Caldwell, et al., 2019), grade point average (GPA) (Assari, 2019; Assari & Caldwell, 2019b; Assari, C. H. Caldwell, et al., 2019), and substance use (Assari, C. H. Caldwell, et al., 2019). Similarly, a high risk of ADHD (Assari & Caldwell, 2019a) and obesity (Assari, Boyce, Bazargan, Mincy, & Caldwell, 2019) is reported among high SES Black children; a pattern that does not exist for high SES White children.

1.1 Aims

Built on MDRs, we compared Black children to White children as for the effect of age on reward sensitivity. We focused on reward sensitivity because it reflects inhibitory control and behavioral activation. It also predicts aggressive behaviors, substance use, alcohol use, and sexual risk taking. We expected an inverse association of age with reward sensitivity; however, this association was reported to be diminished for Black children more than White children.

2. Methods

2.1 Design and Settings

This secondary analysis used cross-sectional design and borrowed data from the Adolescent Brain Cognitive Development (ABCD) study (Alcohol Research: Current Reviews Editorial, 2018; Casey et al., 2018; Karcher, O'Brien, Kandala, & Barch, 2019; Lisdahl et al., 2018; Luciana et al., 2018). ABCD baseline data collection was conducted from 2016 to 2018 in 21 sites across the states in the U.S. For more information on the ABCD study, please check this (Alcohol Research: Current Reviews Editorial, 2018; Auchter et al., 2018).

2.2 Participants and Sampling

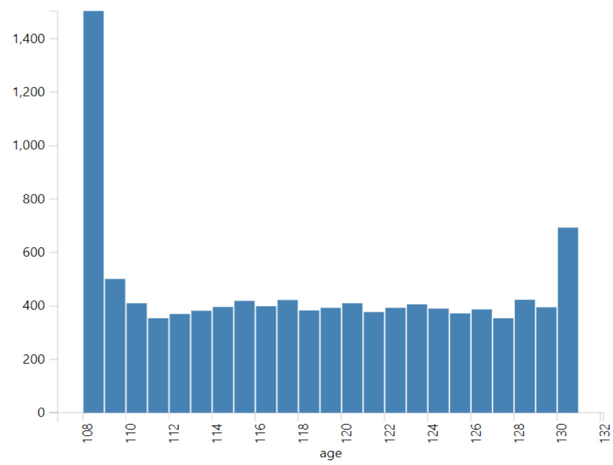
The ABCD participants were 9/10-year-old children who were selected from multiple cities across the states, in the U.S. The ABCD recruitment primarily relied on the U.S. school system. For a detailed description of the sampling and recruitment in the ABCD (Garavan et al., 2018). The eligibility for our analysis had a valid data of all our study variables including race, age, and reward sensitivity. The analytical sample of this paper was 10533.

2.3 Study Variables

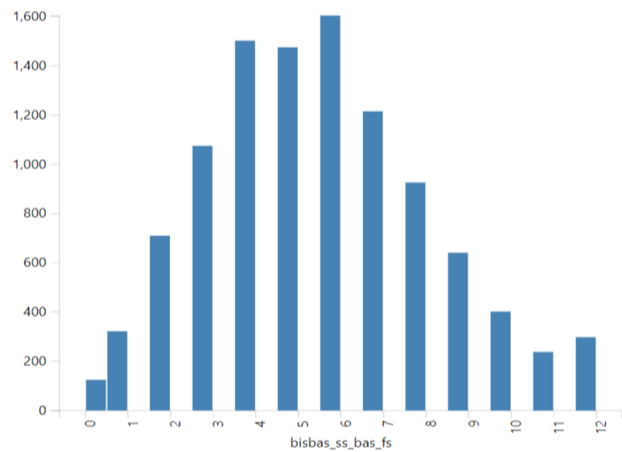
The study variables included race, ethnicity, sex, age, household income, parental education, marital status, and reward sensitivity. Reward sensitivity was evaluated by the BAS (Van den Berg et al., 2010), a component of the reinforcement sensitivity theory (RST), developed by Carver et al. (1994). The BAS-based reward sensitivity can be seen as a trait closely linked to impulsivity (P. L. Johnson et al., 2017) and closely correlated with tobacco use (Barr et al., 2008; Cummings et al., 2019; Janes et al., 2015; Pergadia et al., 2014; Powell et al., 2002; Snuggs & Hajek, 2013), alcohol use (Aloi et al., 2020; Black & Rosen, 2011; Boger et al., 2014; Enoch et al., 2011), emotional eating (Cummings et al., 2020), aggression (Harmon-Jones, 2003), obesity (Carver & White, 1994), and sexual risk taking (Balda et al., 2006; Opel et al., 2015). As suggested by Gray's reinforcement sensitivity theory (RST) (Gray, 1991), higher reward sensitivity reflects the individual's high sensitivity to environmental cues, that condition the individual as well as give him a signal about higher-than-luck probabilities of reward. Race was self-identified: Blacks, Asians, Mixed/Other, and Whites (reference category). Parents reported the age of their children in months. Child sex was 1 for males and 0 for females. Parental marital status was reported by the parents and was 1 for married and 0 for the others. Household income, reported by parents, was a three-level categorical measure: less than 50K, 50-100K, and 100+K.

2.4 Data Analysis

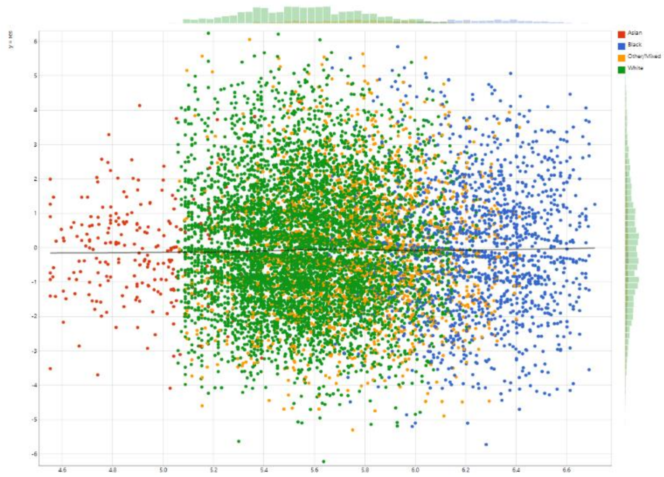
*W*e used DEAP for data analysis. DEAP uses R package for statistical calculations. We reported mean (standard deviation [SD]) and frequency (%) overall and by race. We also performed the Chi-square and ANOVA for our bivariate analysis. For multivariable modeling, we used mixed-effects regression models that allowed us to adjust for the nested nature of our data. Both models were performed in the overall sample. Model 1 did not have the interaction terms. Model 2 added interaction terms between race and age. Regression coefficient (b), SE, 95% CI, t value, and *p*-value were reported.



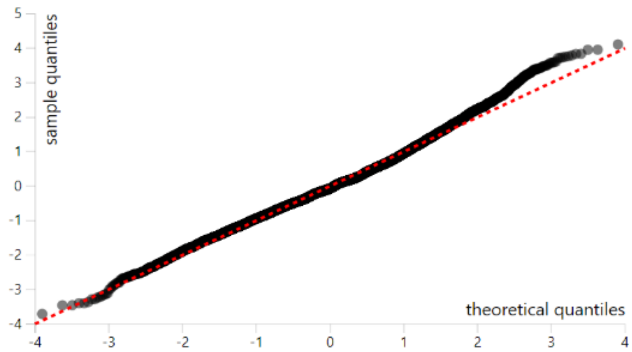
(a)



(b)



(c)



(d)

Figure 1. Distribution of Predictor, Outcome, Qnantiles, and Residuals

Table 1. Model Formula

Model 1
bisbas_ss_bas_fs ~ age + race.4level + sex + high.educ.bl + married.bl + household.income.bl + hisp
Random: ~(1|abcd_site/rel_family_id)
Model 2
bisbas_ss_bas_fs ~ age + race.4level + sex + high.educ.bl + married.bl + household.income.bl + hisp + age * race.4level
Random: ~(1|abcd_site/rel_family_id)

2.5 Ethical Aspect

The ABCD study has the Institutional Review Board's (IRB) approval, and all participants have provided assent or consent, depending on their age (Auchter et al., 2018). Given that our analysis was performed on fully de-identified data, our analysis was exempt from a full IRB review.

3. Results

3.1. Descriptives

Overall, 10533, 9/10-year-old children were analyzed. Participants were White (n = 6974; unweighted 66.2%; weighted 69.1%), Black (n = 1539; unweighted 14.6%; weighted 13.5%), Asian (n = 233; unweighted 2.2%; weighted 3.6%), or from other/mixed race (n = 1787; unweighted 17.0%; weighted 13.8%). Table 2 presents the descriptive data overall and by race. This table also compares racial groups for study variables.

Table 2. Descriptive Characteristics Overall and by Race

		All		White		Black		Asian		Other/Mixed		P	
			weighted		weighted		weighted		weighted		weighted		weighted
N	Level	10533		6974		1539		233		1787			
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Reward Sensitivity		5.68 (2.65)	5.71(2.68)	5.58 (2.59)	5.60(2.64)	6.24 (2.81)	6.27(2.82)	4.79 (2.44)	4.93(2.43)	5.72 (2.68)	5.89(2.75)	<0.001	<0.001
Age (Months)		118.97 (7.46)	119.23(7.48)	119.03 (7.49)	119.30(7.49)	118.96 (7.23)	119.25(7.23)	119.39 (7.79)	119.72(7.82)	118.68 (7.50)	118.77(7.56)	0.267	0.132
		n (%)	%	n (%)	%	n (%)	%	n (%)	%	n (%)	%		
Sex	Female	5052 (48.0)	(49.0)	3291 (47.2)	(48.1)	771 (50.1)	(51.3)	117 (50.2)	(50.5)	873 (48.9)	(50.4)	0.137	0.198
	Male	5481 (52.0)	(51.0)	3683 (52.8)	(51.9)	768 (49.9)	(48.7)	116 (49.8)	(49.5)	914 (51.1)	(49.6)		
High education	<HS Diploma	391 (3.7)	(4.7)	148 (2.1)	(2.9)	124 (8.1)	(9.4)	6 (2.6)	(2.6)	113 (6.3)	(9.4)	<0.001	<0.001
	HS Diploma/GED	872 (8.3)	(9.9)	331 (4.7)	(6.4)	346 (22.5)	(24.9)	3 (1.3)	(1.5)	192 (10.7)	(15.1)		
	Some College	2702 (25.7)	(30.0)	1470 (21.1)	(26.8)	613 (39.8)	(41.5)	18 (7.7)	(8.4)	601 (33.6)	(40.3)		
	Bachelor	2792 (26.5)	(25.0)	2077 (29.8)	(28.3)	230 (14.9)	(13.2)	65 (27.9)	(29.2)	420 (23.5)	(19.0)		
	Post Graduate Degree	3776 (35.8)	(30.4)	2948 (42.3)	(35.6)	226 (14.7)	(11.0)	141 (60.5)	(58.3)	461 (25.8)	(16.3)		
Married Family	No	3205 (30.4)	(37.3)	1429 (20.5)	(28.8)	1076 (69.9)	(76.7)	33 (14.2)	(15.1)	667 (37.3)	(46.9)	<0.001	<0.001
	Yes	7328 (69.6)	(62.7)	5545 (79.5)	(71.2)	463 (30.1)	(23.3)	200 (85.8)	(84.9)	1120 (62.7)	(53.1)		
Household income	<50K	3034 (28.8)	(38.3)	1272 (18.2)	(28.7)	1016 (66.0)	(75.0)	36 (15.5)	(19.3)	710 (39.7)	(55.3)	<0.001	<0.001
	>=50K&<100K	3009 (28.6)	(31.3)	2127 (30.5)	(34.5)	339 (22.0)	(18.9)	54 (23.2)	(29.9)	489 (27.4)	(27.4)		
	>=100K	4490 (42.6)	(30.5)	3575 (51.3)	(36.8)	184 (12.0)	(6.1)	143 (61.4)	(50.8)	588 (32.9)	(17.3)		
Hispanic	No	8551 (81.2)	(77.7)	5800 (83.2)	(80.3)	1463 (95.1)	(92.6)	214 (91.8)	(95.5)	1074 (60.1)	(45.9)	<0.001	<0.001
	Yes	1982 (18.8)	(22.3)	1174 (16.8)	(19.7)	76 (4.9)	(7.4)	19 (8.2)	(4.5)	713 (39.9)	(54.1)		

3.2 Multivariate Models

Table 3 presents the results of two mixed effects regression models in the overall sample. Model 1 showed an inverse association between high age and reward sensitivity. Model 2 showed an interaction between age and race on reward sensitivity. This interaction indicated that the inverse association between high age and reward sensitivity is weaker for Black children than White children (Figures 2 and 3).

Table 3. Mixed Effects Regressions Overall

	b	SE	p	b	SE	p
	Model 1			**Model 2**		
Age (Months)	-0.01**	0.00	0.002	-0.01**	0.00	0.002
Race (Black)	0.54***	0.09	< 0.001	-2.51*	1.23	0.041
Race (Asian)	-0.57***	0.17	0.001	-0.89	2.30	0.700
Race (Mixed/Other)	0.10	0.09	0.257	0.95	1.18	0.423
Race (Black) × Age (Months)	-	-	-	0.03*	0.01	0.013
Race (Asian) × Age (Months)	-	-	-	0.00	0.02	0.889
Race (Mixed/Other) × Age (Months)	-	-	-	-0.01	0.01	0.469

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

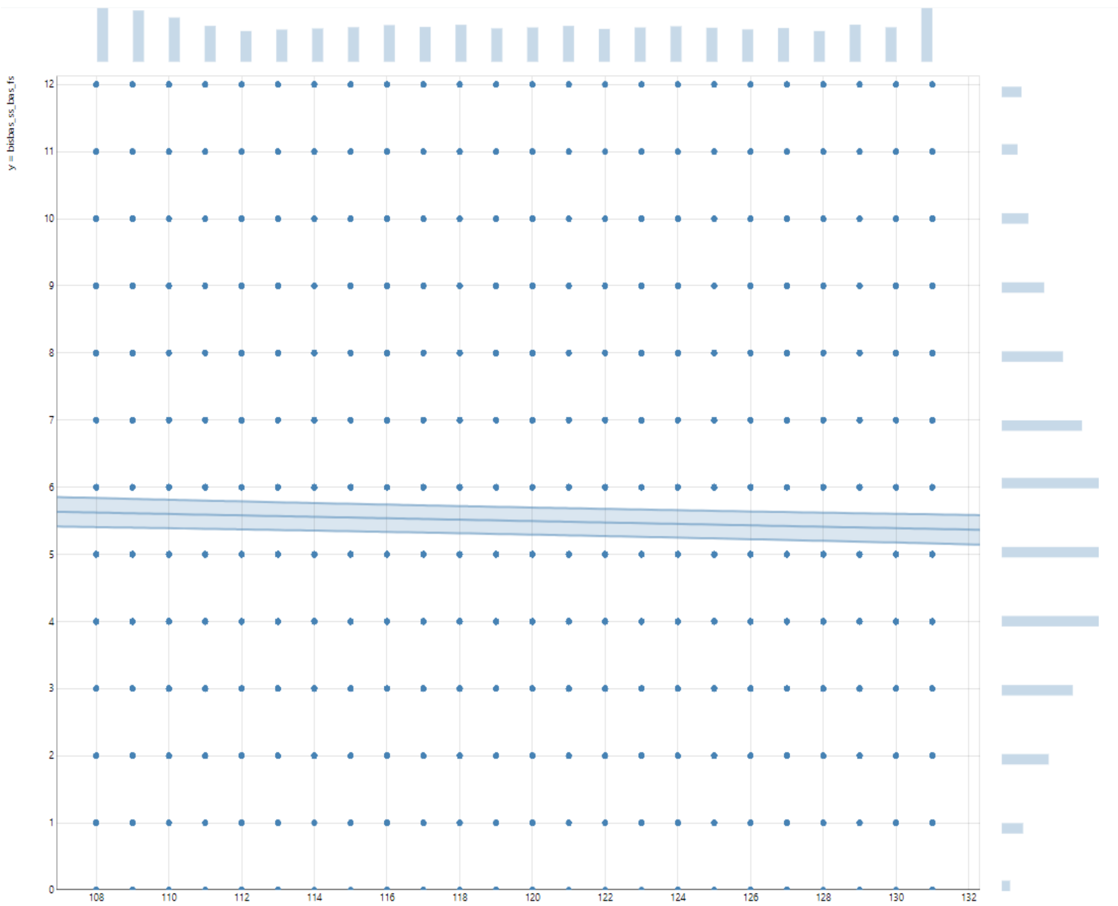


Figure 2. Association between Age and Reward Sensitivity Overall

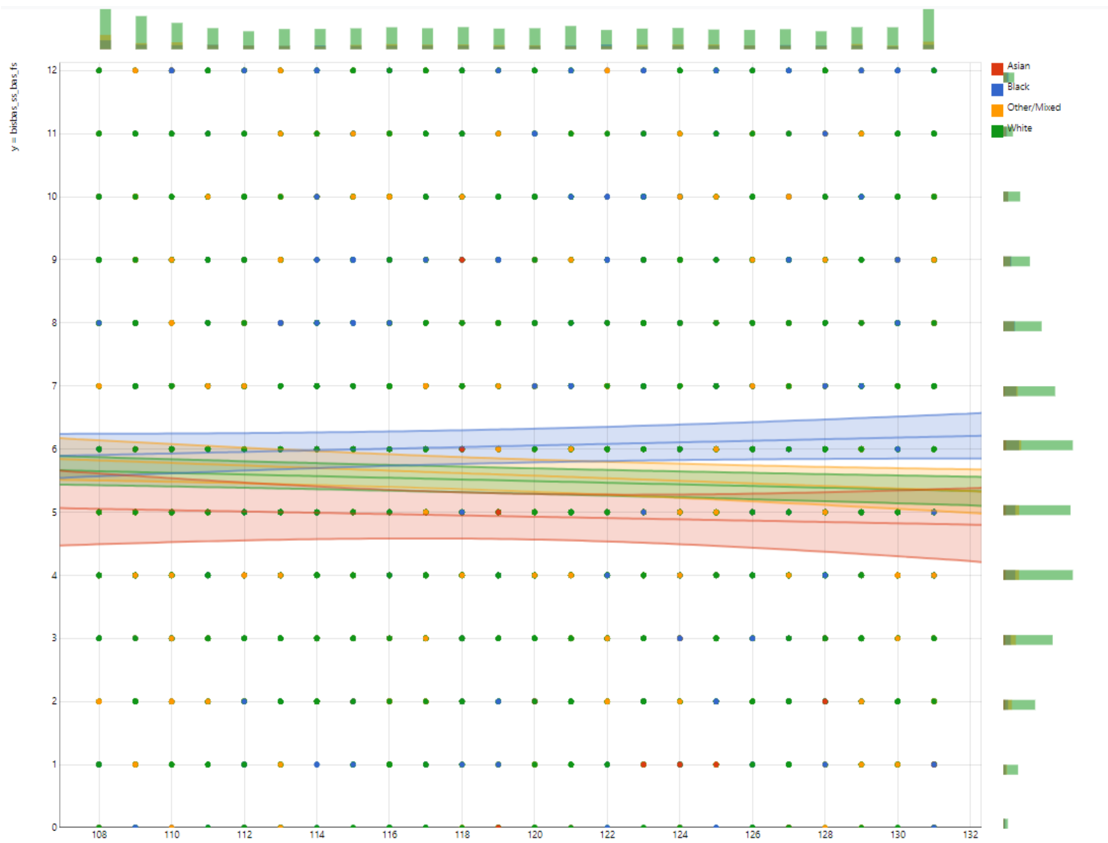


Figure 3. Association between Age and Reward Sensitivity by Race

4. Discussion

This study showed an inverse link between age and reward sensitivity overall; however, this was stronger in White children than Black children. That is, while age reduces the reward sensitivity for American children, this protective effect of age is weaker in Black children than White children. As a result, older Black children maintain their high reward sensitivity; a pattern that is absent in White children.

The observed MDRs of age on reward sensitivity reported here are very similar to the previous publication on the MDRs of parental education, and household income on fun seeking (Assari, Akhlaghipour et al., 2020), reward responsiveness (Assari, Boyce, Akhlaghipour et al., 2020), impulsivity (Assari, Caldwell, & Mincy, 2018a), inhibitory control (Assari, 2020b), and ADHD (Assari & Caldwell, 2019a). Similar MDRs are also reported for the effects of family SES on aggression (Assari, C. H. Caldwell et al., 2019), and substance use (Assari, C. H. Caldwell, et al., 2019), as well as social, behavioral, and emotional problems (Assari, Boyce, Caldwell, & Bazargan, 2020) such as anxiety (Assari, Caldwell, & Zimmerman, 2018) and depression (Assari & Caldwell, 2018a). These are all examples of diminishing returns of family SES in Black youth compared to White youth (Assari, 2018a, 2018c, 2019; Assari, Farokhnia, & Mistry, 2019).

The MDRs are believed to be due to society and not to the culture, behavior, or biology. Thus, age does not have a weaker effect on reward sensitivity in the Black population compared to the White population because the Black population is innately weaker than the White. Similarly, the diminished slope is not because the Black and the White are biologically different. This is evident because similar MDRs are shown for all marginalized groups with a range of marginalizing identities (Assari, 2017b; Assari, 2018). Thus, they are not specific to the Black group (Assari, Thomas, et al., 2018) but are also reported among Hispanics (Assari, 2018e; Assari, 2019; Assari, M. Farokhnia, et al., 2019; Shervin & Ritesh, 2019), Asian Americans (Assari, Boyce, Bazargan, & Caldwell, 2020), Native Americans (Assari & Mohsen Bazargan, 2019), LGBs (Assari, 2019), immigrants (Assari, 2020a), or even marginalized Whites (Assari, Boyce, Bazargan, Caldwell, & Zimmerman, 2020). They are also not specific to a particular age group, as documented for children (Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas, et al., 2018), adults (Assari, 2018a), and older adults (Assari & Lankarani, 2016a). Finally, these MDRs are relevant to economic resources such as SES (Assari, Preiser, Lankarani, & Caldwell, 2018; Assari, M. Farokhnia, et al., 2019; Assari, Caldwell, & Mincy, 2018a; Assari, 2018d; Assari, Caldwell, & Zimmerman, 2018) and non-economic assets such as self-efficacy (Assari, 2017a; Assari & Lankarani, 2016b) and age (Chalian, Khoshpouri, & Assari, 2019).

A wide range of sociological and economic mechanisms explain the MDRs of age and family SES on reward sensitivity in Black related to White families. Black families experience high levels of stress across all SES levels (Bowden, Bartkowski, Xu, & Lewis Jr, 2017). Upward social mobility is more stressful on Black than White families (Chetty, Hendren, Kline, & Saez, 2014). At all SES levels, exposure (Assari, 2018b; Assari, F. X. Gibbons, & R. Simons, 2018a; Assari, F. X. Gibbons, & R. L. Simons, 2018b; Assari, Lankarani, & Caldwell, 2018; Assari & Moghani Lankarani, 2018) and vulnerability (Assari, Preiser, et al., 2018) to discrimination is high for Black families. While low SES Black families struggle with food insecurity, poverty and neighborhood disorder, high SES Black families experience discrimination due to a proximity to the Whites (Assari, Gibbons et al., 2018a; Assari, Gibbons et al., 2018b). As discrimination reduces the chance of healthy brain development (Assari & Caldwell, 2018b; Assari, Lankarani et al., 2018; Assari, Preiser et al., 2018), Black children may remain at a risk of impulsivity all across the SES spectrum.

While low SES and poor outcomes are one of the disadvantages types in Black communities, MDRs reflect a qualitatively different set of disadvantages (Assari, 2017b; Assari, 2018). Knowing that the former is reflective of unequal outcomes and opportunities, the latter is reflective of low response to the presence of individual level resources. It is due to the latter that policymakers may observe a sustained inequality despite investments. To address the latter, there is a need to address systemic causes of inequalities. As a result of these two jeopardies, Black groups are experiencing a double disadvantage, in which not only resources are scarce, but the influence of the individual level resources and assets are dampened, due to the environment (Assari, 2018; Assari, 2018f).

Multilevel economic and environmental mechanisms reduce the marginal returns of family SES (Assari, 2018; Assari, 2018f). MDRs are attributed to multi-level racism that functions across multiple societal functions and institutions (Assari, 2018; Assari, 2018f). Racial injustice, prejudice, and discrimination have historically interfered with the gain of resources and assets for the Black communities (D. Hudson, Sacks, Irani, & Asher, 2020; D. L. Hudson, Bullard et al., 2012; D. L. Hudson, Neighbors, Geronimus, & Jackson, 2012). One of the many causes of MDRs might be childhood poverty (Bartik & Hershbein, 2018). As a result of such an environmental and structural injustice, we observe MDRs among resources, assets, outcomes, settings, and age groups.

4.1 Limitations

The current study, similar to other studies using existing data, comes with some methodological shortcomings. First, because of a cross-sectional design, it is inappropriate for us to draw any causal inferences. Thus, the findings reported here are correlations, not causes. Similarly, we only tested the MDRs of age. Previous work had established MDRs of family SES with similar outcomes (Assari, Caldwell, & Mincy, 2018a; Assari, 2020b; Assari, Akhlaghipour et al., 2020; Assari, Boyce, Akhlaghipour et al., 2020). Future research should test if MDRs of SES explain MDRs of age. In addition to that, were only controlled family-SES and individual-level SES indicators. It is imperative to test if the contextual and neighborhood level indicators cause the MDRs observed here. Finally, we did not study how the observed MDRs contribute to the Black and White inequality in risk-taking.

5. Conclusions

Relative to their White counterparts, Black children show higher levels of reward sensitivity within all age groups. This is important because reward sensitivity is a risk factor for a wide range of high-risk behaviors. To minimize the Black-White gap in brain development and to reduce high-risk behaviors in Black children, there is a need to address societal barriers causing MDRs of resources and assets in Black communities and families. There is a need for public, social, and economic policies that go beyond individual-level risk factors and address systemic, structural, and societal causes of inequalities.

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ABCD consortium investigators. ABCD consortium investigators designed and implemented the study and/or provided data but did not necessarily participate in analysis or writing of this report.

Conflicts of Interest: The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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