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Economic Rationality in Youth With Emerging Mood Disorders

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Cognitive difficulties are common in persons experiencing anxiety or mood disorders. In this article, we explore the economic concept of rational decision-making in young people with emerging mood disorders by using incentive-compatible experiments involving choices over consumer products. At 2 time points, separated by 6–8 weeks, we measured irrational decision-making (defined as violations of the Generalized Axiom of Revealed Preference) concurrently with levels of anxiety and depression levels using the 10-item Kessler Psychological Distress Scale (K10); the 17-item Quick Inventory of Depressive Symptomology, Adolescent Version (QIDS-A17); and the 12-item Somatic and Psychological Health Report (SPHERE-12) in 30 participants (mean age 19.22 years, 19 male) attending a youth mental health clinic. In total, 15 (50%) participants rated high on all three psychological questionnaires combined, scoring "severely" depressed (QIDS-A17 $\geq$ 16), "severely" anxious (K10 $\geq$ 30), and "Level 1 (Type 1)" (SPHERE-12). In Session 2, taking attrition into account, we estimated that of our returning 25 patients, 11 (44%) participants continued to rate high on all three psychological scores. We found that the degree of economic irrationality was higher in young people with more severe mood disorder symptoms (anxiety measured by K10, Pearson's correlation $r = .406$, $p = .026$). These results may have implications for both characterization and treatment of common mood disorders in young people.

Keywords: decision-making, anxiety, depression, emotion, adolescents

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All data generated or analyzed during this study are included in this published article (and its online supplemental materials).

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Adolescents, unlike children, start making important decisions for themselves in a variety of decision-making domains such as social, educational, health, and financial. Unfortunately, statistical evidence suggests that adolescents make decisions that are detrimental to their well-being. For example, mortality rates double in adolescence (Dahl, 2004), and ~77% of these deaths can be attributed to impaired decision-making rather than diseases such as cancer (Eaton et al., 2006). Behavioral studies with healthy adolescents found that they indeed behave differently, for example, they are more reckless and impulsive (Pharo, Sim, Graham, Gross, & Hayne, 2011) and more tolerant of ambiguity (Pharo et al., 2011; Tymula et al., 2012) compared with young or midlife adults.

The reasons for why adolescents make suboptimal decisions that hurt their well-being are not fully understood yet. Research suggests that during adolescence, young people are at their highest lifetime risk of onset of mental health difficulties (Davey, Yücel, & Allen, 2008; Pfeifer et al., 2011; Steinberg, 2008). Young people with mood disorders are often reported to have impairments in many cognitive functions including poor concentration, memory deficits, response disinhibition, and impaired decision-making (Browning, Behrens, Jocham, O'Reilly, & Bishop, 2015; Cáceda, Nemeroff, & Harvey, 2014; Davey et al., 2008; Mukherjee & Kable, 2014; Murphy et al., 2001). More specifically, mood disorders have been shown to have an adverse impact on economic participation, including absenteeism from work and education, and unemployment (Clark et al., 2017; Scott et al., 2014). Although much cognitive research has been done on the impact of more severe disorders, such as major depressive, bipolar, or psychotic disorders on functional impairment (Connor, Ford, Pearson, Scranton, & Dusad, 2017; Hatton et al., 2012; Hermens et al., 2013; Scott et al., 2014; Tickell et al., 2019), little research has addressed the impact of more subtle and more common mood disorders on economically relevant decision-making during adolescence, a critical developmental period (Harlé, Allen, & Sanfey, 2010). A study evaluating social decision-making found that depressed individuals aged 18–24 accepted more "unfair" offers, which is a lower monetary outcome in the social economic task, the Ultimatum Game, as compared with the nondepressed control group (Harlé et al., 2010). However, rational decision-making as defined by the economic literature has not been studied in mental disorders, even though it seems to be particularly relevant question especially in a youth population.

To examine the impact that dysregulated mood has on rational decision-making, we focused on mood disorders—anxiety and depression and used an economic definition of rationality. For each participant, their mood and economic rationality was measured twice, at two time points that were scheduled 6–8 weeks apart. This design allowed us to assess the correlation between dysregulated mood and rationality between participants and within participants over time.

We draw on economic theory where a rational decision-maker is conceptualized as one who has some internal representation of the utility of each feasible alternative and who then chooses the option with the highest utility (i.e., the one giving the highest satisfaction; Glimcher & Fehr, 2014). Unlike perceptual decision-making, where physical features can be measured directly, value-based preference can only be inferred from the observable choices of the participants. Samuelson (Samuelson, 1938) initially proposed a revealed preference theory that created axiomatic choice patterns necessary for utility maximization. Later, the revealed preference approach was extended to identify the necessary and sufficient conditions that if obeyed indicate that subjects make choices in a utility maximization manner (Afriat, 1972; Houthakker, 1950; Varian, 1982). Houthakker demonstrated that the necessary and sufficient condition for individuals to maximize utility is for them to obey the Generalized Axiom of Revealed Preference (GARP; Houthakker, 1950; Varian, 1982). The number of GARP violations is the measure of economic irrationality in our study.

To understand the logic of GARP, consider a person choosing between three affordable treatments: Treatment A, Treatment B, and Treatment C. Imagine that this individual selects Treatment A when Treatment B is available. Imagine that the same individual selects Treatment B when Treatment C is available. GARP says that if we present this individual with a choice between Treatment A and Treatment C, this individual should prefer Treatment A. Such

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transitivity in choice is considered a prerequisite for rationality in economics because if people violate it, they can be exploited via repeated trade. Previous research has shown that young children (Harbaugh, Krause, & Berry, 2001), people with prefrontal cortex damage (Camille, Griffiths, Vo, Fellows, & Kable, 2011), and older people with less gray matter volume in the prefrontal cortex (Chung, Tymula, & Glimcher, 2017) show increased deviation from economic rationality in their choices.

In this study, our goal is to determine whether the relationship between emerging mood disorders and rationality in decision-making exists. Based on previous studies on mood disorders and impairments in cognitive functionality, we hypothesized that young people who experience more severe symptoms of emerging mood disorders, such as anxiety and depression, would show more inconsistency in their economic decision-making.

Method

Participants

A total of 30 participants (19 male, 11 females, M_{age} = 19.2 years, age range: 16–25 years, SD = 2.23 years) were recruited through The University of Sydney Youth Services Clinics (Headspace) in Camperdown and Campbelltown, New South Wales, Australia. Potential participants were screened by their clinicians from Youth Services Clinics to qualify to participate in the study. Key inclusion criteria for this study were (a) age between 16 and 25 years, (b) seeking professional help primarily for a depressive (unipolar or bipolar) syndrome, (c) sufficient fluency in the English language to complete the decision task, (d) no history of neurobiological disease (e.g., head trauma), (e) lack of any intellectual and/or developmental disability, (f) no allergies or dietary sensitivities, (g) abstaining from drug and alcohol use for 48 hr before the appointment, and (h) willingness to participate in two experimental sessions: one on the day they signed up for the study and one ~6–8 weeks later. Study investigators were blind to the duration and type of therapeutic or pharmacological intervention participants were given. All participants were issued Participants Information Statements as part of recruitment for the study. Informed consent was obtained from all study participants. The University of Sydney Human Research Ethics Committee approved the study and the methods were carried out in accordance with the relevant guidelines and regulations. The demographic characteristics of our participants are presented in Table 1. Five participants did not complete Session 2, leaving us with 25 participants completing both of the sessions.

Experimental Procedures

Mood measurement. We assessed participants' mood scores using three psychological self-report questionnaires: the Kessler Psychological Distress Scale (10 items; K10; Kessler et al., 2003), the Quick Inventory of Depressive Symptomatology, Adolescent Version (17 items; QIDS-A17), specifically designed for adolescents (Rush et al., 2003), and the Somatic and Psychological Health Report (12 items; SPHERE-12) questionnaire (Hickie, Davenport, Hadzi-Pavlovic, et al., 2001). We acknowledge that there are varying approaches to the nature of the classification of mood states (Hickie, Naismith, Robillard, Scott, & Hermens, 2013; Hickie, Scott, Hermens, Naismith, et al., 2013). The purpose for evaluating mood using three separate psychological questionnaires is to account for their variations. These mood measures evaluate various aspects of what could be an

Table 1
Background Information

Session	*N*	Sex ratio (M: F)	Age (years)	Education (participant)	Education (mother)	Education (father)	Wealth
Session 1	30	19:11	19.22 (2.23)	3.23 (1.01)	3.73 (1.11)	3.69 (1.23)	6.33 (1.79)
Session 2	25	16:09	19.09 (2.15)	3.24 (1.01)	3.80 (1.12)	3.75 (1.26)	6.52 (1.76)

Note. M = male; F = female. Education: 1 = primary; 2 = Year 10; 3 = Year 12; 4 = Tafe College; 5 = undergraduate; 6 = postgraduate. Wealth is self-assessed: 1 = very poor; 10 = very rich. Standard deviations are in parentheses.

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emerging or underlying disorder that do not fully overlap. For example, K10 measures anxiety that presents as a trait like symptom, as compared with evaluating state-like symptom presentation such as depression, as measured using QIDS-A17. Depression is known to often present with somatic symptoms, such as pain, insomnia, and other complaints (Petersen et al., 1993). What is defined as "somatic" should not be confused with "somatomization," classified as medically unexplained somatic symptoms coupled with psychological distress and help-seeking behavior. The somatic may be presenting as a psychological illness (such as depression) and vice versa. For this reason, we included the SPHERE-12 questionnaire, which has been used in large, adolescent studies (Hansell et al., 2012) to understand if depression is presenting in this way. In what follows, we give a more detailed account of the battery of tasks.

The *K10* evaluated participant's severity of anxiety on the day of the study. K10 total scores range between 0 and 50 (10–19 likely to be well, 20–24 likely to have a mild disorder, 25–29 likely to have a moderate disorder, 30–35 likely to have a severe disorder; Kessler et al., 2003). The K10 is a general measure of an individual's depression and anxiety (Kessler et al., 2003). Each question asks participants to self-rate anxiety and depressive symptoms (fatigue, restlessness, nervousness, hopelessness, sadness, worthlessness and effort) that they may have experienced in the recent 4-week period. For example, participants are asked to rate on a scale from 1 (*none of the time*) to 5 (*all of the time*) responses to the following questions: "During the last 30 days, about how often did you feel that everything was an effort?" and "During the last 30 days, about how often did you feel restless or fidgety?" Total K10 score ranges from 10 to 50, with scores of 10–19 suggesting the individual is likely to be "well," and higher scores indicating distress. A score of >30 is typical of severe mental disorder (Scott et al., 2013).

QIDS-A17 assessed the severity of participants' depressive symptoms, on the day of testing sessions and for the previous 7 days (Rush et al., 2003). QIDS-A17 total score ranges between 0 and 27 (0–5 Not Depressed, 6–10 Mild, 11–15 Moderate, 16–20 Severe, >21 Very Severe). QIDS-A17 total score ranges between 0 and 27 (0–5 Not Depressed, 6–10 Mild, 11–15 Moderate, 16–20 Severe, >21 Very Severe). QIDS-A17 covers additional domains of depression, including sleep, mood, weight, decision-making, suicide, self-outlook, energy rating, social outlook, and psychomotor movement. The ratings in these nine domains allow for the characterization of depression (Bernstein et al., 2010). This rating scale is used to assess the severity of participants' depressive symptoms, on the day of testing sessions and for the previous 7 days (Rush et al., 2003). It includes a total of 17 questions that ask participants to rate their sleep, mood, weight, decision-making, suicide, self-outlook, energy rating, social outlook and psychomotor movement on a scale from 0 to 4.

SPHERE-12 is a tool that identifies psychological and/or physical symptoms commonly experienced by young people with depression and anxiety and somatization (Berryman, McAuley, & Moseley, 2012; Hickie, Davenport, Scott, et al., 2001). SPHERE-12 can act as a combination of somatic and psychological screening tools. The questionnaire is divided into six PSYCH items and six SOMA items and participants rated how troubled they felt in these areas over the past weeks. PSYCH refers to psychological distress, and SOMA to the physiological distress. Positive scores on both scales reflect a mix of PYCH and SOMA, classified as Level 1 (Type I) where these are the most symptomatic patients; Level 2 (Type II) where patients reports PSYCH subscale or psychosocial symptoms only; Level 2 (Type 3) where patient reports SOMA subscale or somatic symptoms only; and finally, "No Symptoms," where patient reports insufficient psychosocial and somatic symptoms to justify any mental order characterization.

All three mood questionnaires were administered by the researcher before the economic experiment started. At Session 1 participants met with their clinicians before they participated in the study. Participants scheduled to complete Session 2 directly with the researcher, who did not know whether a clinical session was booked on the day of the study.

Rationality in decision-making measurement. We assessed economic rationality using an experimental task originally designed to study development of economic rationality across the life span (Harbaugh et al., 2001). This task has since been used in both economics

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(Brocas, Carrillo, Combs, & Kodaverdian, 2016; Burghart, Glimcher, & Lazzaro, 2013) and neuroscience (Camille et al., 2011; Chung et al., 2017) research. To allow for direct comparison with these earlier studies, we used the same procedures and rewards as were previously used by Harbaugh (Harbaugh et al., 2001) in experiments for youth.

In the decision task, participants were asked to select their preferred bundle from up to seven different options presented on the computer screen. Each bundle consisted of some quantity of cookies and juice boxes (recognized home brand). Figure 1 shows an example of a screenshot of one of the decision trials in the experiment. Here an individual has seven bundles of different quantities of juice and cookies to choose from. In this example, goods (juices or cookies) trade one-for-one—to have one more cookie, the participant needs to give up one juice box. Participants were instructed to select a bundle that they liked the most from those displayed on their individual screen by clicking with their mouse on that image. For example, in Figure 1, if they preferred the bundle with two juice boxes and four cookies (lower left corner), they would click on the picture of that bundle. After each selection, participants were told to double check their answer (which could be changed at that point) before they moved to the next trial at which point, they could not change their decision anymore. Participants could take as much time as they needed to consider their choices and make their decisions. Therefore, any observed violations of rationality could not be due to time pressure.

The task consisted of 11 unique trials with different choice sets (each with three to seven different bundles to choose from). We visualize all choice sets in Figure 2 where the dots represent bundles (options) and lines represent choice sets (trials). The straight line between linking points (0,6) and (6,0) shows the example trial presented in Figure 1. Some of the lines are steeper than others, which captures the relative tradeoffs between the two goods. In our example from Figure 1, the slope of the choice set line is equal to -1; moving down the line, every time the number of juice boxes (Good 1) decreases by one, the number of snacks (Good 2) increases by one. When the slope is steeper, the number of juice boxes the participant has to surrender to get one more snack decrease. In our steepest choice set, one snack is worth three juice boxes. The relative price of a snack is higher because by "selling" one snack the individual can "buy" three boxes of juice in this choice set. The choice trials were presented in an order randomized independently for each participant. The researcher was not in the room when participants completed the task.

We define rationality as consistent with the GARP. In Figure 2 right, we demonstrate a hypothetical example of a GARP violation. The

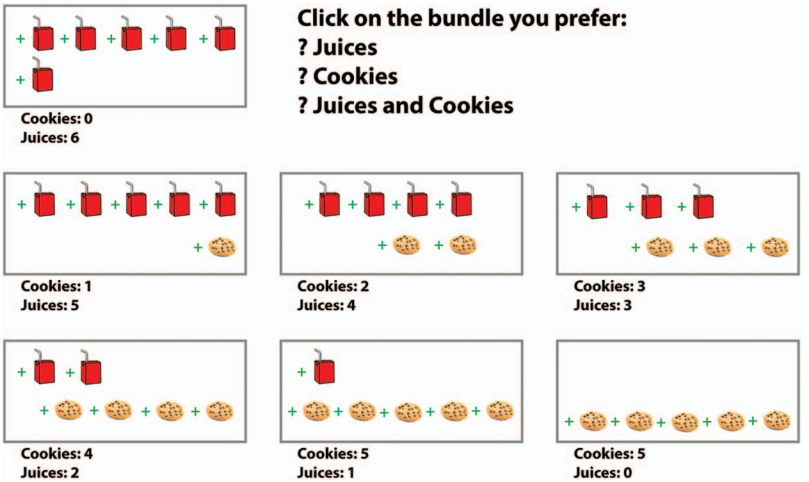

Figure 1. Experimental design. Sample screenshot of one trial from the experiment.

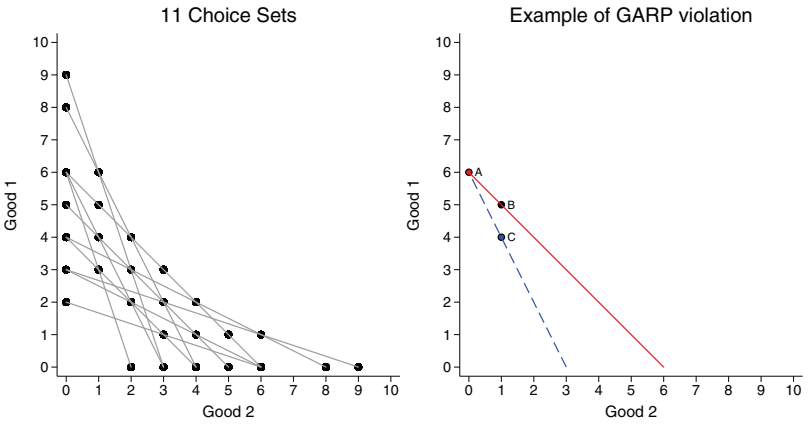

Figure 2. GARP violations. Left: All 11 choice sets used in the experiment. Right: One example of choices that violate GARP. GARP = Generalized Axiom of Revealed Preference.

red dot labeled (A) depicts the bundle that a participant selected from the red, solid line choice set. The blue dot labeled (C) depicts the bundle that a participant selected from the blue, dashed line choice set. These two choices together form a violation of GARP. That is, because the red bundle (A) was selected from red solid line choice set, we can conclude that (A) was revealed to be preferred to all other bundles on the solid red line. Similarly, we can conclude that (C) is preferred to all bundles on the blue dashed line, including bundle (A). Now notice that, by monotonicity (the assumption that more is preferred to less), bundle (B) must be preferred to bundle (C) because it has more of good one and the same quantity of good two. Because (B) is better than (C) and (C) is better than (A; recall the choice from blue dashed bundle), a chooser who obeys GARP should prefer (B) over (A). Therefore, by choosing (A) out of red solid choice set when (B) is available, the participant violated GARP. For more explanation, the reader can turn to Varian (Varian, 1982) and Chung, Tymula and Glimcher (Chung et al., 2017). In this article, we present results with the *sum of the GARP violations in choices* as the economic rationality score. An economically rational participant will make zero GARP violations, and the participant showing the most severe deviation from economic rationality will have 11 GARP violations in this task. In addition to GARP, we report results using two alternative measures of economic rationality in online supplemental materials, Section 7.

Participants were told that at the end of Session 1 their choices may be randomly picked and realized as actual payment and therefore they should pay attention to their choices. Because every choice had a probability of being realized, the choosers had a real incentive to reveal their true preferences in each of their choices. To reinforce to the participants that the rewards are real, we showed them the actual items and the amounts of items before they started the experiment. In addition to this task, subjects also performed a task that measured their patience and attitudes toward risk and ambiguity. These results will be reported elsewhere.

Control measures. In the first session, participants completed a demographic questionnaire including age, gender, education level, their father's and mother's/guardian's education level, postcode, and income. The demographic information was captured after the participants completed the mood assessment questionnaires and economic tasks but before they received their payment.

Timeline of the experiment. Participants first completed mood assessment questionnaires and then the incentive-compatible decision-making tasks. Participants took part in two sessions: Session 1 (immediately after their appointment with the clinician) and an identical Session 2 that took place 6–8 weeks later.

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Results

Clinical Profile

Out of 30 patients in Session 1, 26 were experiencing a mental health condition according to their answers to our questionnaires. In total, 15 (50%) participants rated high on all three psychological questionnaires combined: "severely" depressed (QIDS-A17 $\geq$ 16), "severely" anxious (K10 $\geq$ 30) and "Level 1 (Type 1)" for SPHERE-12 (see Figure 3A). Based on their psychological scores, five participants did not have any condition.

In Session 2, 20 out of 25 participants experienced a mental health condition. In total, 11 (44%) participants rated high on all three psychological scores: "severely" depressed (QIDS-A17 $\geq$ 16), "severely" anxious (K10 $\geq$ 30), and "Level 1 (Type 1)" for SPHERE-12 (see Figure 3B).

At the second appointment, 6–8 weeks later, only slight changes occurred individually on the self-reported anxiety and depression measures (compare Figure 3A and Figure 3B). Among the 25 participants who came back for Session 2, we found no significant changes in their mood scores over time (see Table 2), and there was a significant positive correlation between scores in Session 1 and Session 2 for K10 and QUIDS-A17. The results showed very little change in mood for the group, that is, stability in the mood measures.

Decision-Making

In Session 1, participants had a mean average of 3.23 GARP violations (*SD* 3.36) and only 40% (12 out of 30 participants) made no GARP violations. Economic rationality scores between Session 1 and Session 2 were not significantly different (3.4 violations in Session 1 and 2.44 in Session 2, $p = .270$ in paired t test). To better understand how strong the impairment in economic rationality is in our sample, we compare our sample to previous study (Harbaugh et al., 2001) of individuals of similar age (mean average age 21). The proportion of fully rational individuals (who made no GARP violations) is lower than the proportion of such individuals (65%) among college undergraduates in Harbaugh's study (Harbaugh et al., 2001). Compared with participants in the Harbaugh study, our participants, despite being much older, place on their rationality scores somewhere around what would be the expected scores of fourth graders (see Table S6 in the online supplemental materials). We note that because of the lack of detailed information about the participants in their study (i.e., their mood states), the results should be interpreted cautiously.

Relationship Between Economic Rationality and Mood

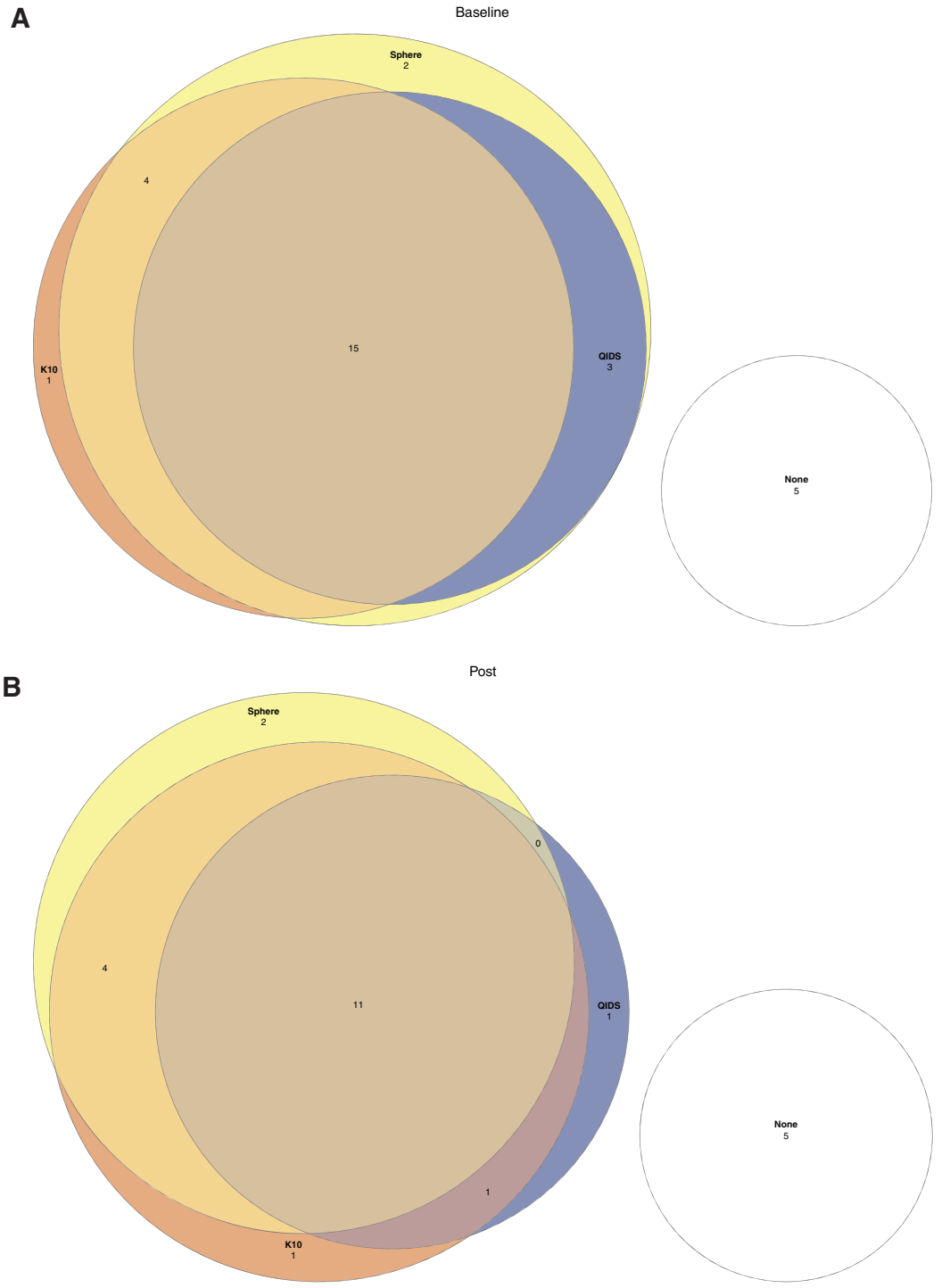
To assess the relationship between mood changes and changes in economic rationality, we conducted a multivariate analysis with economic rationality scores from two sessions as dependent variable and anxiety and depression scores as independent variables. We found significant relationships between economic rationality and K10 (anxious) and SPHERE-12 (depressive) scores. However, after controlling for age, gender, and income, only K10 score was a robust predictor (Table 3, Model 2).

Although QIDS-A17 and SPHERE-12 did not have a robustly significant relationship with economic rationality, we note that the coefficients on mood scores were positive for all tests, consistent with a decrease in economic rationality as mood symptoms become more severe (Table 3). We present the individual data illustrating the relationship between mood scores and economic rationality in Figure 4.

Discussion

Recently, studies have recognized the importance of researching emerging mood disorders in adolescents to potentially develop better prevention and treatment in their early stages (Gershon, Johnson, Thomas, & Singh, 2018; Grierson et al., 2016; Kaur et al., 2019; Scott et al., 2014). Large epidemiological surveys longitudinally provided information on the lifetime prevalence, correlates, and treatment of mood disorders (Avenevoli, Swendsen, He, Burstein, & Merikangas, 2015; Merikangas et al., 2010). However, we still do not have a proper understanding of whether there is a relationship between emerging mood disorders and impaired decision-making in adolescents, especially using measures that make economic sense.

Many researchers suggest that decision-making in patients with mood disorders is im-



. *Figure 3.* (*opposite*)

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Table 2
Average Mood Scores in Session 1 and Session 2 for 25 Participants Who Attended Both Sessions

Session	K10	QIDS-A17	SPHERE-12
Session 1	29.3	13.6	1.1
Session 2	27.6	13.3	1.1
Paired t test (*p*)	1.68 (.16)	0.32 (.81)	0.00 (1.00)
Correlation coefficient (*p*)	0.80 (<.01)	0.39 (.06)	−0.04 (.84)

Note. K10 = 10-item Kessler Psychological Distress Scale; QIDS-A17 = 17-item Quick Inventory of Depressive Symptomology, Adolescent Version; SPHERE-12 = 12-item Somatic and Psychological Health Report. The paired *t*-test reports the difference between the means of each mood measure and in Sessions 1 and 2 and its significance in parentheses. The correlation coefficient reports the correlation between the mood measures from Session 1 and Session 2 and its significance in parentheses.

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paired (Davey et al., 2008; Harlé et al., 2010; Mukherjee & Kable, 2014). Here, we presented results that young people with more severe symptoms of anxiety demonstrated greater deviations from rational decision-making as measured by the violations of the GARP (Houthakker, 1950). Although based on a small sample due to the challenge to recruit an ill-health youth population in a clinical setting, this is the first study, to our knowledge, to demonstrate an association between a relevant mood state (anxiety) and economic rationality in adolescents. Our article does not take any particular theoretical position on the causes of the psychological and physiological symptoms of the mood disorders. However, the finding that adolescents who suffer more severe anxiety symptoms are more inconsistent in their economic decision-making may be suggestive for characterization of the disorder and its treatment.

Our empirical findings add to a growing body of literature suggesting that help-seeking youth with an emerging mood disorder arriving for treatment for mental health care are volatile in their economic decision-making (Davey et al., 2008; Harlé et al., 2010; Mukherjee & Kable, 2014). Our findings align with the studies that identified that anxious and depressed adults and adolescents made suboptimal choices (Cáceda et al., 2014; de Ridder, Kroese, Adriaanse, & Evers, 2014; Han et al., 2012; Larquet, Coricelli, Opolczynski, & Thibaut, 2010; Takahashi et al., 2008). It is known that depressed individuals care less about the outcomes of their overall decisions (Harlé, Guo, Zhang, Paulus, & Yu, 2017), especially decisions related to financial rewards (Harlé & Sanfey, 2007; Henriques & Davidson, 2000).

At the neurobiological level, previous studies suggest that biological factors may correspond to both the economic rationality and mood disorders. Recent neuroimaging studies suggest that neuroanatomical variations, such as decreased gray matter volume in the prefrontal cortex, may account for GARP violations (Chung et al., 2017). Other larger studies found that anxious and depressed patients, specifically those with major depressive disorders, had similar neuroanatomical variations in prefrontal cortex and other brain regions (Korgaonkar, Fornito, Williams, & Grieve, 2014; Phillips, 2003; Schmaal et al., 2017). In addition to the

Figure 3.(*opposite*). (A) Mood condition at Round 1. Venn diagram presenting study participant numbers ($N = 30$) at Round 1 who rated as "severely" depressed (QIDS-A17 ≥ 16), "severely" anxious (K10 ≥ 30), and "Level 1 (Type 1)" for SPHERE-12. "None" are participants who did not show severe symptoms on any of the questionnaires. "None" does not mean a participant is generally well. This is their self-reported score on the day of the study. It may be a patient in treatment or a help-seeker at the clinic. (B) Mood condition at Round 2. Venn diagram presenting study participant numbers ($N = 25$), 6–8 weeks later, who rated as "severely" depressed (QIDS-A17 ≥ 16; $n = 1$), "severely" anxious (K10 ≥ 30), and "Level 1 (Type 1)" for SPHERE-12. "None" does not mean a participant is well. Their score is self-reported on the day of the study. They may be a patient in treatment or a help-seeker at the clinic. QIDS-A17 = 17-item Quick Inventory of Depressive Symptomology, Adolescent Version; K10 = 10-item Kessler Psychological Distress Scale; SPHERE-12 = 12-item Somatic and Psychological Health Report.

Table 3
Number of GARP Violations Regressed on Mood and Demographic Variables

	Economic rationality (GARP)			
Variables	(1)	(2)	(3)	(4)
K10	0.15* (0.06)	0.18* (0.07)	0.27* (0.10)	0.33** (0.09)
QIDS-A17	−0.10 (0.09)	−0.09 (0.09)	−0.15 (0.17)	−0.09 (0.18)
SPHERE-12	1.16* (0.49)	1.06† (0.63)	1.30 (1.27)	0.82 (1.84)
Female		0.38 (1.02)		−0.92 (1.15)
Age		0.21 (0.22)		0.47† (0.27)
Income		−0.24 (0.30)		−0.46 (0.42)
Constant	−1.47 (1.63)	−4.83 (4.35)	−4.05 (2.70)	−11.62 (7.40)
N	55	55	30	30
Random effects	Y	Y	N	N
Adj. R^2			0.14	0.25
R^2 within	0.03	0.03		
R^2 overall	0.14	0.18		
R^2 between	0.23	0.28		

Note. Models (1) and (2) use data from Session 1 and Session 2 analyzed with the random effects model with standard errors clustered on the individual reported in parentheses. Models (3) and (4) analyze data from the first session only using OLS with robust standard errors reported in parentheses. Female is an indicator variable equal to 1 if participant is female and 0 otherwise. Age is age in years. Income is self-rated from 1 (*very poor*) to 10 (*very wealthy*). GARP = Generalized Axiom of Revealed Preference; K10 = 10-item Kessler Psychological Distress Scale; QIDS-A17 = 17-item Quick Inventory of Depressive Symptomology, Adolescent Version; SPHERE-12 = 12-item Somatic and Psychological Health Report; Y = yes; N = no; OLS = ordinary least squares.
† $p < .10$. * $p < .05$. ** $p < .01$.

central nervous system, somatic levels, which could involve changes in bodily functions, may also play an important role. For example, our experimental setup gave participants discrete choices using food and beverage samples, but it is possible that their glucose levels on the day of the study could have biased their preferences. This is a recognized limitation of other decision-making studies in humans and especially youth (Hoyland, Dye, & Lawton, 2009; Lee, 2013; Orquin & Kurzban, 2016).

Another issue in relation to the neuroscientific approach is whether economic rationality in young people is associated with a particular stage of brain development. Are all adolescents more likely to violate GARP in general? Could the purported impact of emotion on economic decision-making be due to the natural brain

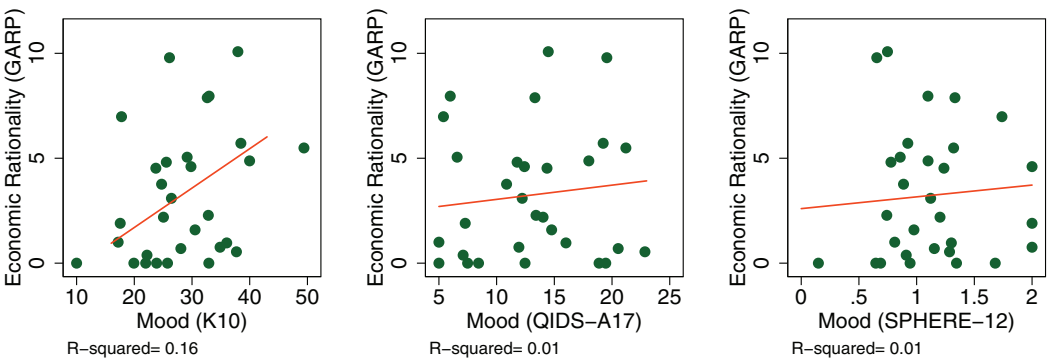

Figure 4. Relationship between economic rationality and mood scores in Session 1.

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maturation process of the developing adolescent (Baker et al., 2015)? Or is the onset of anxiety and depression that happens at this stage of life that intensifies the propensity to make irrational choices (Casey, Getz, & Galvan, 2008; Romer, 2010)? Surveying the literature, it turns out that the decline in economic rationality does not seem to universally hold for all youth. Harbaugh et al. (2001) using the same methodology as ours to quantify economic rationality found that economic rationality is established early on in adolescence in the general population. Our study adds to these findings by suggesting that adolescents who are more economically rational, also rate better on mood scores. To better understand the relationship between adolescent brain development, mood disorders, and rationality, further work could investigate other and larger youth populations, incorporating other longitudinal models. For example, the mental health clinical staging model could be used, which aims to pick up signs and symptoms in young help-seekers over time and before advanced depression arising (Hickie, Scott, Hermens, Scott, et al., 2013). Such an approach would support collaborative, international efforts at early intervention (Hansell et al., 2012).

Additionally, future research is necessary to establish whether economic rationality is malleable and whether young individuals can be taught how to make better decisions. Perhaps, as suggested in the literature, improving the quality of adolescents' decision-making can lead to better mood and alleviate depressive and anxiety symptoms. If these two phenomena go hand in hand, then part of the treatment for mood and depression could be expanded to include decision-making tasks. An important consideration is whether irrational decision-making may actually cause anxiety rather than just be its outcome. Studies show that when uncertain situations arise, such as the inability to gauge the situation, people have difficulty in making decisions, which can be anxiety inducing (Berns, Capra, Moore, & Noussair, 2008). This perspective suggests that improving decision-making skills among young people may emerge as a preventive approach or be an effective treatment. Hence, the time course of irrational decision-making of young people in relation to their mood is an important empirical question.

Overall, our study serves as evidence that economic measures can be applied to gain insight into human behavior. These results contribute novel insights to psychiatry.

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