Cognitive Development 36 (2015) 20–30

Contents lists available at ScienceDirect

Cognitive Development

The rational adolescent: Strategic information processing during decision making revealed by eye tracking

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ARTICLE INFO

Article history:
Received 19 November 2014
Received in revised form 24 July 2015
Accepted 11 August 2015
Available online 2 September 2015

Keywords:
Adolescent
Decision strategy
Eye tracking
Heuristics

ABSTRACT

Adolescence is often viewed as a time of irrational, risky decision-making—despite adolescents' competence in other cognitive domains. In this study, we examined the strategies used by adolescents ($N = 30$) and young adults ($N = 47$) to resolve complex, multi-outcome economic gambles. Compared to adults, adolescents were more likely to make conservative, loss-minimizing choices consistent with economic models. Eye-tracking data showed that prior to decisions, adolescents acquired more information in a more thorough manner; that is, they engaged in a more analytic processing strategy indicative of trade-offs between decision variables. In contrast, young adults' decisions were more consistent with heuristics that simplified the decision problem, at the expense of analytic precision. Collectively, these results demonstrate a counter-intuitive developmental transition in economic decision making: adolescents' decisions are more consistent with rational-choice models, while young adults more readily engage task-appropriate heuristics.

1. Introduction

Adolescence is commonly characterized as a period of unhealthy decision making; for example, adolescents are disproportionally likely to engage in risky behaviors such as reckless driving and abuse of addictive substances (Benthin, Slovic, & Severson, 1993; Parsons, Siegel, & Cousins, 1997; Viner et al., 2012). In recent years, much work has been done in cognitive and developmental neuroscience to explain the underlying mechanisms of adolescent decision making (for reviews see Blakemore & Robbins, 2012; Casey, Jones, & Somerville, 2011). The canonical model in the current scientific literature contends that adolescents make poor decisions because of a transient imbalance between a late-developing cognitive control system and an early-developing affect/reward system (Casey, Getz, & Galvan, 2008; Somerville, Jones, & Casey, 2010; Steinberg, 2005, 2010). Specifically, it is argued, development of the affect/reward system outpaces that of prefrontal cortex regions supporting cognitive control, driving adolescents to potentially engage in riskier, reward-seeking behavior.

Laboratory studies of decision making have typically tested predictions of the imbalance model through paradigms that directly contrast a safe option with a risky but higher-value option (i.e., something with higher expected value but also

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http://dx.doi.org/10.1016/j.cogdev.2015.08.001
0885-2014/

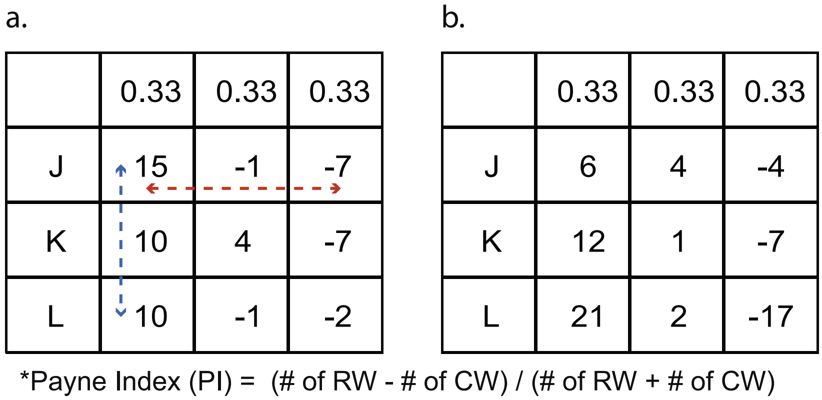

Fig. 1. Examples of structured (a) and random (b) trials from the gambling task. The rows are different gamble alternatives. The columns are potential gamble outcomes. In structure trials, a gamble alternative maximizes possible gain (G_{max}, response key "J"), maximizes the probability of positive (i.e., winning) outcomes (P_{max}, "K"), or minimizes possible loss (L_{min}, "L"). The top row displays the (rounded) probability of each outcome. In random trials, the three gamble alternative types are not defined. The red arrow in (a) depicts row-wise data acquisition (RW) and the blue arrow depicts the column-wise data acquisition (CW) used for calculating Payne Index. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

higher variance) (Burnett, Bault, Coricelli, & Blakemore, 2010; Harbaugh, Krause, & Vesterlund, 2002; Paulsen, Platt, Huettel, & Brannon, 2011). These paradigms can uncover tradeoffs between decision variables, such as whether decision-makers seek to minimize potential losses or maximize potential gains. However, such approaches can miss a critical aspect of decision making: the strategies by which an individual simplifies complex decision problems into something more manageable.

Strategic components of decision making have become a primary focus of decision science research in adult participants (Camerer, 2003; Gigerenzer & Goldstein, 1996; Payne, Bettman, & Johnson, 1988). Evidence shows that when faced with a complex decision space, people typically adopt one of many heuristic strategies to simplify the problem, excluding some information and prioritizing other information. The specific strategy to be adopted depends on the structure of the decision problem and the cognitive limitations of the individual (Simon, 1955). Importantly, heuristics support many forms of adaptive decision making—and decision performance can improve dramatically as people learn to apply the right heuristic in the right context (Johnson & Weber, 2009). Supporting this notion, older adults show greater reliance on heuristics during complex decision making to compensate for their reduced cognitive capacity (Peters, Finucane, MacGregor, & Slovic, 2000).

Much less is known about whether and how adolescents use heuristics in their economic decisions. One intriguing perspective from studies of reasoning and judgment argues that children and adolescents use heuristics less frequently than adults (Klaczynski, 2004; Reyna & Adam, 2003; Reyna & Farley, 2006), in part because of an inability to recognize contexts in which heuristics would apply. Maturation of cognitive abilities associated with the developing prefrontal cortex (Blakemore & Robbins, 2012; Casey et al., 2011) may be particularly critical for processes of pattern recognition and strategy selection (Venkatraman, Payne, Bettman, Luce, & Huettel, 2009). This leads to the strong but counterintuitive predictions that adolescents (compared to adults) exhibit *increased* consistency with rational-choice models of economic decisions and *decreased* use of simplifying heuristics.

In the current study, we used a complex economic gambling task that places rational-choice models and heuristics into opposition (Payne, 2005; Venkatraman et al., 2009; Venkatraman, Payne, & Huettel, 2014) (Fig. 1), while using eye-tracking measures to uncover the pattern of information processing that leads to a given decision (Glockner & Herbold, 2011; Johnson, Schulte-Mecklenbeck, & Willemsen, 2008; Krajbich, Armel, & Rangel, 2010). Specifically, when faced with decisions between pairs of gambles that contain a distribution of monetary gains and losses, adult participants reliably adopt overall *probability maximizing* choices in which they ignore the magnitudes of each potential gain and loss, instead focusing on the overall probability of winning compared to losing (Payne, 2005). Such choices are inconsistent with the predictions of traditional models of economic choice, including both expected utility (EU) maximization (Bernoulli, 1954; von Neumann & Morgenstern, 1944) and cumulative prospect theory (CPT, Tversky & Kahneman, 1992).

Choices, by themselves, can only provide partial and indirect evidence for heuristic use. Much stronger evidence could come from examination of the processes leading to choice—specifically, patterns of information acquisition and how that information is integrated into a decision. Using eye-tracking data, we characterized how the specific information acquired for a given gamble predicts choices, and how information acquisition and integration changes across time and decision contexts (Payne et al., 1988). By combining choice data with multiple measures of information acquisition behavior, as revealed through eye-tracking, our results provide strong support for a revised perspective on the development of economic decision making: from rational, analytic processing in adolescence to flexible, heuristic-based processing in young adulthood.