Introduction to Special Issue

"Understanding Cognition and Decision Making by Children"

Studying decision-making in children: challenges and opportunities *

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Abstract

Decision-making in children and adolescents is receiving increasing attention among economists. Studies shed light on opportunities for economists to understand the developmental causes of anomalous behavior in adults and to propose interventions at a young age capable of improving adult outcomes. Nevertheless, the study of children brings also new challenges that require methodological adjustments. Indeed, children are not little adults. They have their own ways of accounting for information, their own motivations, and their own limitations. These are critically linked to brain development and cognitive development, which operate in concert and shape behavior. These differences with respect to adult populations impose constraints on experimental designs. This special issue provides several examples of paradigms in which children behave differently from adults. All these studies share the need to account for age-related factors in the design of protocols. In this introduction, we discuss the pitfalls, challenges and opportunities associated with experiments in children and adolescents.

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1 Why study children?

Experimental economics has traditionally focused on adult behavior. Only recently has the field started to investigate more systematically the choices of children.[1] As emphasized in the recent surveys by Sutter et al. (2019) and List et al. (2018), most of the experimental literature on decision making by children and teens focuses on individual decision-making paradigms (rationality of choices, time preferences, risk preferences and social preferences), starting with the seminal contribution by Harbaugh et al. (2001). There are some exceptions of strategic games played by children (see e.g., Sher et al. (2014); Czermak et al. (2016); Chen et al. (2016); Brocas et al. (2017); Brocas and Carrillo (2018); Fe and Gill (2018)) and, to our knowledge, only two examples of market experiments (List and Millimet, 2008; Brocas and Carrillo, 2019b).

This Special Issue "Understanding Cognition and Decision Making by Children" presents an outstanding collection of articles on decision-making by children and adolescents. It is a representative, but by no means exhaustive, sample of the frontier research on the topic. The studies cover an impressive array of subjects (preferences, biases, emotions, strategic thinking), a large age span (from 3 to 18 years old participants), a global population (from Europe, America and Asia) and a variety of methods (field experiments, laboratory experiments, survey data) from researchers in both Psychology an Economics.[2] Rather than detailing the individual contributions of each paper, this introduction discusses the reason why economists should be interested in understanding developmental decision-making. It also addresses some pitfalls, challenges and opportunities that may be encountered when performing experiments with children and adolescents.

There are at least two reasons why economists should be interested in children. The first one is rooted in the wealth of knowledge that a developmental approach to decision-making can bring to the understanding of adult behavior. What we are is what we have become, and the process through which we become what we are is likely to hide important clues. In particular, irrational behavior may be a natural tendency that remains uncorrected or, on the contrary, an acquired reflex due to educational mistakes. For instance, self control is known to be limited throughout childhood and adolescence (Mischel et al.,

[1] Other non-traditional populations that have received attention recently include infrahumans, professionals, the elderly and institutionalized patients (see Fréchette (2016) for a focused review).

[2] Given the multidisciplinary nature of the special issue, we have deliberately relaxed the standard methodological requirements in economics and, in particular, considered papers that used deception. However, it is unlikely that a regular research article would survive the review process in this journal if it followed those procedures.

1969), and it remains underdeveloped among adults (Berns et al., 2007). At the same time, there is evidence that very young children test hypotheses against data and make causal inferences. Their learning and thinking are strikingly Bayesian (Gopnik, 2012) whereas adults are often prone to learning fallacies (Rabin and Vayanos, 2010). Even though studies have found correlations between certain types of behavior and potential factors such as general intelligence (Shamosh and Gray, 2008), the (causal) processes through which changes do or do not occur are still not well-understood. Finally, a developmental approach can help understanding the foundation of differences in behavior (see, for example, Houser and Schunk (2009) for a developmental study of differences in fairness and prosociality based on gender).

The second reason why economists may care about child development is the potential to bring economic knowledge and expertise to address salient issues, to design interventions and to contribute to solving societal problems. Economists are in a unique position to propose mechanisms to influence behavior among teenagers, for example in the context of substance abuse or risk taking. By identifying cognitive biases associated with such behaviors in the context of development, nudges can be designed to reinforce positive factors and improve behavior (Thaler and Sunstein, 2009). Researchers can also revisit the current educational environment to improve the outcomes of all children and decrease future inequality. Understanding the impact of cognitive and non-cognitive factors to life outcomes may help design an educational system that promotes good choices (Heckman and Rubinstein, 2001).

Even though the exploration of topics related to children and adolescents is relevant for the field of economics, research in the area requires a reassessment of the economic toolkit. In particular, studies should take into consideration the key developmental changes that occur from childhood to adulthood. Such changes place critical boundaries on how we can import our current questions and methods. Children are not little adults. They have their own cognition, their own ability to understand their environment and their own way to relate to others. Where an adult may be logical, a child may be creative; where an adult may feel challenged, a child may feel lost. Assessing how children make decisions requires reliable measures. At minimum, we need to adapt our current experimental methods to account for age-related cognitive limitations (such as those linked to attention and inhibition), as well as for differences in social intelligence. Policy research should also benefit from a reevaluation of its methods. For instance, there is no doubt (and much evidence) that schooling has positive effects on people's outcomes later in life. Increasing access to school is thought to be an efficient way to decrease inequality, raise income and improve adult health (Conti et al., 2010). However, these positive effects cannot be optimized if we do not understand why or how they operate. Does school improve the set of options of children or does it improve the ability to make the best possible choices when faced with suboptimal options? These questions cannot be answered if we do not understand how cognition and decision-making evolve and how each educational feature interacts with development.

2 Methodological Challenges

As emphasized above, laboratory experiments in Economics have, with notable (and increasing) exceptions, been predominantly conducted in a population of young, educated adults (typically, college students). The same is true in Psychology. Therefore, the experimental methods have been developed with this population in mind. Researchers have adapted protocols for laboratory experiments to the object of study, resulting in specific methods of describing what is expected from experimental subjects and specific procedures to elicit their responses. This implies in particular that scholars have put emphasis on designing experiments that ensure the comprehension and interest of highly educated adults. They have also relied on statistical analyses and inference methods that presuppose such comprehension is achieved.

Harrison and List (2004) recognize and emphasize the difference between studying college students and studying other populations, and propose a taxonomy to differentiate experiments depending on methods and populations. In this section, we take a complementary approach. We focus on one special group–children and adolescents–and discuss desirable adaptations of standard practices to this population. Naturally, we are not the first to think about this issue. Developmental psychologists have for a long time studied decision making in children and they have contributed a methodology that takes into account some of the considerations reviewed in the previous section. In particular, they pay close attention to the age range of participants and design experiments that optimize comprehension: young children need to manipulate objects (Glenberg and Robertson, 1999), older children still need visual representations and story-telling components (Boonen et al., 2014), and abstract tasks with abstract stories are rarely adequate. Some innovations and game presentations are extremely clever, for example, adapting the "Tower of Hanoi" game (Simon, 1975) to study planning by young children (Klahr and Robinson, 1981). However, the methodological differences in experimental practices between the two fields is long standing and still unresolved. Therefore, we believe it is valuable to provide general guidelines on how to adapt experimental protocols–within the economics methodology and for the paradigms of interest for economists–in order to obtain reliable information from the decisions of children.[3]

Typical economic lab experiments contain long instructions that require a significant attention span from participants. They feature monetary rewards and the protocols rely on abstract representations of rules, outcomes and rewards. The experiments involve a homogenous population and the results are rarely compared to the behavior of other groups. There are five major challenges that need to be taken into consideration when conducting experiments with young participants. First, children have limited attention. Second, children respond differently to incentives. Third, children have a limited ability to grasp abstract representations. Fourth, children do not develop uniformly. Fifth, children's behavior is best understood if it can be contrasted with adult behavior. These challenges impose strong limitations on the inferences that can be made when children participate in experiments designed for a different (adult) population. At the same time, they present opportunities for methodological innovations. In the next paragraphs we outline some modifications of standard procedures that may prove beneficial, together with a rationale for their inclusion. The advice is based on our experience running experiments with children. While we think we have accumulated a good grasp of the pros and cons of some procedures, we realize that the evidence is sometimes limited. We believe that developing systematic comparisons of experimental protocols in non-traditional populations is a fruitful line of research for scholars interested in methodological investigations.

1. Attention and motivation. Attention is one of the main challenges experimenters need to take into consideration when designing protocols for children. Tasks must be adapted to ensure that children in the tested age group are able to attend to the instruction period and are not lost, overwhelmed or simply bored by the task. It usually requires simplifying and shortening instructions compared to adult experimental sessions. It also requires decreasing the total length of the experiment, possibly by reducing the number of rounds involved. This inevitably results in some information sacrifice that needs to be accepted. A good rule-of-thumb for children up to middle school is to design an experiment that does not exceed one class period, which is usually 40 to 50 minutes long.

Because of the limited attention span of children, it is also helpful to introduce pauses and breaks between tasks, and even some breathing or gymnastic exercises in the case

[3] Fréchette (2016) discusses, albeit briefly, the methodological challenges posed by different populations, including but not limited to children.

of very young children (preschoolers and kindergartners).[4] Practice rounds where participants experience the consequences of different choices usually work better than instructions detailing all contingencies and implications. Finally, the motivation for participating in an experiment is also different between children and adults. While most adults are interested exclusively in maximizing their final payment, children expect to enjoy the experience. They are more likely to provide meaningful answers if the task is lively and engaging, that is, if they are happy to be participating (needless to say, it is still crucial to keep the experiment under control at all times).

2. Incentives and rewards. A related challenge in experiments with children is to obtain reliable responses. Studying decision-making requires producing a system of incentives to ensure that the task is perceived as a real choice with real consequences. The common way to accomplish this in economic experiments with adults is to allocate points to the decisions, which are then converted into money at the end of the session. However, young children do not care about money and older children do not care about it the same way as adults do. An experiment with children requires implementing an age-appropriate incentive scheme. In order to compare decisions across age groups, the researcher must equalize as best as possible marginal incentives and opportunity cost of time rather than equalize absolute payments. If laboratory experiments in economics typically pay college undergraduates $12-$20 per hour plus $5-$7 show up fee, we recommend as a rule-of-thumb a 25% to 33% decrease in exchange rate for middle school and high school students.[5]

Incentivizing younger children adequately is more involved. One method we (and some other researchers) favor is to set up a shop with pre-screened, age-appropriate toys, trinkets and stationery.[6] Before the session starts, the experimenter takes the children to the shop and shows the rewards they are playing for.[7] The experimenter informs them about the point price of each toy and, for the youngest subjects, explicitly tells them that more points result in more items. At the end of the experiment, participants learn their

[4] While participants sometimes try to discuss their choices with peers and experimenters during those breaks, it is easy to move the conversation away by asking them orthogonal questions (for example, their favorite after-school activity).

[5] In schools, cash is often not allowed. An alternative option is to pay school-age participants with amazon e-giftcards sent immediately after the session to their school email address. Show-up fees may sometimes not be necessary if sessions are run during class time and subjects are already on premises.

[6] These include bracelets, erasers, sharpies, gel pens, figurines, die-cast cars, bouncy balls, poppers, trading cards, apps, calculators, earbuds, fidget spinners, slime, play-doh, squishies, etc. Variety is key because preferences often depend on age and gender. It is also helpful to investigate which items are trendy in a given year, since popularity changes fast.

[7] This procedure requires some extra time but it adds to the excitement of participating and the value of accumulating points.

point earnings and are accompanied to the shop to exchange points for toys.[8] A budget of \$4-\$5 per participant is sufficient to ensure an assortment of exciting rewards.

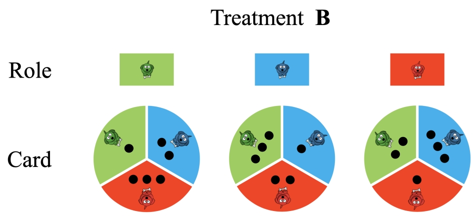
Finally, it is important to consider the appropriate variance in payments across participants. In traditional experiments, a large spread in payoffs is usually a desirable property, as it implies that, at the margin, choices have large consequences. Adults accept large fluctuations, even if they realize that losses are sometimes affected by (bad) luck or other people's (poor) choices. With children, the researcher may consider reducing the variance to avoid a dramatic emotional response of children who are unsuccessful or unlucky. This, in turn, ensures that actions matter but the experience is enjoyable for everyone.

3. Presentation and instructions. Experiments with adults usually rely on neutral, abstract representations of games and decisions. It is a desirable feature to study the underlying ability of people to think about a generic problem, that is, in the absence of a context that may prompt a heuristic, framed or habitual response. Abstraction is, however, problematic with children because it may prevent them from understanding the task. Indeed, it is well-known that capacity of abstraction and mathematical skills develop at different rates in different individuals during childhood and adolescence, and are facilitated by extra years of schooling. When the goal is to compare behavior across ages, a graphical, non-analytical interface based on objects and colors and a story involving characters playing some game is more likely to elicit reliable and comparable responses than a sterile game mathematically represented by a numerical payoff matrix with a set of players, actions and payoffs. Developing such stories requires creativity and effort but can add substantial value to the understanding of age-related changes in decision-making. In our recent research, we have put special emphasis in developing new and attractive game presentations. Figure 1 provides some examples of the graphical user interfaces used in our experiments. They include one individual choice consistency problem (Figure 1a - Brocas et al. (2019)), one market trading (Figure 1b - Brocas and Carrillo (2019b)) and three games of strategy: a two-player beauty contest game (Figure 1c - Brocas and Carrillo (2020)), a repeated alternating dictator game (Figure 1d - Brocas et al. (2017)), and a three-player, dominance solvable simultaneous game (Figure 1e - Brocas and Carrillo (2019a)).

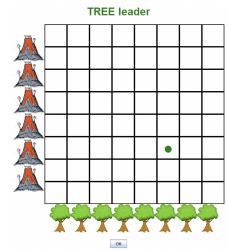
Facing a young population also adds constraints on the level of abstraction regarding the instructions. While precise explanations are preferable with adults, sacrificing rigor for simplicity might be optimal with children. Just to give an example, a 10% random

[8]Most children are familiar with this system of accumulating points or tickets that are subsequently exchanged for rewards since it is commonly employed in arcade rooms and fairs.

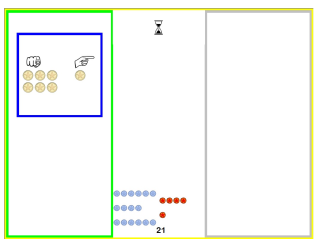
(a) Choice consistency



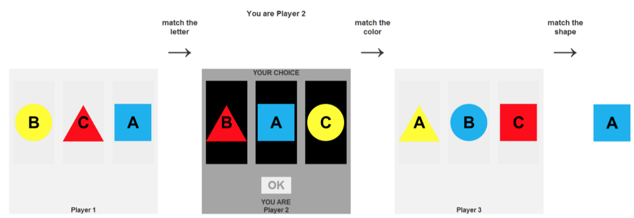
(b) Market trading



(c) Beauty contest



(d) Repeated dictator



(e) Dominance solvable game

Figure 1: Screenshots of games run with children

termination rule in a repeated game can be explained to a population of children (toss a 10-face dice at the end of each round and the game ends whenever it lands on 1). However, it may confuse more than help them, as they will likely miss the purpose of such a convoluted procedure. In our opinion, with children it is sometimes preferable to remain slightly imprecise. In this example, the experimenter may just state that the game is going to be played "many times". Naturally, this will prevent comparative statics on the termination rate but, once again, simplicity sometimes requires a methodological compromise.

4. Child development and heterogeneity. Many factors affect the development of children and adolescents beyond age itself. These include socio-economic characteristics but also school curriculum, peer group, class size, school size and extra-curricular activities. We know from existing research that a population of college students in the US is likely to differ from a population of working professionals in the US or a population of college students in Europe. For the same reason, children and teens attending different schools in different neighborhoods and following different programs should not be expected to behave equally. It is not uncommon in experiments to pool choices from children in different schools. This is mostly a compromise to obtain more data, as access to this population is difficult and one single school is often insufficient for statistical analyses. Controlling for individual and school characteristics is an obvious way to alleviate the problem. However, we advocate focusing on a single school or a set of homogenous schools, unless the objective is to compare choices across schools, tracks or other characteristics, in which case the data collection and statistical analysis should reflect this goal.

A second key choice is the age group of study. As emphasized earlier, the design of the task must bear in mind the developmental stage of the population. Other things being equal, a wide age range (for example, 5 to 18 years old) is most informative of developmental changes. A long span allows us to answer questions such as: Are changes with age gradual or stepwise? Is there a plateau? Is choice non-monotonic in age? Unfortunately, it is sometimes hard to access a homogenous population of children in that range. More importantly, it also requires an experimental paradigm that is accessible to participants with very different abilities. A question of interest for the mind of young children may be trivial for teens whereas a question relevant for high schoolers may be unintelligible for elementary school children. In any case, knowledge of the evolution of general cognitive and non-cognitive abilities is essential to determine the target population and the presentation details of the experiment.

Finally, child development is heterogeneous. Behavioral changes sometimes track the "intellectual age" of the individual rather than the "physical age." It can therefore be informative to perform complementary tests whose results can be correlated with the decisions in the experimental tasks. The most natural candidates are IQ tests. The Raven Progressive Matrices test is a nonverbal test of analytic intelligence that focuses on the ability to induce abstract relations and the ability to dynamically manage a large set of problem-solving goals in working memory (Carpenter et al., 1990). Other tests, such as the Wechsler Intelligence Scale for Children, also include verbal intelligence components (Wechsler, 1949). Psychologists have developed a myriad of highly creative computerized tasks that test different elements of cognitive functions, such as sustained attention and response control (Go/No-Go task), verbal working memory (Digit Span task), spatial working memory (SWM task), inhibition in the context of cognitive interference (Stroop task) and planning (Tower of London task). Last, a key aspect of logical thinking in game theoretical settings is the capacity to take the perspective of others. This ability, referred to as Theory-of-Mind, may be tested with False-belief tasks of increasing complexity.

5. Comparison benchmark. Researchers might sometimes be concerned with economic decisions that are relevant only for children and teens. However, more often than not, a question of interest is to compare the choice of children with that of adults. In order to perform such comparison, one possibility is to rely on the (typically vast) body of research on adults to determine a behavioral benchmark. As discussed in this essay, procedures in adult experiments are often very different. We therefore favor the inclusion in the experiment of an adult control group that follows identical protocols to those employed in the children population, including instructions, presentation and interface. This, however, is not a flawless solution, and it is essential to acknowledge that the comparison will be imperfect. In particular, and as a follow-up to the previous point, even if the researcher tries to find an adult population that is as close as possible to the children under study, individual characteristics are likely to differ between the two.

Overall, applying the scientific method requires formulating clear hypotheses and designing controlled experiments to test those hypotheses. The main challenge of social sciences is the complexity and heterogeneity of human behavior. Most studies cannot control for a variety of unobserved (and sometimes unknown) features that interact with experimental designs. There is no perfect experiment with humans, no perfect subject pool and no perfect design. The best strategy to advance our knowledge is to rely on existing evidence whenever this evidence is pertinent. We believe that accounting for age-related differences in attention, comprehension and motivation are critical to formulate better hypotheses, to implement better designs and to carry out better interpretation of our results.

3 Concluding remarks

The study of decision-making in children and the inferences we can draw from data critically depend on our understanding of how children develop. We cannot stress enough the importance of the underlying biological mechanisms that impact development. What we do and what we feel depend on the way we process information and this changes with age. This evolution is related to the development of the brain, a process that begins before birth and continues well into adolescence and early adulthood.

Cognition is a complex phenomenon that refers to the mental processes–such as attention, memory, or perception–that affect behavior. Early developmental theories (Piaget and Cook, 1952) suggested well-defined stages of cognitive development (inductive logic, hypothetical thinking, counterfactual thinking). Subsequent theories support the view that developmental stages are not as marked (Vygotsky, 1980), and recent studies emphasize large heterogeneity in development across children (Bjorklund and Causey, 2017).

There is also a strong relationship between cognitive development and brain development (Casey et al., 2000, 2005). Recognizing this relationship is critical because adults and children rely on different brain systems due to age-related anatomical differences in brain organization. This implies that they process information differently resulting in differences in behavior. For instance, in some situations, teenagers might rely on brain regions associated with emotions, impulses and instinctive behavior whereas adults rely on region associated with planning and strategizing (Spear, 2000). Overall, physiological differences in brain organization imply that children cannot be modeled as miniature or simplified versions of adults.

From a more general perspective, the biological mechanisms that underly the way we process information and make decisions should receive more attention in economics in general,[9] but especially in developmental decision making. Indeed, when conducting a game theoretic experiment with adults, it may not necessarily matter to know whether abstract thinking is associated with certain brain mechanisms. However, when performing that same experiment with children, it does matter to know if the functions underlying abstract thinking are in place, and whether children can handle the level of abstraction required to play that particular game.

While the study of decision-making in children and adolescents brings challenges, it also offers opportunities. Indeed, tracking developmental changes in behavior and revealing their cognitive correlates may help get to the root of anomalous behavior in adults. Researchers usually adopt a black box approach by taking biases in judgement and anomalous preferences as given. However, if they are acquired through development, they should be viewed as the result of an endogenous process. And if the process is endogenous, anomalies might be correlated. For example, if cognitive functions develop better in certain educational contexts and if these developments yield greater ability to process complex information, we should observe fewer biases in judgement and more rational choices in these populations. Naturally, this also brings the opportunity to correct anomalies by focusing on their causes. In the case of behavioral anomalies and disorders, standard tools include the design of incentives schemes and nudges as well as the promotion of awareness. Shaping behavior from a young age to prevent people from being in a place that later requires corrections is a promising alternative strategy.

Finally, working with children and teenagers has led us to adopt the view that some traditional experiments are excessively abstract and tedious also for adults, and most are

[9] For theoretical neuroeconomic research that incorporates biological mechanisms into economic decision-making, see Brocas and Carrillo (2008) and Alonso et al. (2014).

not adequate for less educated or older adult populations. An abstract framework increases our confidence that people are not framed. At the same time, it multiplies the risk that subjects process their choices differently compared to an ecologically valid framework. Long instructions reassure us that all information has been provided. However, it may be optimistic to assume that participants have assimilated every piece of instruction. In our research, we have noticed that simple designs which guarantee children understanding do not give away the correct/rational solution of the paradigm to adults. They also result in unexpected patterns of behavior (Brocas and Carrillo (2019a) and Brocas and Carrillo (2020)). If we are interested in testing the limits of rational behavior, it is essential to control for orthogonal factors and ensure comprehension through a simple design. Overall, some of the challenges that seem obvious when designing experiments with children may also extend to traditional populations.

References

Ricardo Alonso, Isabelle Brocas, and Juan D Carrillo. Resource allocation in the brain. *Review of Economic Studies*, 81(2):501–534, 2014.

Gregory S Berns, David Laibson, and George Loewenstein. Intertemporal choice–toward an integrative framework. *Trends in cognitive sciences*, 11(11):482–488, 2007.

David F Bjorklund and Kayla B Causey. *Children's thinking: Cognitive development and individual differences*. Sage Publications, 2017.

Anton JH Boonen, Floryt van Wesel, Jelle Jolles, and Menno van der Schoot. The role of visual representation type, spatial ability, and reading comprehension in word problem solving: An item-level analysis in elementary school children. *International Journal of Educational Research*, 68:15–26, 2014.

Isabelle Brocas and Juan D Carrillo. The brain as a hierarchical organization. *American Economic Review*, 98(4):1312–46, 2008.

Isabelle Brocas and Juan D Carrillo. Iterative dominance in young children: Experimental evidence in simple two-person games. *Journal of Economic Behavior & Organization*, 2018.

Isabelle Brocas and Juan D Carrillo. Steps of reasoning in children and adolescents. USC Working Paper, 2019a.

Isabelle Brocas and Juan D Carrillo. Young children use commodities as an indirect medium of exchange. USC Working Paper, 2019b.

Isabelle Brocas and Juan D Carrillo. The evolution of choice and learning in the two-person beauty contest game from kindergarten to adulthood. *Games and Economic Behavior*, 120:132–143, 2020.

Isabelle Brocas, Juan D Carrillo, and Niree Kodaverdian. Altruism and strategic giving in children and adolescents. USC Working Paper, 2017.

Isabelle Brocas, Juan D Carrillo, T Dalton Combs, and Niree Kodaverdian. The development of consistent decision-making across economic domains. *Games and Economic Behavior*, 116:217–240, 2019.

Patricia A Carpenter, Marcel A Just, and Peter Shell. What one intelligence test measures: a theoretical account of the processing in the raven progressive matrices test. *Psychological review*, 97(3):404, 1990.

BJ Casey, Jay N Giedd, and Kathleen M Thomas. Structural and functional brain development and its relation to cognitive development. *Biological psychology*, 54(1-3): 241–257, 2000.

BJ Casey, Nim Tottenham, Conor Liston, and Sarah Durston. Imaging the developing brain: what have we learned about cognitive development? *Trends in cognitive sciences*, 9(3):104–110, 2005.

Jingnan Chen, Daniel Houser, Natalia Montinari, and Marco Piovesan. Beware of popular kids bearing gifts: A framed field experiment. *Journal of Economic Behavior & Organization*, 132:104–120, 2016.

Gabriella Conti, James Heckman, and Sergio Urzua. The education-health gradient. *American Economic Review*, 100(2):234–38, 2010.

Simon Czermak, Francesco Feri, Daniela Glätzle-Rützler, and Matthias Sutter. How strategic are children and adolescents? experimental evidence from normal-form games. *Journal of Economic Behavior & Organization*, 128:265–285, 2016.

Eduardo Fe and David Gill. Cognitive skills and the development of strategic sophistication. Working Paper, 2018.

Guillaume R Fréchette. Experimental economics across subject populations. *The handbook of experimental economics*, 2:435–480, 2016.

Arthur M Glenberg and David A Robertson. Indexical understanding of instructions. *Discourse processes*, 28(1):1–26, 1999.

Alison Gopnik. Scientific thinking in young children: Theoretical advances, empirical research, and policy implications. *Science*, 337(6102):1623–1627, 2012.

William T Harbaugh, Kate Krause, and Timothy R Berry. Garp for kids: On the development of rational choice behavior. *American Economic Review*, 91(5):1539–1545, 2001.

Glenn W Harrison and John A List. Field experiments. *Journal of Economic literature*, 42(4):1009–1055, 2004.

James J Heckman and Yona Rubinstein. The importance of noncognitive skills: Lessons from the ged testing program. *American Economic Review*, 91(2):145–149, 2001.

Daniel Houser and Daniel Schunk. Social environments with competitive pressure: Gender effects in the decisions of german schoolchildren. *Journal of Economic Psychology*, 30 (4):634–641, 2009.

David Klahr and Mitchell Robinson. Formal assessment of problem-solving and planning processes in preschool children. *Cognitive Psychology*, 13(1):113–148, 1981.

JA List, R Petrie, and A Samek. How experiments with children can inform economics. Working paper, 2018.

John A List and Daniel L Millimet. The market: Catalyst for rationality and filter of irrationality. *The BE Journal of Economic Analysis & Policy*, 8(1), 2008.

Walter Mischel, Joan Grusec, and John C Masters. Effects of expected delay time on the subjective value of rewards and punishments. *Journal of Personality and Social Psychology*, 11(4):363, 1969.

Jean Piaget and Margaret Cook. *The origins of intelligence in children*, volume 8. International Universities Press New York, 1952.

Matthew Rabin and Dimitri Vayanos. The gambler's and hot-hand fallacies: Theory and applications. *The Review of Economic Studies*, 77(2):730–778, 2010.

Noah A Shamosh and Jeremy R Gray. Delay discounting and intelligence: A meta-analysis. *Intelligence*, 36(4):289–305, 2008.

Itai Sher, Melissa Koenig, and Aldo Rustichini. Children's strategic theory of mind. *Proceedings of the National Academy of Sciences*, 111(37):13307–13312, 2014.

Herbert A Simon. The functional equivalence of problem solving skills. *Cognitive psychology*, 7(2):268–288, 1975.

Linda P Spear. The adolescent brain and age-related behavioral manifestations. *Neuroscience & Biobehavioral Reviews*, 24(4):417–463, 2000.

Matthias Sutter, Claudia Zoller, and Daniela Glätzle-Rützler. Economic behavior of children and adolescents–a first survey of experimental economics results. *European Economic Review*, 111:98–121, 2019.

Richard H Thaler and Cass R Sunstein. *Nudge: Improving decisions about health, wealth, and happiness.* Penguin, 2009.

Lev Semenovich Vygotsky. *Mind in society: The development of higher psychological processes.* Harvard university press, 1980.

David Wechsler. Wechsler intelligence scale for children. 1949.