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Change over Time: Conducting Longitudinal Studies of Children's Cognitive Development

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Abstract

Developmental scientists have argued that the implementation of longitudinal methods is necessary for obtaining an accurate picture of the nature and sources of developmental change (Magnusson & Cairns, 1996; Morrison & Ornstein, 1996; Magnusson & Stattin, 2006). Developmentalists studying cognition have been relatively slow to embrace longitudinal research, and thus few exemplar studies have tracked individual children's cognitive performance over time and even fewer have examined contexts that are associated with this growth. In this article we first outline some of the benefits of implementing longitudinal designs. Using illustrations from existing studies of children's basic cognitive development and of their school-based academic performance, we discuss when it may be appropriate to employ longitudinal (versus other) methods. We then outline methods for integrating longitudinal data into one's research portfolio, contrasting the leveraging of existing longitudinal data sets with the launching of new longitudinal studies in order to address specific questions concerning cognitive development. Finally, for those who are interested in conducting longitudinal investigations of their own, we provide practical on-the-ground guidelines for designing and carrying out such studies of cognitive development.

Over the past four decades, there has been a marked increase in the use of longitudinal studies to examine children's development. This expansion has been fueled in part by progress in refining methodologies that are appropriate for examining change over time, with increased sophistication being seen in research design, measurement, statistics, and analytical tools. Although a number of longitudinal studies – such as the Abecedarian Project and other long-term investigations of children's outcomes as a function of early experience (Campbell et al., 2008; Reynolds, Englund, Schweinhart & Campbell, 2010) – have impacted our understanding of children's cognitive functioning, when considering the field of cognitive development broadly, it is still difficult to identify many influential longitudinal studies specifically focused on cognition. An exception to this broad statement is the LOGIC (Longitudinal Study on the Genesis of Individual Competencies) study carried out by Weinert and Schneider (1999) and their colleagues in Munich, but it is nonetheless the case that a review of recent issues of this and other developmental journals reveals few reports of longitudinal investigations of cognition.

Why might that be the case? We recognize that longitudinal methods may not be appropriate for all research questions and acknowledge that carrying out a longitudinal investigation is a

complex, time- and resource-intensive undertaking. Nevertheless, we argue here that longitudinal work is extremely important for understanding the dynamic processes of developmental change in children's cognition. After describing the benefits of employing longitudinal methods, we outline practical strategies for addressing questions of cognitive development longitudinally, including making creative use of existing longitudinal datasets through secondary data analyses and carrying out new longitudinal investigations.

The Merits of Longitudinal Work

A number of research designs have been used to explore children's cognitive development. Each approach – including cross-sectional, longitudinal, experimental, observational, microgenetic, and intervention, and various combinations of these methods – provides a unique perspective on children's changing abilities. These methodological approaches can inform and complement each other and also enable researchers to make more informed decisions about how and when to investigate change over time. A variety of practical and theoretical factors influence the choice of study design, but the implementation of different methodological approaches provides an enhanced picture of the ways in which children's cognition develops.

Embarking on a longitudinal study can be challenging, and it is necessary to ask why one might want to take the leap and conduct such an investigation. As we outline below, longitudinal investigations (1) contribute uniquely to our knowledge of individual developmental trajectories, (2) help us to identify precursors or other factors that predict later cognitive abilities when these factors cannot be manipulated experimentally, (3) provide insight into the development of interacting processes over time, and (4) can inform our understanding of the role of context in changes in children's abilities.

Exploring Developmental Trajectories Longitudinally

Longitudinal studies can elucidate developmental trajectories of skill acquisition, allowing for the examination of inter- and intra-individual variability in children's cognitive growth. Consider, for example, findings that emerged from the field of children's memory that were only possible to obtain with longitudinal data. The majority of early research in this area was cross-sectional and demonstrated that with increases in age, children become more proficient in the use of memory strategies (Schneider & Pressley, 1997). In the context of tasks that involve deliberate memorization, researchers described a systematic transition across the elementary school years from relatively passive to more active techniques of remembering, with age-related trends revealing a picture of gradual development throughout childhood. However, Schneider and his colleagues (e.g., Schneider & Sodian, 1997; Sodian & Schneider, 1999) working on the Munich LOGIC longitudinal study revealed that at the level of the individual children the pattern of development was anything but gradual, demonstrating instead that individual children's acquisition of a sorting strategy was best characterized by dramatic leaps in performance. In addition, there is extensive variability in individual children's developmental trajectories of the acquisition of skills that is often masked by cross-sectional findings (e.g., Schneider, Kron, Hunnerkopf, & Krajewski, 2004).

These examples suggest that in order to understand cognitive *development*, with an emphasis on developmental change, as opposed to *cognitive* development, with an emphasis on describing cognitive skill at different ages, it is necessary to make use of longitudinal methods in which children are tracked over time (Ornstein & Haden, 2001). By considering the data only from a cross-sectional perspective, it is impossible to document the actual transitions that individual children make in the development of specific skills and strategies.

Understanding the Origins of Later Abilities

Longitudinal studies can also help to identify precursors of cognitive skills. With the documentation of preschoolers' abilities, it is possible, for example, to examine the extent to which early mathematical competence may be associated with subsequent mathematical skill at school entry in Kindergarten and later facility with more complex mathematics in the third and fourth grades (see, e.g., Krajewski & Schnieder, 2009; Fuchs, et al., 2010; Purpura, Baroody, & Lonigan, 2013). Knowledge of the relation between early abilities and children's later skills can also inform questions regarding the contextual factors that promote these early skills and can be an important first step toward developing interventions designed to promote the growth of later abilities.

Expanding on Trajectories: Relating Interacting Processes over Time

Longitudinal data can also enable an examination of questions related to the mechanisms that may underlie developmental change, as well as an exploration of associations between related skills over time. For example, with a longitudinal design, it is possible to examine change over time in two or more abilities – as well as relations among them – during the period when one would expect these skills to be developing.

Again, consider an example from the memory literature that involves temporal associations between children's use of memory strategies and their metamnemonic knowledge. One common assumption in research in the area of metamemory is that children's knowledge about the operation of memory is likely to be important for developmental changes in the use of mnemonic strategies. Despite the assumption that these two skills – knowledge and the use of strategies – are related, one cannot test assumptions about the importance of metamemory for growth in strategy use without having within-individual information regarding developmental trajectories and the potential linkages between them over time. However, by making use of latent curve models to estimate the trajectories of these skills in a longitudinal data set, it was possible to determine that metamnemonic knowledge at earlier time points was predictive of subsequent strategy use, providing insight into the relations of these related abilities over time (Grammer, Purtell, Coffman, & Ornstein, 2011).

The Importance of Context as a Mechanism for Change

Development occurs in context, and changes in children's abilities and their environments are dynamically related across time. Although cross-sectional investigations can be used to examine the role of context for children's skills at specific ages, this complex interplay can be oversimplified when drawing conclusions exclusively from cross-sectional data, potentially leading to erroneous conclusions regarding the role of context in children's development.

By making use of longitudinal studies it is possible to explore the importance of early experiences for development. For example, there is an established literature documenting linkages between aspects of the home environment – and more specifically mothers’ conversational styles – and the autobiographical memory abilities of their children. This research demonstrates clearly that differences in mothers’ conversations with their children about previously experienced and ongoing events are associated with later differences in children’s autobiographical memory (Reese, Haden, & Fivush, 1993; Hedrick, San Souci, Haden, & Ornstein, 2009; for a review see Fivush, Haden, & Reese, 2006). Moreover, just as children’s skills develop over time, aspects of their home environments can change, too. Indeed, longitudinal evidence indicates that improvements in the early home learning environment as children approach elementary school are related to development of language, literacy, and academic skills (e.g., Son & Morrison, 2010; Hindman & Morrison, 2011).

Longitudinal studies have also provided information regarding the role of specific aspects of the school environment in children’s cognitive development. For example, in several large-scale investigations researchers have incorporated global measures of the classroom context experienced by children across multiple school years and have provided further evidence of the importance of classroom factors for children’s academic growth (e.g., Crosnoe, Levanthal, Wirth, Pierce, & Pianta, 2010; Crosnoe, Morrison, Burchinal, Pianta, Keating, Friedman, & Clarke-Stewart, 2010; Mashburn et al., 2008). Moreover, linkages between classroom context and cognition are not limited to domains of academic achievement. Indeed, growth in children’s abilities to employ strategies in the service of remembering in the first and second grades is related to their first-grade teachers’ use of cognitively-rich instruction during math and language arts lessons (Coffman, Ornstein, McCall, & Curran, 2008; Ornstein, Coffman, Grammer, San Souci, & McCall, 2010).

Challenges Associated with the Design and Implementation of Longitudinal Studies

Notwithstanding these important benefits of employing longitudinal methods, we would be remiss if we failed to outline some caveats associated with a longitudinal approach. We outline here a number of challenges associated with longitudinal research, but we also discuss several ways in which the consequences of these problems can be minimized.

To begin, it must be emphasized that several measurement-related questions that are inherent in longitudinal work. To be sure, measurement issues are paramount in all aspects of developmental research, but in some ways longitudinal studies compound this complexity. For example, to what extent is the behavior being studied modified as a result of repeated assessments? What kinds of controls may need to be employed? In addition, as is always the case when comparing the performance of children of different ages, it is important to consider the extent to which measures of the constructs under investigation are operating similarly with children of different ages. To this end, in a longitudinal investigation one must wrestle with issues related to homotypic and heterotypic continuity.

Adding additional interpretive challenges, many large-scale longitudinal studies are, by necessity, “design-by committee” projects involving many collaborators with diverse research questions. Although the presence of multiple perspectives certainly can inform the collective understanding of the issues under investigation, there is nonetheless a potential down-side to this form of collaborative work. Consider, for example, some of the potential consequences of “competition” among investigators to include specific tasks and instruments in the research protocol. Under these conditions, the study may be compromised at the outset because the participants may be presented with a heterogeneous set of tasks that are not selected on the basis of an underlying conceptual perspective and because at the same time there is not thorough enough measurement of a set of key theoretically-driven constructs. Including too many tasks in the protocol can further complicate the situation, resulting in participant fatigue and the possibility of data loss and compromised measurement.

Finally, despite all of the advances in methodology, it must be remembered that longitudinal studies are still correlational in nature and therefore limit our ability to make causal statements. That is, no matter how important the relations that are uncovered in the course of longitudinal research, it is not possible to impute causality without supplementary experimental work. Indeed, after exploring the linkages between context and development using longitudinal data, it is possible to build on these findings by carrying out experiments. In our own research, for example, we have built on associations identified between classroom instruction and growth in children’s strategic memory (Coffman et al., 2008) by developing school-based experiments to further explore the linkages between differences in teacher-led instruction and children’s changing memory skills (Grammer, Coffman, & Ornstein, 2013). Through the interplay between longitudinal and experimental methods – with longitudinal observations in the field leading to experiments in the laboratory and then back for another round of observations – we have systematically gone about exploring the mechanisms that underlie the developmental changes observed longitudinally. Indeed, this combination of methods may be one way in which we can capitalize on the richness of observations that serve to identify important associations and the analytic power of laboratory experimentation.

Strategies for Conducting Longitudinal Research

The potential problems notwithstanding, we hope that you are convinced about the importance of incorporating longitudinal studies into your program of work, but where does one start? For over a decade, we have conducted longitudinal investigations in laboratories, homes, and schools in an effort to examine changes in autobiographical and strategic memory, literacy, and executive functions. In this work, we have tracked development from toddlerhood through pre-adolescence, while simultaneously including measures of family and school context. Drawing on these experiences, we first describe the benefits of – and strategies for – using existing data sets, and then turn to practical tips for designing and conducting new longitudinal investigations.

Implementing Longitudinal Methods: Utilizing Existing Datasets (Secondary Data Analyses)

There are a number of useful existing large-scale data sets (e.g., the findings from the Early Childhood Longitudinal Program [ECLS] and the NICHD Study of Early Child Care and Youth Development [SECCYD]) that have been used to examine children's cognitive skills and still can be used to explore new questions concerning cognitive development. Greenhoot and Dowsett (2012) provide an excellent review of the considerations involved in utilizing existing data sets in the study of cognitive development, so we refrain from going into great detail here. Although most of the population-based studies whose data are now available were not necessarily designed with an emphasis on children's cognition, they often include measures of constructs such as academic skills or executive functions and can thus be utilized to address questions of cognitive development, if one accounts for the strengths and weaknesses that come along with using them.

The benefits of using data from these studies are not limited to the fact that data collection has already been conducted. Indeed, the real strengths of these data sets stem from the fact that they were generated by impressive sampling methods and have enough power to examine complex associations over time, allowing for exploration of the role of context in development and variability in children's developmental trajectories. These strengths are particularly important to the extent that researchers are interested in the development of all children and not just those who can come into the laboratory. However, the use of these types of data sets can also introduce unique challenges. The types of measures available often differ from those that one would include in a newly designed study. Additional practical limitations that are not often considered are the time and knowledge that are necessary to analyze large-scale data sets appropriately. Learning about the analytic techniques needed – and often the data sets themselves – can be time consuming and require technical skills.

Implementing Longitudinal Methods: Collecting Longitudinal Data (Primary Data Analyses)

For many researchers, designing and launching a new longitudinal investigation is the only way to truly address the research questions of interest. But where does one begin? We have found that success in carrying out new large-scale projects involves skills in both research design and methodology, on the one hand, and practical administrative matters, on the other hand. Developing the design for a new longitudinal investigation requires making number of decisions, including choosing the target age-range of the participants, the most appropriate measures, and the most suitable statistical approach. However, once these decisions have been made, the success of the work often hinges on another set of factors – recruiting and maintaining a research staff that is well trained and skilled in strategies for engaging the population that is being studied. We devote the rest of this article to describing some strategies that we have utilized for addressing each of these points.

Choosing the Best Design

Like any other investigation, much of the important work on a longitudinal project takes place during a planning phase, well in advance of beginning the research. Given the realities

of the current funding climate, the decisions made initially are often informed by the ways in which one can get the most bang for one's research buck.

For each decision that is made, the rationale and justification must be strong. To this end, you must first determine whether the type of longitudinal design selected is necessary for addressing your research question, as well as the most appropriate analytic strategy. Although space does not permit a full discussion of alternative designs here, it is possible, for example, that cohort-sequential or accelerated longitudinal approaches could generate useful information on focal age groups more quickly than single-cohort longitudinal investigations. It is also important to consider the approach you will take to analyzing the data. Knowing that you will implement a specific analytic technique, such as growth curve modeling (see e.g., Curran, Obeidat, & Losardo, 2010), can inform decisions regarding the number of repeated measures to include in the design. These decisions will also inform the number of participants you will need. When planning your study, it is also necessary to consider one of the unfortunate inevitabilities inherent in longitudinal work: the loss of data. It is thus necessary to account for potential attrition when deciding upon your sample size and also to have a strategy in place for handling missing data after the fact.

Once you have determined which design is appropriate, you must select the target age-range of the participants, decide how long you would like to follow these individuals, and choose the types of measures that would be most appropriate across the duration of the investigation. Fortunately, it is possible to draw on evidence from cross-sectional and experimental studies to inform these choices. Not all longitudinal investigations need to last the entire course of development from infancy to young adulthood! Indeed, it is possible to conduct a relatively short-term longitudinal investigation that can provide enormous insight into an important developmental period. For example, based on cross-sectional investigations, we know that a great deal of growth in executive functions occurs around the time of transition into elementary school. By targeting this time of transition for a short-term longitudinal investigation, we increase the likelihood of isolating the developmental process in which we are interested.

Once you have decided the age-range that is of greatest interest to you, it is important to consider how often you will want to conduct assessments in order to observe the changes in which you are interested. For example, if you are studying skills that are developing rapidly over a relatively brief period of time, more frequent measurement intervals might be necessary. Alternatively, if you are examining an outcome with a more protracted developmental course, a wider time-frame between assessments would be more appropriate. In making these design decisions, consider your analytic plan, as it is also important to strike a balance between the number of repeated assessments that you will be making and the number of children in your investigation (Raudenbush, 1997).

Thinking about the developmental periods during which the greatest amount of change may occur raises additional analytic questions. If you know that a skill is developing as children are transitioning into early schooling environments, it would likely be important to consider the role of these contexts in understanding developmental change. Of course, introducing the exploration of context presents a range of other methodological considerations, including the

determination of suitable measures of the environment and the selection of analytic techniques to account for the impact of context (e.g., using HLM to adequately account for the nesting of repeated measures within subjects and students within classrooms). The more factors that are under focus in your investigation, the more participants your analyses will require in order to enable you to have adequate power.

Task selection is another important aspect of the research design. As described previously, assessing changing skills over time presents a great challenge in many cases for developmental researchers. It is challenging to identify measures that characterize the same abilities at different ages and that are sensitive enough to reveal subtle changes across a wide age range. Moreover, when conducting repeated assessments, it is important to consider the impact of test-retest effects on children's performance. There is no definitive way to avoid this challenge and to fully mitigate the impact of issues related to task selection, but one can draw on previous research or utilize statistical approaches to address these challenges (Hoffman, Hofer, & Sliwinski, 2011). In addition to seeking out published reports of research that included specific measures of interest, it can also be helpful to contact research groups that have been using them, so as to determine if problems have arisen that have not been documented in the literature. For example, you might find that a specific measure has been used with children outside of the reported age range and that ceiling or floor effects resulted, thereby enabling you to select alternative measures that would be likely be more informative. Similarly, it is always worth pilot testing your measures on a small group of children in advance of your investigation in order to examine the impact of test-retest experience on children's performance. Finally, it can be a good idea to build a small pilot group of children into your project who can be assessed in advance of the larger group of participants to allow for last minute changes to task protocols.

After weighing these and other considerations, it has been our experience that one often ends up with project designs that involve conducting as many assessments as possible, with every measure that could possibly capture the target skill (and many possible related abilities), as well as aspects of the home and school context. In short, it sometimes seems as if everything is proposed but the kitchen sink! At this point it is important to step back and refine the dream study into a focused and feasible project.

Strategies for Conducting Longitudinal Research

In our experience, we have found that the key considerations for conducting longitudinal studies fall into four main categories: (1) building and maintaining good relationships with communities of research participants, (2) working to develop a skilled staff of researchers, (3) conducting child-centered investigations, and (4) giving back to the individuals who have participated in your research.

Building Relationships to Examine Relations over Time—When conducting longitudinal investigations, it is critical to remember that you are working with a specific community whose members deserve your time, patience, and respect. To facilitate your progress, consider involving community partners long before you begin data collection. Ask these individuals – including those who work directly with children, families, or schools you

are trying to recruit – about issues in the community, the identity of possible stakeholders, and the names of people with whom you should meet. For example, it may be very important for you to interact with teachers, principals, ministers, and other community leaders. The participation of members of the community from the ground up can be very beneficial, as these individuals can become recruiters and/or liaisons. They also can recommend what sorts of incentives the children, families, or teachers may appreciate.

When reaching out to the community, it is also important to use a little marketing savvy to generate excitement for the work that you are doing. Come up with an easy-to-remember project name, adopt a fun logo, and use these things widely. In our elementary school-based longitudinal studies, we have found that there are no better advertisements than T-shirts, pencil boxes, and tote bags with our logos. We also give students who participate in our investigations books with stickers that have a “thank you” and references to our laboratories. These incentives given to study participants increase their classmates’ and their parents’ knowledge of our presence in the school. It is not every day that children ask their parents to let them participate in research, but we have found that word spreads quickly when a study logo is on a new backpack or lunch bag. Other longitudinal researchers have bolstered continued participation by giving new baby gifts to families or sending out holiday or birthday cards to participants. Most of these efforts involve a time commitment on the part of staff, but are well worth the return when it comes to maintaining a longitudinal sample.

Once the word is out, it is also important to use simple reminders – such as refrigerator magnets with your contact information – so that you make sure that participants know how to get in touch with your research group. It is also important for you have an accessible presence on the web so that families can find project updates and other relevant information. Employ social media such as Facebook or Twitter to keep in touch with participants and provide them with information about new phases of your investigation. Finally, make sure that you have additional ways of reaching out to the families of your participants; for example, if you will be working with a child over a long period of time, get the names and contact information of others who may know where the family can be found if they move. Maintaining communication in this way can ensure continued participation and engagement of families.

The Role of Research Staff—Although it is always a good idea to have highly skilled staff members involved in data collection with young children, the need for highly skilled and relatable research staff is particularly important in conducting longitudinal investigations. These individuals are the ones who “connect” with the participants on a day-to-day basis. Directors of successful longitudinal studies know that building trust between participants and researchers is incredibly important, and they are able to prioritize employing the right research assistants and project directors.

For example, it is worthwhile to ensure as much continuity in staff across the project as possible. If a family becomes familiar with an assistant on a project, especially one who takes a sincere interest in how their children are developing, they are much more likely to look forward to participating again in the future. In addition, consider hiring staff and

project administrators from within the community. Have these individuals help build networks, as they will be more likely to identify liaisons and advocates to promote the project.

Conducting Child-Centered Research—Once you have established a sample of participants, guaranteeing their continued involvement – or even insuring that they are still at the same address by the next time point of your investigation – can be tricky. One easy way of keeping families involved is making participation worth their while. Offering fun incentives for children in the form of books, toys, or small gift cards to local bookstores, as well as appropriate financial compensation to their families at each assessment point, goes a long way toward ensuring that they will be excited to return for follow-up visits.

Another consideration is the comfort of the participants. If families are coming into your laboratory, make sure that it is welcoming space with a home-like atmosphere and child-friendly furnishing and activities. Many researchers are guilty of designing studies that are perfect from a research perspective, but that are less than ideal in terms of the participants' experiences. When families come into the laboratory for a single assessment, if the measures are not engaging or if the experience is uncomfortable or lasts too long, the researchers may generally end up with the data for which they had hoped – but not always, if the participants are so “over-tested” that assessments are made when they are fatigued. However, even if useful data are obtained, these families may not be inclined to participate in further assessments or studies, and this is not sustainable in a longitudinal investigation. In addition to considering the theoretical motivations for task selection, it is important to be realistic about the burden that this type of testing places on young participants. Pilot test your task battery to determine what can realistically be expected of participants at different ages, being sure to include breaks and downtime in between tasks.

In addition, be mindful of any potential barriers to participation for your participants. If families with non-participating children will be coming into the laboratory, have arrangements in place to supply baby sitters for siblings. Consider providing transportation or money for gas, and be flexible in scheduling visits at times that are convenient for families. College campuses can be confusing places to navigate, particularly when it comes to parking. Provide participants with clear information about parking and, if possible, reserve parking spaces on campus for your visitors. Alternatively, when working in schools, be mindful not to interfere with teachers' instruction in the classroom. Instead, work around their schedules to determine when to work with students in their classrooms. In our school-based projects in which the majority of the assessments are carried out before or after school, we have found that parents who are unable to provide transportation are much more likely to allow their children to participate if we are able to negotiate assessment times with their children's teachers during non-instructional periods in the school day.

Giving Back—Finally, many children and families are motivated to be involved in research because they are interested in contributing to building knowledge regarding children's development. One way of acknowledging these contributions is to provide each child with a certificate of participation. With parental permission, in our studies these certificates have included photos of children who are proudly displaying their Lego

creations or “dressed up” in an ERP cap. We have also provided families with videos of enjoyable parent-child activities that were conducted as a part of the research assessment. Many children are proud of their involvement, and this provides them with an opportunity to share what they have done with others.

As your research begins to generate results, keep participants apprised of this progress. One way of doing this is to offer yearly newsletters. Tell your participants and their families about the work, and provide them with an idea of the scientific advances that their participation has helped make possible. It has been our experience that participants sincerely appreciate feedback and are genuinely interested in status reports on research. In our studies, we provide group-level findings from previous phases of our investigation, generic information about measures that we are using, and fun anonymous quotes from participating children that can be sent home and posted on our website. When working with teachers or in school settings, offer to give them a presentation of your findings, or to conduct professional development sessions for teachers.

For the Future

As we, as researchers in cognitive development, plan longitudinal studies of cognition, it is also important that we think about the levels of analysis that are under examination. Longitudinal designs make it possible to link environmental and contextual effects with children’s outcomes, allowing researchers to explore the possible environmental sources of the changes that we observe. These considerations should not be limited to context, but should include potential biological and neurological origins of these same developmental processes. Recently, there has been an increased emphasis on the inclusion of neuropsychological and genetic data to address questions related to cognition. By understanding the range of possible origins for individual variability – including factors in children’s environments and their biology – we will be better able to understand how to intervene and promote the development of cognition.

Addressing such complex questions often requires involving new colleagues with areas of expertise outside of development, thus necessitating a move to carefully designed investigations involving broad interdisciplinary integration. We firmly believe that the next wave of influential studies of cognitive development will be designed and implemented by interdisciplinary teams of scholars who are collaborating with quantitative methodologists and are able to secure funding for multi-level, multi-methods studies that shed light on the interplay between physiological, behavioral, and contextual factors that dynamically shape and are shaped by children’s cognitive performance.

Getting Started: Recommended Resources

We hope that the ideas outlined here will provide you with useful information regarding practical approaches to conducting longitudinal research. More broadly, however, we hope that you take away the message that including longitudinal studies in your program of research can increase our collective understanding of cognitive development and also open up a range of new research questions. There are a growing number of available resources for those interested in longitudinal techniques, which we suggest that you research before

launching your own investigation. First, we encourage those who are new to longitudinal methods to explore some of the key theoretical issues in developmental science that provide a foundation for the longitudinal approach to studying cognition and development that is advocated here (see e.g., Cairns, Elder, & Costello, 2001; Magnusson & Stattin, 2006; Ornstein & Haden, 2001).

We also recommend sources for thinking about the interplay of longitudinal and experimental methods. Experimental methods allow for causal statements, whereas longitudinal approaches allow the exploration of change over time. As we have outlined above, by utilizing a combination of methods, it becomes possible to use experimental methods to make causal statements concerning key linkages that were identified initially in longitudinal work. To better understand this interplay, and the importance of balancing the two approaches, we recommend Singer and Willett's (2003) introductory comments in their text on applied longitudinal data analysis, Raudenbush's (2001) discussion of longitudinal data and causal inference, as well as a Shadish, Cook, and Campbell's (2002) comprehensive description of experimental and quasi-experimental methods and causal inference.

Finally, we urge that cognitive developmentalists watch the literature for the emergence of analytic techniques that will allow them to refine the questions that they address in longitudinal work. New statistical methods and refinement to old techniques are constantly emerging to meet challenges posed by developmental researchers. Although a complete review of longitudinal methods is outside of the scope of this article, we point the reader to review articles describing different approaches to modeling developmental data (Bauer & Reys, 2010; Curran, Obeidat, & Losardo, 2010).

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