




Bored of the rings: Methodological and analytic approaches to operationalizing Bronfenbrenner's PPCT model in research practice

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Abstract

Bronfenbrenner's ecological (and later bioecological) theory has been a mainstay in the theoretical wheelhouse of developmental and family sciences since its inception in the 1970s. However, few studies accurately operationalize Bronfenbrenner's process-person-context-time (PPCT) research model. The aim of this paper is to provide a practical guide to the design, implementation, and analysis of PPCT research studies. Using recent qualitative and quantitative publications from developmental and family science journals, we illustrate how his theory can be operationalized simply and effectively in 21st-century research. The eight studies, three qualitative and five quantitative, feature participants from Chile, China, South Africa, Turkey, and the United States.

KEYWORDS

bioecological theory, Bronfenbrenner, developmental theory, ecological theory, PPCT, proximal process, systems theory

Although Bronfenbrenner's ecological (and later bioecological) theory has been cited tens of thousands of times, examples of studies that adhere to the process-person-context-time (PPCT) model are in short supply. Of those papers, the majority do not correctly use bioecological theory or appropriately implement the PPCT model (see Tudge et al., 2009, 2016). This is no wonder, given the ubiquity of inaccurate information about Bronfenbrenner's theory. A simple Google search of "Bronfenbrenner" will yield a plethora of images featuring concentric rings of context as the defining feature of the model, despite Bronfenbrenner's assertion (in publications

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from 1993 onwards) that proximal processes are the driving forces of development: "...today's bioecological model goes far beyond its predecessors both with respect to basic constructs and their bidirectional, synergistic interrelationships" (Bronfenbrenner & Morris, 2006, p. 799).¹

As the title of this paper suggests, we are indeed "bored of the rings"; these simplistic portrayals of Bronfenbrenner's theory suggest that it is merely one of context, omitting the synergistic and interrelated influences of proximal processes, person characteristics, context, and time on development. Rather than relying upon what other people have written about his theories, scholars interested in utilizing bioecological theory should utilize the primary sources written by Bronfenbrenner himself. Further, unless there are valid reasons for using an earlier version (in which case the reasons should be specified), scholars should use the final iteration of the theory—the bioecological theory of human development and the PPCT research model—and any adaptations should be explicitly delineated. Misuse of Bronfenbrenner's theory (a) misleads scholars and students about the tenets and applications of the theory and (b) does not allow for the theory to be adequately tested (Tudge et al., 2009).

Bronfenbrenner never conducted his own research utilizing the PPCT model, and instead relied on discussions of other scholars' work to illustrate his ideas. As such, interpreting and implementing the PPCT model can be a difficult endeavor, especially given the advancements in research methodology and statistical analyses that have occurred since the publication of his final chapter (i.e., Bronfenbrenner & Morris, 2006). Most of the examples from which Bronfenbrenner drew, even in this posthumous chapter, were from studies completed from the 1960s to the 1980s. Following other publications seeking to clarify Bronfenbrenner's theory and research model (e.g., Merçon-Vargas et al., 2020; Tudge et al., 2009, 2016; Xia et al., 2020), the aim of this paper is to provide an accessible and practical guide to the design, implementation, and analysis of PPCT research studies.

In the first half of this paper, we will briefly describe the development of the theory, before discussing each component of the PPCT model utilizing Bronfenbrenner's examples. The second half of this paper presents three qualitative and five quantitative studies published between 2010 and 2021. Our previous publications (e.g., Tudge et al., 2009, 2016) evaluated the strengths and weaknesses of research completed by researchers who explicitly stated that their research was based on Bronfenbrenner's theory. The current paper adopts a different position and embraces a strengths-based approach used by Bronfenbrenner to exemplify his research. We utilize high-quality contemporary publications (not based upon Bronfenbrenner's theory) to exemplify how bioecological theory and the PPCT model could have been implemented, had the authors wanted to do so. With modifications, these articles provide illustrative examples of how the theory can be utilized in qualitative and quantitative research in the 21st century. We use these studies as Bronfenbrenner used the work of Drillien (1964) and other researchers—as examples that allow readers to see how research could be conducted that conforms to bioecological theory and PPCT.

BIOECOLOGICAL THEORY AND THE PPCT MODEL

The development of the theory

Bronfenbrenner's contributions to the field of child development spanned four decades and three distinct phases: (a) 1973–1979, (b) 1983–1993, and (c) 1993–2006 (Rosa & Tudge, 2013). Although his theory changed significantly over time (Rosa & Tudge, 2013; Tudge et al., 2022), it was always focused on *ecology* (i.e., synergistic interrelations between people and their

¹We have consistently quoted from this 2006 chapter, but it is almost identical to Bronfenbrenner and Morris (1998), with the addition of some material from Bronfenbrenner (2001).

environments). The first phase of Bronfenbrenner's career was marked by the publication of his monograph, *The Ecology of Human Development*, in 1979. In this seminal publication, Bronfenbrenner used the metaphor "like a set of Russian dolls" (1979, p. 3), thereby contributing to the idea that context constituted separate layers. However, the writing revealed that he saw the relations among the developing individual and each of the layers of context as synergistic. Bronfenbrenner's focus on culture, which he delineated as a macrosystemic influence, was developed in the second phase when he wrote about subcultural variation. In the third phase, Bronfenbrenner renamed it the bioecological theory of human development, to emphasize the importance of person characteristics ("bio") as well as person–environment interrelations ("ecological"). It was in this third phase that Bronfenbrenner added proximal processes, which he said were "the engines of development" (Bronfenbrenner, 2001, p. 6967), and outlined the PPCT model.

As recommended by Rosa and Tudge (2013), further discussion of Bronfenbrenner's theory and model in the current paper will be limited to bioecological theory and the PPCT model. However, two adaptations to the theory are integrated into the current paper, the incorporation of the macrosystem from phase two, and inverse proximal processes (Merçon-Vargas et al., 2020). Each of these adaptations is discussed below in relation to their role in the PPCT model.

THE PPCT MODEL

In their 2006 publication, Bronfenbrenner and Morris described the development as "the combination of Person and Context exhibit[ing] a mutually reinforcing, multiplicative, indirect effect on the power of proximal processes as the engines of development" (p. 801). As such, all four components of the PPCT model function interdependently and synergistically. However, for heuristic and organizational purposes, these elements must be discussed independently before discussing their synergy and interrelation. Throughout his writings, Bronfenbrenner relied heavily upon the work of other researchers (e.g., Drillien's [1964] work on child–mother dyads in differing socioeconomic contexts, and Small and Luster's [1990] research on adolescents) to illustrate his theoretical framework. These examples serve as excellent vehicles for explaining and simplifying Bronfenbrenner's model and, as such, a number of these examples are included in the following summaries of the PPCT components.

Proximal processes

Proximal processes are progressively complex, reciprocal interactions between a developing individual and other people and/or objects and symbols in their immediate environment (Bronfenbrenner & Morris, 2006). Proximal processes must also occur frequently for an extended length of time to be efficacious. Bronfenbrenner almost exclusively wrote about proximal processes as involving positive interactions (i.e., leading to competence and buffering against deleterious influences), like mother–infant interactions that occur frequently and become more complex over time. However, recent scholars have challenged this viewpoint, noting that development is also influenced by interactions that become progressively more complex and yet lead to dysfunction (Merçon-Vargas et al., 2020).² By incorporating both perspectives (i.e., positive and inverse proximal processes), bioecological theory and PPCT may be more

²Bronfenbrenner wrote explicitly about inverse proximal processes only once, in his discussions of Small and Luster's (1990) study of adolescents' sexual activity, from which he theorized that "progressively more intense interaction with peers who are already sexually active" (Bronfenbrenner & Morris, 2006, p. 808) constituted a proximal process leading to dysfunction (i.e., teenage pregnancy).

applicable to diverse fields of inquiry and represent a more realistic lens through which to study children, youth, and families.

Bronfenbrenner and Morris (2006) provided examples of proximal processes drawn from research conducted before they developed that concept. They conceptualized Small and Luster's (1990) view of parental monitoring (given that it focused on regularly occurring and bidirectional interactions) as a proximal process in which parents asked questions about the adolescents' activities and the adolescents disclosed information about their activities. Bronfenbrenner and Morris also discussed Drillien's (1964) research on mother–infant interactions in terms of proximal processes but critiqued Drillien's approach as it focused on only the mother's contribution to the interactions as opposed to bidirectional responsiveness between mother and child. Ideally, a measure of mother–child interactions would be reflective of the actions of both mother *and* child over time (i.e., bidirectional and reciprocal). Regarding operationalization of proximal processes, Bronfenbrenner and Morris (2006) presented parental monitoring in the Small and Luster (1990) study as a continuous measure. However, rather than viewing scores of interaction quality as a continuous variable in Drillien's (1964) study, Bronfenbrenner and Morris reorganized her data to reflect the proximal process at two levels: poor quality and good quality. As such, Bronfenbrenner provided two examples of how proximal processes can be measured and analyzed, as both continuous and categorical variables. In sum, measurement of proximal processes should entail: (a) progressing complexity (leading to either competence or dysfunction), (b) duration and frequency, and (c) interactional reciprocity.

Person characteristics

Person characteristics are present twice in the PPCT model, once as an input (i.e., an antecedent of proximal processes) and once as an output (i.e., an outcome of the synergistic interrelations among person, context, and proximal processes over time). However, before the selection of person characteristics within the research design, the developing person(s) of interest must be identified, as this shapes the theoretical and empirical basis for the selection of person characteristics as the input and outcomes of the PPCT model.

In describing person characteristics in the context of Drillien's (1964) work, Bronfenbrenner delineated one resource characteristic as an antecedent (i.e., infant birthweight in three levels—very low, low, and normal) and child behavior problems, a force characteristic, at ages 2 and 4 as the outcome (Bronfenbrenner & Morris, 2006). In Small and Luster's (1990) study, two-person characteristics, mother's education (more or less than High School graduation) and adolescent gender (boys and girls), were treated as inputs, and average grades of the adolescent were the outcome of interest. Although Small and Luster's study demonstrates a 2×2 model of person characteristics as inputs (i.e., four possible combinations—high/male, low/male, high/female, and low/female), the PPCT model does not require this level of complexity; a simpler model, focusing on either mother's education or adolescent gender, would suffice. At a minimum, antecedent person characteristics must have two levels. Most importantly, the choice of person characteristics should be substantively and theoretically driven, "maximally relevant to the research question under investigation and complementary to each other in relation to the given developmental outcome" (Bronfenbrenner & Morris, 2006, p. 808).

Context

Throughout the development of ecological (and later bioecological) theory, context was a central tenet of Bronfenbrenner's theory and model. Our previous publications (e.g., Rosa & Tudge, 2013; Tudge et al., 2022; Xia et al., 2020) are useful resources for additional information

about micro-, meso-, exo-, and macrosystemic influences. The macrosystem featured in the first two phases of theory development but was addressed more implicitly in writings about bioecological theory and the PPCT model.

Small and Luster's (1990) study demonstrated a microsystemic contextual influence on proximal processes; Bronfenbrenner presented their data in three levels of the microsystem: two-parent, single-parent households, and step-parent households. When analyzing Drillien's (1964) data, Bronfenbrenner and Morris (2006) utilized socioeconomic status (high, middle, and low SES) as the contextual influence of interest; in this instance, socioeconomic status is a macrosystemic influence on development. As with person characteristics, at least two levels of a contextual influence on development must be included within a simple PPCT research design. Combined with a minimum of two levels of a person characteristic, a PPCT-based research design is, at minimum, a four-group model. This perspective will be elucidated in further discussion of synergy.

Time

Time is the fourth component of the PPCT model and Bronfenbrenner delineated it as being comprised of three types: micro-, meso-, and macrotime. Microtime is defined as "continuity versus discontinuity in ongoing episodes of proximal process" (Bronfenbrenner & Morris, 2006, p. 796), reflecting the extent to which participant(s) are focused upon the episode. Mesotime refers to the frequency with which the developing individual engages in a proximal process, over the course of days, weeks, and years. Both microtime and mesotime are necessary for an interaction to qualify as a proximal process, as the definition states that "to be effective, the interaction must occur on a *fairly regular basis over extended periods of time*" (Bronfenbrenner & Morris, 2006, p. 797, italics added). Macrotime reflects pertinent historical events and changing social norms across ontogenesis and generations. Paralleling person characteristics, time appears twice in the PPCT research model: (a) microtime and mesotime as elements of proximal processes, and (b) the influence of macrotime upon the person, context, proximal processes, and their synergistic interrelation. In the current paper, time largely relates to developmental and macrotime, while microtime and mesotime are discussed in relation to proximal processes.

Synergy

As mentioned previously, all four elements of the PPCT model are interdependent and function synergistically. In explaining synergy, Bronfenbrenner cited Webster's Dictionary: "Synergism refers to cooperative action of discrete agencies such that the total effect is greater than the sum of two or more effects—taken independently" (Bronfenbrenner & Morris, 2006, p. 800). Bronfenbrenner did not believe that synergy could be operationalized using linear regressions where the independent contribution of each variable is parsed from the total statistical variance. Such methods obscure the synergism between process, person, context, and time. Instead, Bronfenbrenner and Morris suggested that synergism be addressed by studying interactions, which, given the examples provided throughout this chapter, involved the use of multigroup models. As we illustrate later in this paper, by selecting two levels of a theoretically relevant antecedent person characteristic and two levels of a contextual influence, the PPCT model has, at minimum, four comparison groups (i.e., four groups of person/context combinations). These groups can then be used in a mediational model in quantitative research to analyze whether significant differences exist in developmental trajectories and outcomes between person/context groups across time. Qualitative researchers, by contrast, will need to select their individual participants in such a way that this requirement is satisfied.

Bronfenbrenner and Morris (2006) wrote that “developmental outcomes at Time 1 indirectly influence developmental outcomes at Time 2 through their effect on proximal processes during the intervening period” (p. 812). Although not explicitly outlined as such in his writings, this quote supports the conceptualization of the PPCT model as one of mediation. Figure 1 illustrates PPCT as a mediational model. At the top left, at time point j , there exist at least two (but as many as n) levels of both the antecedent person characteristic and context (e.g., P1, P2, Pn, and C1, C2, Cn), resulting in a minimum of four groups of developing individual(s) (i.e., P1-C1, P1-C2, P2-C1, and P2-C2). Next, the proximal process(es) at time point j mediates continuity or change in person and context at time k . The proximal process (illustrated in the Figure as $f | P \times P_j$) is a function of its inputs (i.e., person and context) and time, represented as M_i (microtime) and M_e (mesotime). The outcome person characteristic (P_o) also influences and is influenced by proximal processes.

As researchers we are unable to measure every proximal process; we use various methods to measure interactions and activities (e.g., naturalistic observations, tasks, self-report surveys, biomarkers, daily diaries, and interviews) and yet these methods most frequently only measure the process at one or two points in time. We ask questions and make assumptions about the duration and regularity of processes. As such, research designs most frequently reflect the first row of the figure. However, beneath this simplification, we know that proximal processes, person, context, and time are continually influencing one another; proximal processes are both impacting and being impacted by person and context over time in ways largely beyond our skills of measurement and/or observation. The second row of the figure represents these complex, ongoing synergistic interrelations at times j_1, j_2, j_3, j_4 , and j_n . The frequency of proximal

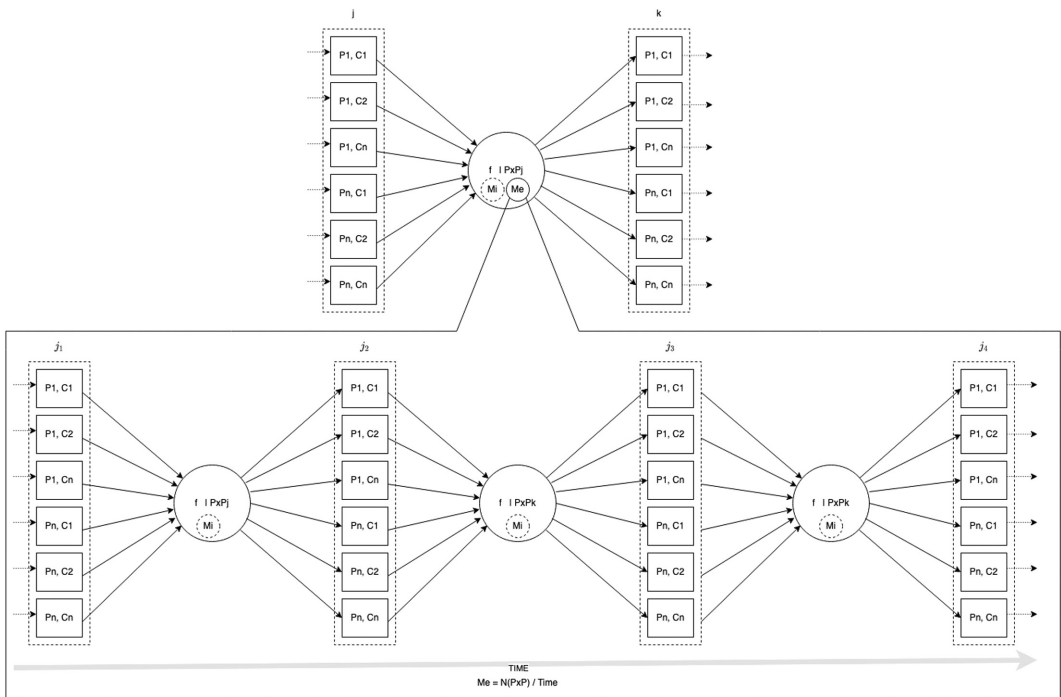


FIGURE 1 PPCT as a mediational model. P1 = person characteristic #1, Pn = person characteristic #n, C1 = level of context #1, Cn = level of context #n, $f | P \times P$ = proximal process, j = time point 1, k = time point 2, j_i = time point after j but before k , M_i = microtime, M_e = mesotime.

processes (i.e., mesotime) is therefore calculated as the number of proximal processes taking place divided by the length of the intervening period.

Our model of PPCT as mediational represents a simplification. Person and context also impact each other through mechanisms outside of the proximal processes in question, and a multitude of other unstudied and unmeasured variables (and their synergistic interrelations) likely explain large portions of variance in the outcome(s). In utilizing bioecological theory and the PPCT model, it is of critical importance that the selection of relevant person, context, process, and time components be based on thorough examinations of the empirical literature and relevant theoretical perspectives. However, Bronfenbrenner envisioned PPCT as a stepwise approach, an "...iterative process of seeking more differentiated formulations that merit further exploration both on theoretical and empirical grounds" (Bronfenbrenner & Morris, 2006, p. 802). Future studies and analyses can build upon each other, iteratively building towards a consensus.

OPERATIONALIZING AND ANALYZING PPCT STUDY DESIGNS

Although Bronfenbrenner and Morris's (2006) chapter provides several examples of how PPCT can be operationalized and analyzed, more recent advances in study design, data-collection methods, and analytic methods are not reflected in the chapter. Moreover, the authors paid no attention to qualitative research. This section of the paper therefore provides recent examples of how PPCT can be realized in practice, using: (a) qualitative studies, and (b) quantitative studies. The authors of these studies did not use bioecological theory or the PPCT model; nonetheless, they provide a starting point for a discussion of how the theory and model can be implemented in 21st-century developmental and family sciences. For each article discussed, we will examine each element of the PPCT model in the following order: Person, Context, Time, and Proximal Processes (including issues of microtime and mesotime). This ordering is for heuristic purposes, as it is more closely aligned with the mediational model described above. We have also added discussion on synergy within each of these studies to underscore the necessity for PPCT studies to explicitly address how it is the interrelation and integration of influences driving development—that is, formal, rather than efficient or material, causes. A summary of how each study addressed the PPCT components (including synergy) and how it could be modified to be in line with the PPCT model is displayed in Table 1.

Qualitative studies

Erdermir and Brutt-Griffler (2020)

Erdermir and Brutt-Griffler's (2020) case study involved 33 peer interactions featuring a monolingual Turkish-speaking 4-year-old and 15 monolingual English-speaking peers, with the outcome of interest being the focal child's improvement in English-language use. The study's conceptual framework was drawn from Vygotsky (1978).

Person characteristics

The developing person of interest in this study was a single Turkish-speaking child. The antecedent person characteristic most central to the study was the child's English vocabulary at the start of the school year (the authors estimated 52 words). Additionally, the child's parents described him as neither shy nor extroverted and that he was interested in animals and technological devices. Each of these characteristics influenced the proximal processes in which the

TABLE 1 Requirements of a process-person-context-time (PPCT) study design

At a minimum, a PPCT study must address the following requirements. These requirements are not a “grocery list” from which scholars can pick; rather, *all* these requirements must be met to ensure that the study design enables a Bronfenbrennerian synergistic analysis (i.e., a process-focused longitudinal multigroup mediational model)

Person characteristics

Three different constructs of person characteristics must be addressed in a PPCT study:

- The *developing person of interest* must be identified early in the study design process, as this will frame the selection of process, person, context, and time components
- The *antecedent person characteristic(s)*
 - Must be measured (or analyzed) categorically
 - Should have a minimum of two contrasting levels
 - Only one antecedent person characteristic is necessary, additional variables will increase complexity
- The *outcome person characteristic(s)*
 - Can be measured categorically or continuously (or both)
 - Must be measured after the proximal process
 - The developing person of interest must be the focus of the outcome variable(s)

Context

- One *contextual influence at the micro-, meso-, exo-, or macrosystemic level*
- Must be measured (or analyzed) categorically
- Should have a minimum of two contrasting levels

Time

Time must be addressed throughout the study design process:

- *Microtime* must be examined related to proximal process(es) to examine their duration
- *Mesotime* must be examined related to proximal process(es) to examine their frequency
- PPCT studies must be *longitudinal* as the outcome person characteristics must be measured at a developmentally relevant time point after the proximal process(es)
- *Macrotime* is a consideration for all studies and study findings must be discussed in relation to the historical time in which they were gathered

Proximal processes

The measure(s) of proximal process(es) must examine:

- *Increasing complexity* of the process across time (either inverse or positive)
- *Reciprocity* between the developing individual and the person(s)/object(s) with which they are interacting
- *Duration* (i.e., microtime) and *frequency* (i.e., mesotime) of the process to make sure it is happening regularly for an extended period of time

Note:

- Processes can be analyzed as either categorical or continuous variables
- Studies must include at least one process, but should ideally include two or more
- Processes should be measured after the antecedent and before the consequent person's characteristics

child engaged. As this was a case study of a single child, it does not meet the PPCT requirement of having at least two groups that can be clearly differentiated by two levels of a person characteristic. As such, to modify this study to reflect PPCT, it would be necessary to include at least one other child who differed on at least one relevant person characteristic (e.g., a child who was either shy or extroverted). This would have allowed the researchers to examine the ways in which this person characteristic both influences and is influenced by the on-going and developing interactions—the proximal processes, in other words.

Context

The PPCT model requires a comparison of at least two levels of a contextual influence at the micro-, meso-, exo-, or macrosystem. Erdermir and Brutt-Griffler (2020) only observed the child in the preschool setting (i.e., a microsystem). The authors observed the impact of interactions on the focal child when he was involved either in free play, while seated, and when he was involved in more structured activities, but this approach to capturing differences within the classroom context would not satisfy PPCT requirements for context. To modify this study to adhere to a PPCT approach, two different microsystems in which the developing child (or children) are situated, such as preschool and home (thereby making it a mesosystemic study), in which case the researchers could focus on the different language-learning proximal processes occurring in each setting. Given that two of the focal child's preschool friends lived close to him, and they played together outside of school, this would have been a second very interesting context to use. Alternatively, the study could involve two different types of preschools; the researchers could compare proximal processes afforded by second-language learners (and outcomes) in (a) a traditional, more formal, preschool classroom and (b) a child-centered and less formal preschool classroom. An alternative approach to context would be at the level of the macrosystem. One possibility would be to focus on social class differences, for example examining the ways in which either shy or outgoing second-language learners engaged in proximal processes in preschools that catered for predominantly working-class children vs. in those for children of middle-class parents.

Time

As the authors examined peer interactions over time, the study was longitudinal and satisfies this PPCT requirement. An additional issue that they could have raised was attitudes in the community towards immigrants that prevailed during their data collection (i.e., macrotime). Perhaps, in a more welcoming period (or one that was more negative), proximal processes might have played out differently. As always, bioecological theory warns that just as one should not generalize across spatial contexts, one should also not do so over those that are temporal.

Proximal processes

The authors observed interactions lasting from 2 to 8 min each over a 9-month period. Thus, from the point of view of proximal processes, the researchers were able to examine the different activities and interactions in which vocabulary and language skills were developed, their duration and frequency (i.e., microtime and mesotime), and the extent to which they became progressively more complex over the length of the study.

Synergy

Synergy is nicely illustrated in this study, as the focal child changes from mostly being a silent observer or non-verbal participant, to engaging in interactions with peers and learning many new words from them, which he used in his play, to being able to use his words, in conjunction with what he has seen outside of preschool, to explain to his peers. Most of the words he used were not originally his but became so in the course of interactions, and then could be used in novel ways. Moreover, the number and type of words used varied greatly both by virtue of person characteristics of his peers (he learned very little from children who were more linguistically competent, and who therefore spoke too fast) and of the context (different types of words were gained during free play than when engaged in "table activities" (Erdermir & Brutt-Griffler, 2020, p. 18). And it was during free-play interactions that the focal child was far more likely to use, and expand upon, the new words learned while seated.

Kelly (2018)

This study drew on the theories of Vygotsky (1978) and Lerner (2006). Perhaps not surprising, therefore, Kelly's methods, like those of Erdermir and Brutt-Griffler (2020), can easily be modified to demonstrate how the PPCT model could be put into practice in early childhood education research. Kelly drew on 4 months of observations in a preschool classroom and two lengthy interviews with the two lead teachers in that classroom, examining children's problem-solving behavior and teachers' language.

Person characteristics

The cast of characters is varied—the children in the study vary by gender, ethnicity, and socioeconomic status; the teachers vary by gender. Antecedent person characteristics, at least in the sense that Bronfenbrenner described them, were not considered as part of this study. It is also not clear what the outcome of interest was; at times Kelly wrote as though it was teachers' pedagogy, but elsewhere about the development of children's autonomy and efficacy while becoming capable problem solvers. To transform the study appropriately, Kelly (2018) could have set the children as the developing person(s) of interest and focused on two subsets of the children—those who the teachers described as becoming easily frustrated and those who, at the start of the study, were more calmly persistent. Relevant questions about proximal processes, then, could focus on whether there was some consistent pattern in the ways in which the teachers interacted with children from the two groups, and what were the problem-solving outcomes 4 months later.

An alternative approach would have been for Kelly (2018) to have completed a parallel study at the same school but in a separate classroom in which the teachers' person characteristics were different in a relevant way. The two lead teachers both had 10 years of teaching experience and so both had many years to develop their classroom management strategies. Teachers with limited teaching experience might have handled similar child problems in different ways, and the children would have reacted differently to them. A juxtaposition between an experienced and inexperienced teacher would have allowed Kelly to examine the ways in which proximal processes were influenced by teacher characteristics, and the impact on outcomes (i.e., children's problem-solving). Needless to say, if the developing persons of interest were the teachers, the outcome would need to be something related to changes in their pedagogical style.

Context

To modify this study to be in line with PPCT, Kelly could have also collected data from teachers in a different type of preschool (e.g., child-centered preschool vs. traditional preschool). The university child-care center in which she collected her data "embraces a constructivist philosophy and uses a child-centered, play-based curriculum" (p. 316). A testable hypothesis would be that, even when considering the relevant person characteristics of the teachers and children, proximal processes would be less likely to show encouragement of autonomy and self-efficacy in a setting that was more structured.

Time

Kelly (2018) observed interactions in the classroom for 4 months, satisfying the PPCT requirement to be longitudinal. Although she did not consider macrotime, it would have been easy to write about the changing fortunes of constructivist philosophy as relevant to early childhood education, and to reflect on contemporary implications for the center in which she gathered her data.

Proximal processes

Although not named as such, Kelly's focus is on the daily, repeated, ways in which teachers and children engaged with one another while trying to solve naturally occurring problems.

Interactions are described in detail (i.e., duration/microtime), and the corpus of field notes would make it easy to show the extent to which these problem-solving interactions occurred (frequency/mesotime), and how the teachers' strategies changed as the children became better (more autonomous and efficacious) problem solvers (i.e., complexity).

Synergy

The type of language used by the teachers to help children solve problems is, over time, incorporated by children into their own speech and thought patterns. The children's ways of thinking, talking, and problem solving are not just their own, but have been constructed in the course of talking and problem solving with their teachers. At the same time, the teachers' ways of talking to and helping individual children are influenced by what the children are saying and trying to do, which have, in turn, already been influenced by their teachers. Of course, it is possible to print out a transcript that shows exactly who said what, but from Kelly's (and any systemic theory's) perspective, it is misguided to imagine that either the teachers' or the children's words are solely their own personal creation. In Kelly's words, "it is important to acknowledge the reciprocal role of children's language in problem-solving interactions" (p. 315). As for context, over historical time, that too is implicated in the types of problems deemed to be important and accepted manners of solving them. Kelly quotes Smagorinsky (2011) approvingly, to the effect that problem solving "is a function of both how problems are defined socially and how people have historically solved those problems with particular cultural goals in mind" (pp. 230–231, quoted in Kelly, 2018, p. 314). Over historical time, cultures have developed different ways to care for and educate young children (Tudge, 2008).

Sung (2010)

Sung (2010) interviewed 20 mother–adolescent dyads from either (a) a Korean American or (b) a Chinese American background. Sung's focus was on the relation between maternal parenting style and adolescent use of emotional intelligence, the outcome of interest. A questionnaire to assess the latter was given to the adolescents, but the "actual utilization of emotional intelligence was captured in a brief follow-up interview with [the] adolescents" (p. 203).

Person characteristics

Sung (2010) did not attempt to choose participants who differed according to characteristics of interest. Instead, these differences emerged through the interviews with mothers and adolescents. The most relevant were parental control, communication, and emotional awareness. Three typologies of parent–child relationships emerged: (a) parents were highly controlling, communication was parent led, and parents had little or no interest in discussing their adolescent's emotional state; (b) parents "still had the same directive and authoritarian mentality but had incorporated flexibility ... [and also] made efforts to be reciprocal in their approach to communication" (p. 206); (c) parents "made efforts to consider their adolescents' emotions when disciplining and making decisions ... [and] created an atmosphere of reciprocal communication" (p. 207). Sung could have centered the mother–child dyad as the developing "person" of interest, and these typologies could have served as three levels of a person characteristic.

Context

Although Sung (2010) argued that she was interested in studying the effects of cultural background, and included families of Chinese and Korean heritage, Sung treated all families as coming from the same macrosystem (i.e., East Asian culture), minimizing the cultural heterogeneity between these distinct cultural groups. She also made no attempt to assess different types of home microsystems (e.g., single-generation or multi-generational households). This study

therefore did not meet Bronfenbrenner's requirements for context as part of the PPCT model. However, a follow-up study, involving participants who were similar in age and educational background but who were from a different cultural background, would easily allow assessment of the ways in which cultural context (the macrosystem) influences the proximal processes of interest.

Time

Unlike observations, which allow time to be considered prospectively, interviews deal with time retrospectively. In this regard, present feelings and understandings shape one's recollections of the past, particularly when the mothers were asked to recall the ways in which their own mothers raised them. Nonetheless, although it is impossible to assess microtime even when asking both the mothers and the adolescents about current interactional patterns, at least it is possible to get a sense of the frequency with which these types of interactions, whether positive or negative, occur. Two ways in which Sung (2010) could have strengthened her study, at least from a Bronfenbrennerian point of view, would have been to consider contemporary East Asian–North American relations, recognizing that parents' views about the value (or not) of acculturation, are likely to alter depending on factors that change over historical time. Alternatively, Sung could have considered temporal norms related to parenting practices. And although Sung mentioned that there was a "follow-up interview" to assess the adolescents' utilization of emotional intelligence, this seems to have been at the end of the main interviews. From a PPCT perspective, it would have been helpful to assess this "utilization" some weeks later.

Proximal processes

The interviews examined, among other things, parenting practices, disciplinary methods, and the type and extent of communication between parents and adolescents. Unlike observations, which allow one to view the ways in which interactions occur on a regular basis, interviewers interested in assessing proximal processes need to gather information on participants' common interactional patterns. In other words, it is what typically occurs, rather than any one-off exchanges. Interviews could have assessed duration and frequency of these interactions (i.e., microtime and mesotime) and increasing complexity through additional follow-up questions.

Synergy

Sung (2010) demonstrated very well the synergistic relations among each of the different factors in which she was interested. For example, with reference to those adolescents whose parents were highly controlling, Sung concluded by discussing the interdependent relations between parents' beliefs and children's choices across time:

...the belief that children do not know how to make good choices puts parents in the position of making all the decisions for their children, taking away opportunities to learn from mistakes. This leaves children unable to make future decisions, fulfilling parents' belief that the children cannot make good choices. (p. 209).

Quantitative studies

Ugarte et al. (2020)

Ugarte et al. (2020) utilized mixture modeling to identify latent subgroups in their heterogeneous sample of 8860 families in the Chilean Longitudinal Study of Early Childhood. Using mediational multigroup regression models, Ugarte et al. found indirect effects between child

group assignment and externalizing behaviors, through harsh parenting and maternal emotional support. Of all studies discussed in this paper, Ugarte et al.'s article is closest in approach and structure to a PPCT study.

Person and context

Ugarte et al. (2020) used latent class analysis (LCA), a form of person-centered analysis (i.e., finite mixture modeling) that looks for latent subgroups in heterogeneous populations based on theoretically and empirically relevant variables. Ugarte et al. estimated four latent classes of children (the developing persons of interest) based on several risk-related variables, including maternal education, poverty level, teenage mother, father absence, prenatal depression, post-natal depression, and maternal neuroticism. These variables encompass both person (e.g., education, depression, and neuroticism) and context (e.g., poverty level and father absence) components of the PPCT model. As opposed to creating groups based on two levels of each person and context (at a minimum), Ugarte and colleagues utilized LCA to identify four latent subgroups (i.e., subgroups of individuals who share unique combinations of risk factors): low-risk, low socioeconomic status, father absent and impoverished, and depressed and impoverished. Mixture modeling is an innovative and data-driven approach to identifying latent subgroups and offers a multitude of possibilities in the PPCT framework. For example, latent class and latent profile approaches could also be used to identify subgroups of individuals who share unique combination of proximal process-related variables or outcome variables. As such, latent group membership could also be utilized as a mediator or outcome variable.

Time

Ugarte et al. (2020) utilized data from two time points (35 and 61 months); person/context (i.e., latent group assignment) was measured at time 1, proximal processes (harsh parenting and maternal emotional support) were measured at time 2, while child externalizing behaviors were measured at both time points. This allowed for analysis of associations between group membership and externalizing behaviors at time 2, controlling for their baseline level at time 1, mediated by proximal processes.

Proximal processes

Parenting practices functioned as proximal processes in Ugarte et al.'s (2020) study design. At time 2, study staff completed an observational measure in the home, and two subscales (harsh parenting and maternal emotional support) were used in the analyses. Although this measure of proximal processes could be improved in similar ways as those discussed below for the Armstrong-Carter et al. (2021) study (i.e., assessment of the duration and frequency of parenting practices, growing complexity, and reciprocal interactions between child and parent), this study provides an illustrative example of a recommendation delineated by Bronfenbrenner and Morris: "From a theoretical perspective, the power of a PPCT design is most effectively enhanced by including more than one proximal process in the model" (2006, p. 808). In measuring two proximal processes, one inverse (i.e., harsh parenting) and one positive (i.e., maternal emotional support), the authors were able to gain insight into the complex and differential mechanisms at work. For example, the authors found different directions of effects for the four latent groups in their sample. Compared to the low-risk class, lower maternal support (but not harsh parenting) mediated relations between assignment in the impoverished and depressed class and higher levels of child externalizing behaviors. However, harsh parenting (but not emotional support) mediated the association between assignment in the father absent and impoverished group and child externalizing behaviors at time 2. Further, both harsh parenting and emotional support mediated this relation in the low socioeconomic group.

Synergy

Ugarte et al. (2020) utilized a synergistic approach, as they identified latent classes based on a data-driven combination of person and contextual components, measured two proximal processes, and a child-centered outcome variable at a second point in time. In their analysis, they used a multiple group mediational design, with the low-risk profile serving as the reference group in the regression model. Their approach demonstrates how the synergy between person, context, process, and time can be implemented elegantly and effectively.

Armstrong-Carter et al. (2021)

Armstrong-Carter et al. (2021) utilized a longitudinal design to examine how neighborhood environment impacted children's prosocial behavior and later academic outcomes. Drawn from the Born in Bradford Study, completed in the United Kingdom, their sample included 1175 children (50% South Asian and 50% White or other) and, in this paper, data were utilized from three time points. Armstrong-Carter et al. found that those children from lower SES neighborhoods who had lower social skills at ages 4–5 had poorer academic outcomes at later time points. In other words, high levels of prosocial behavior buffered against the deleterious effects of low neighborhood socioeconomic status.

Person

Armstrong-Carter et al. (2021) utilized demographic information as control variables. Both gender and self-identified ethnic identity were significant in the overall model related to early learning goals, suggesting that at least one of these two variables would be an excellent choice as an antecedent person characteristic. As such, the study would have satisfied the PPCT requirement of two levels of gender and/or two levels of ethnic identity (South Asian and White/other). Armstrong-Carter et al. delineated three types of academic achievement as their person-related outcomes. Rather than selecting one time-invariant variable to represent achievement, they used three separate developmentally appropriate constructs, measured and analyzed as continuous variables. A simpler study with only one outcome (e.g., academic performance at age 6–7) would have satisfied minimum PPCT requirements. However, the choice to include all three reflects the authors' acknowledgment of the crucial role of developmental time and strengthens their findings, as it suggests that prosocial behavior at an early age has both immediate and long-term protective properties.

Context

Armstrong-Carter et al. (2021) utilized an interesting approach to operationalizing neighborhood socioeconomic status, a macrosystemic context. They employed a measure utilized by the UK government, the Index of Multiple Deprivations, which is a composite measure of neighborhood income, employment, health/disability, education, crime, living environments, and barriers to housing. Neighborhoods were separated into deciles (i.e., 10% groupings) and decile rank (from 1 to 10) was utilized as a continuous measure in their regression analyses and statistical interactions. When approached from a multigroup PPCT perspective, it would be more efficacious to utilize terciles, as comparisons across 10 contextual groups would be challenging logistically and could suffer from low power. Terciles are advantageous because they allow comparisons between the lowest and highest terciles, highlighting inequities between these groups.

Time

Armstrong-Carter et al. measured their person-related outcome at three time points (age 4–5, 5–6, and 6–7). This demonstrated the lasting effects of prosocial behavior in buffering against low neighborhood SES in their sample across children's transition into primary school.

Proximal processes

In Armstrong-Carter et al. (2021), from a bioecological perspective, the proximal processes could be operationalized as the child's prosocial behaviors at time 1, when they were 4–5 years of age. Prosocial behavior was measured through a teacher-reported survey, the prosocial subscale of the Strengths and Difficulties Questionnaire (SDQ). The measure asks the teacher to rate the five statements about the child's behaviors from 0 to 2 (0 = *not true*, 1 = *somewhat true*, or 2 = *certainly true*). The authors utilized this construct as both a continuous variable and as a categorical high/low variable to visually demonstrate the influence of the proximal process on academic outcomes. Although this measure was adequate for the authors' purpose (as it demonstrated the profound effect of prosocial behavior), when viewed from a bioecological perspective and in terms of proximal processes, this survey would need to be amended to reflect the duration and frequency of the behaviors the children engage in, the growing complexity of proximal processes, and reciprocal interactions among the children and their peers. In addition, it would be optimal to measure prosocial behaviors at each time point, as prosocial behavior is not time invariant; rather it would change and be changed by the children's context and academic performance across the course of the study. A longitudinal growth curve or autoregressive cross-lagged approach could address the interdependent associations among these time-varying constructs of interest across the length of the study.

Synergy

Armstrong-Carter et al. (2021) demonstrated the power of early prosocial behaviors to protect against deleterious effects using regression models, in which they controlled for gender and ethnicity, and modeled the bidirectionality between SES and prosociality as an interaction term. To get at synergy, this study could have utilized a multigroup mediational model. Person/context groups could have been created based on gender and neighborhood SES terciles, creating six groups (male/1st tercile, female/1st tercile, male/2nd tercile, female/2nd tercile, etc.). Group membership at T1 could have been used to predict scores of prosocial behaviors at T2, which could have been used to predict academic outcomes at T3. The indirect effect from group membership to prosocial behaviors would quantify the extent to which prosociality functioned as a mediator. A follow-up study or analysis could then examine the impact of skin color as a demand person characteristic input.

Yrttiaho et al. (2021)

Yrttiaho et al. (2021) utilized a lab-based approach to examine the interrelation of infant distress, socioeconomic status, maternal mental health, and maternal stress response (measured by pupil dilation and speed). Across two samples, drawn from diverse socioeconomic populations, the authors demonstrated that mothers in higher socioeconomic groups had stronger pupillary response and quicker saccadic reaction time to images of infants in distress. The authors suggest that their results challenge notions of universally held physiologic maternal responses, as they found a good deal of sociocultural variation.

Person

With mothers as the developing persons of interest, the antecedent person characteristics of interest were standardized pictures of infants in different states of distress (Yrttiaho et al., 2021). In Study I, the authors tested four possible faces as stimuli: strong positive (smiling baby), mild positive (neutral baby), mild negative (frowning baby), and strong negative (crying/screaming baby). In Study II, the authors utilized only mild positive and strong negative faces as they were the most significant in the prior study. These images served as demand characteristics; they triggered immediate biophysiological responses in the mothers in the study, to various

degrees based on their context (socioeconomic status). The authors also included maternal depressive symptomatology as an additional person characteristic, but found, in stepwise hierarchical regressions, no significant effects of maternal mental health. Although this study approaches person-characteristics from a novel perspective (i.e., the “input” person characteristic was a standardized infant stimulus), they did not report person-related outcomes; their model ended with the mothers’ biophysiological response. If this study were completed using a PPCT framework, the pupillary biomarker would become a mediator, and data on a theoretically relevant person outcome (e.g., parenting practices or child self-regulation) would need to be collected at a later point in the child’s development.

Context

Yrttiaho et al. (2021) also examined the influence of socioeconomic status in their studies of South African mothers, a macrosystem-level contextual factor. In one study they recruited mothers from a public low-income health clinic and a private high-income health clinic. In their second study, they broke their sample into terciles based on income. In both studies, the authors used a multigroup approach, which highlighted the disparity in maternal reaction between the low- and high-income groups. Their results call into question organicist perspectives on maternal responsiveness (i.e., a universal trait) and support Bronfenbrenner’s proposition that “...the model identifies any *differences in developmental processes and outcomes associated with different ecological niches*” (1989, p. 200).

Time

Yrttiaho et al.’s (2021) study was not longitudinal, and this is a major limitation from a bioecological perspective. To address this limitation, the authors could collect data on an outcome (e.g., parenting practices) at a theoretically relevant point in time. In addition, the authors could have considered the relevance of historical time in their results; to what extent might housing or poverty-alleviation policies (at the time the data were collected) impact the results of the study?

Proximal processes

Although Yrttiaho et al. (2021) used biophysiological measures of pupillary and attentional responses in mothers as an outcome variable, this biomarker could also be viewed as one side of a proximal process taking place between mother and infant. Although not explored in Bronfenbrenner’s writing, the use of biomarkers raises interesting questions related to proximal processes: Do these measures avoid bias (e.g., self-report, observer, and social desirability)? Or do they merely reflect observable processes? The potential to utilize biomarkers within the bioecological framework presents interesting possibilities for future research. To fully realize Bronfenbrenner’s model, Yrttiaho et al. could have measured the mothers’ biophysiological response to their *own* baby in the lab setting or possibly the home, although assuring mild-positive or strong-negative faces is no guarantee with real infants. The authors could have also simply supplemented their lab-based findings with home-based observations: How did the mothers respond to their infants? How did the infants respond back to their mothers? This approach would yield two perspectives about mother–infant interactions and be in line with Bronfenbrenner’s recommendation to include more than one proximal process in the model.

Synergy

Yrttiaho et al. (2021) demonstrated synergy through a simple multigroup approach; the mothers from the high-income groups had faster pupillary dilation and attentional response time in response to strong negative infant stimuli. The authors utilized another person characteristic, maternal mental health, but did not use it as a grouping factor; instead, it was included as a covariate in hierarchical regressions. However, there were significant differences in

maternal symptomatology between the two groups; the low-income group had significantly higher rates of mental illness, post-partum depression, and previous trauma compared to the high-income group (Study I). These imbalances between the two groups call into question the validity of their results with respect to mental health, and obscure possible multidirectional associations between SES and mental health, and their synergistic joint influence on maternal physiological response to infant distress.

Claridge (2021)

Claridge (2021) used a comprehensive, longitudinal approach to examine the association between pregnancy intention and externalizing behaviors and parental stress, mediated by positive parenting practices. The author collected data in the United States at multiple time points across the 3 years, which allowed for a close examination of the interrelations across time among the variables under study using an autoregressive cross-lagged analytic approach. Claridge found that the first-time mothers in her study who had accidentally become pregnant had significantly higher parenting stress and their child had more externalizing behaviors, through an indirect effect of fewer positive parenting practices.

Person

In terms of person characteristics, Claridge's (2021) approach closely mirrored that of PPCT. Claridge utilized mothers' intention to become pregnant as an antecedent person characteristic, with both a child-centered outcome (externalizing behaviors at 36 months) and a maternal-centered outcome (parenting stress at 24 months). To facilitate scientific discovery, Bronfenbrenner and Morris (2006) suggested the inclusion of "two different developmental outcomes that complement each other" (p. 825). In addition, Claridge also included other time-varying person characteristics in her model—depressive symptomatology and co-parenting satisfaction, neither of which were associated with parenting practices or child behaviors in her sample. It is worth noting that the two groups in Claridge's sample were not of equal size (intended $n = 53$, unintended $n = 171$), and had significantly different levels of maternal age (a person characteristic), as well as of maternal education and race/ethnicity (context). To account for these variations, Claridge statistically controlled for these covariates; however, from a bioecological perspective, controlling out such important person and contextual factors obscures multiplicative and synergistic interrelations between pregnancy intention and these relevant variables. Bronfenbrenner disapproved of such approaches, writing that it would "require that the relation between proximal processes and frequency of problem behaviors be the same at every level, which is not the case" (Bronfenbrenner & Morris, 2006, p. 802).

Context

A central critique of Claridge's (2021) study, from a bioecological perspective, is the neglect of contextual influences. As noted above, Claridge controlled out maternal education and race, which varied significantly between the intended and unintended pregnancy groups. Alternatively, Claridge could have "control[ed] in as many theoretically relevant contrasts as possible" (Bronfenbrenner, 1977, p. 518). Educational differences between the two groups were the most significant and thus could have been selected to serve as a relevant macrosystem contextual variable, reflecting socioeconomic variation. Claridge could have adopted a multiple-group approach, separating the sample into two groups: high school education or less, some college and above. Combined with the intended and unintended person characteristics, this would have created a 2×2 analysis structure (i.e., high education/intended, high education/unintended, low education/intended, and low education/unintended).

Time

Claridge (2021) utilized a longitudinal approach, collecting data at multiple time points from pre-natal recruitment to when the child of interest was 36 months old. This approach allowed for the examination of reciprocal relations between the variables of interest using an autoregressive cross-lagged model.

Proximal processes

Claridge (2021) measured positive parenting practices at two time points (i.e., when the child was 18 and 30 months old). This variable was measured using the Landry Instrument and involved three 20-min home-based observations at each time point. Positive parenting practices were measured across five domains: warmth, positive affect, responsivity, teaching, and verbalness. This observation-based assessment incorporates some element of reciprocity as mother–child interactions were the process under study, and incorporates microtime to some degree, particularly in the responsivity subscale. In addition, by observing parenting practices at 18 and 30 months, assumptions of mesotime were addressed; higher scores reflect the degree to which those practices were happening on regular basis. However, as noted in regard to the Armstrong-Carter et al. (2021) study, this measure could be improved by incorporating the reciprocity between mother and child more explicitly.

Synergy

In terms of synergy, Claridge (2021) closely mirrored studies exemplified by Bronfenbrenner. The longitudinal research design, intensive data collection of proximal processes, and statistical analyses designed to examine reciprocal and mediational pathways map on to the PPCT model. However, as opposed to using a multiple-group approach, Claridge utilized pregnancy intention as a predictor in the model, which does not allow for statistical-invariance testing between groups to determine which path(s) are statistically different among groups. As such, it is difficult to determine where the synergistic differences between the two groups of mothers arise. More importantly, Claridge did not incorporate context as a variable of interest, and instead chose to control out variation in education, age, and race between the two subsamples of mothers. Further, Claridge did not provide information about whether these covariates were significant in the full model. As Bronfenbrenner reiterated from his 1979 monograph: “*In ecological research, the principal main effects are likely to be interactions*” (Bronfenbrenner & Morris, 2006, p. 802). Without the incorporation of key contextual factors (e.g., socioeconomic status) and the interaction between contextual and person elements, the findings of this study are inadequate from a bioecological perspective.

Mustillo et al. (2021)

Mustillo et al. (2021) used a data-intensive, daily-diary approach to study differences between two- and three-generation households in China. Of the studies discussed, this paper is the only one to use a daily diary approach, which offers unique insights into day-to-day interdependence both within and between families. To limit selection effects, Mustillo et al. used propensity scores to match seventh graders from two- and three-generation families on a range of variables (e.g., single child or not, parent age, child gender, migrant status, father and mother education, income, global work-to-family conflict, etc.). Using a multigroup approach, Mustillo and colleagues found statistically significant differences between the types of households with regards to the associations between daily reports of work-to-family conflict (WTFC) and next-day child negative affect.

Person

Mustillo et al. (2021) did not include an antecedent person characteristic in their model, and instead used propensity scores to match seventh-grade students from two- and three-generation families on several person and context variables. As such, the two groups in the study were not significantly different in terms of person characteristics. Although this approach does not incorporate antecedent person characteristics as recommended by Bronfenbrenner, it is superior to statistically controlling for these variables as it “controls in” these sources of selection effects and between-group variation that may alter findings. As an outcome, Mustillo et al. focused on child negative affect, as measured by daily self-report.

Context

Unlike the other studies discussed above, Mustillo et al. compared types of microsystems: two- and three-generation households in Zhengzhou province, China. This choice was based on theory suggesting that grandparents in three-generation households can buffer deleterious parental influences on child outcomes. Their two-group analyses supported this hypothesis; parent-reported daily WTFC was significantly associated with next-day child negative affect in two-generation households, but not three-generation households.

Time

Mustillo et al. (2021) utilized a daily-diary approach, which offers unique insights into mesotemporal factors both within and between families. Although the authors did not explore all these avenues in this article, they could have examined the frequency of high WTFC days and duration of WTFC (i.e., number of days in a row of high WTFC scores) as another variable of interest related to proximal processes.

Proximal processes

Mustillo et al. (2021) utilized a multigroup moderation model in their study of the impact of grandparent co-residence on WTFC and child negative affect. Alternately, they could have used a multigroup mediational approach, with WTFC as an inverse proximal process. As mentioned above, the daily diary approach allows for the collection of mesotemporal data related to the frequency, intensity, and duration of this variable. However, is WTFC a proximal process or a person-level characteristic? As conflict implies interrelations between persons, we believe that it could be a proximal process, and that work-related stress is a person-level characteristic. Although it may be a proximal process (i.e., WTFC is happening frequently for an extended period and getting more difficult to deal with) for some families, for others it may not. The results from this study highlight this dichotomy; for two-generation families, the deleterious effects of WTFC impact children’s outcomes, but for three-generation families they do not. Put another way, WTFC could be an inverse proximal process that is more likely to occur in two- than three-generation families.

Synergy

Mustillo et al. (2021) utilized a thought-provoking approach to modeling synergy between process, person, context, and time. Through their daily-diary data collection, they were able to get at microtime and mesotime, and interdependence between parent WTFC and the outcome variable, child negative affect. In addition, Mustillo et al. used a two-group approach, comparing regression models of the two- and three-generation families. Statistical differences between these groups reflect differences in how the synergy of context (i.e., living in a household with grandparents or not), process, and time impact child negative affect. Although the authors did not include an antecedent person characteristic, they did match the two groups on a wide variety of person characteristics. In Bronfenbrenner’s terms, they “control[led] in as many theoretically relevant contrasts as possible” (Bronfenbrenner, 1977, p. 518). By using this approach, they tried to isolate how context alone contributes to the proximal process. In studies where the

purpose may be to examine only person- or context-related synergy, propensity matching is an excellent approach to reducing between-group differences and assuring that the preponderance of variation is due to the component under consideration. In addition to the multiple-group approach, which found significant differences between the two groups, the authors also ran another regression model on the whole sample and included an interaction term between WTFC and grandparent co-residence. They found the exact same regression coefficient for the interaction. This raises some interesting questions about synergy: Are statistical interactions between person and context inferior to a multiple group approach? Were these results parallel to the multigroup model because they only examined differences in context? These questions are subject to empirical test and have important implications for applications of the PPCT model in the future.

CONCLUSION

We hope that this paper answers more questions than it raises and offers some illustrative examples for how scholars of developmental and family science can utilize bioecological theory and PPCT in a straightforward manner. The requirements for utilizing a PPCT model in designing a study are summarized in Table 1. Of equal importance to the aforementioned requirements of each of the PPCT components, and their synergy, is a necessary exposition—that the study design, including the selection of all variables, be driven by theoretical and empirical a priori reasoning. As Bronfenbrenner and Morris (2006) wrote:

Perhaps, even more in developmental science than in other fields, the pathways to discovery are not easy to find. The trails are not marked, there are many dead ends, the journey is far longer than expected, and at the end, little may be there. What counts is what one learns along the way and passes on to future explorers of uncharted terrain. (p. 825)

Although this omen may seem bleak, it underscores the necessity of utilizing a systematic framework and theory to gain incremental insight into human development. Bronfenbrenner's bioecological theory and PPCT model offer that structure, and with a priori planning and rigorous implementation, Bronfenbrenner's theory can be just as relevant in the next 50 years as it has been in the last.

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