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Neuroeducation and Early Elementary Teaching: Retrospective Innovation for Promoting Growth with Students Living in Poverty

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Introduction

Neuroeducation, or educational neuroscience, is an emerging field combining various scientific disciplines as it relates to learning to study the relationships between the biological processes of the brain and students' cognitive development. Researchers and educators, increasingly working together, attempt to bridge these fields to increase positive learning experiences for increased school readiness and academic achievement, especially for children experiencing significant adversity. In fact, brain research remains such a timely topic that the May 2017 issue of *Young Children* highlighted articles focused on the important role of neuroeducation in preschool education. While researchers agree that brain development during early childhood is a critical period of growth comprised of both extreme vulnerability and competence (Lally & Mangione, 2017), the brain remains malleable or plastic throughout children's years of schooling (Pakulak et al, 2017; Shonkoff, 2017). Early elementary educators can utilize emerging research to help make their classroom environments growth-friendly to support children's developing capacities

for success in K-12 school environments. Therefore, this manuscript outlines a strong rationale for promoting academic growth with students living in poverty through instructional strategies that might even be considered retrospective in many ways.

Teachers of early elementary classrooms are more and more in need of strategies for those children most in need. Neuroeducation brings much hope to the field, creating growth-promoting classrooms that are language rich, emotionally rich, steeped in play (Hassinger-Das, Hirsh-Pasek, & Golinkoff, 2017), and protected from excessive stress can "dramatically improve the life prospects of all young children" (Shonkoff, 2017, p. 15). The critical difference between children who overcame extreme toxic stress or hardships and children who were unable to persist comes down to significant, stable, and responsive relationships (Shonkoff, 2017).

The field of education is beginning to understand more concretely how specific conditions, such as poverty, affect brain and cognitive development and the related impacts on academic achievement. More than 10 million children who live below the poverty threshold attend public preK-12 schools, and over 1 million of these children attend public prekindergarten and kindergarten (National Center for Children in Poverty, 2017). Especially in early childhood, poverty poses the single greatest threat to children's well-being and educational equity. As educators, early childhood professionals commit to a mandate to ensure all students are afforded every opportunity for school success. Innovative approaches in the primary grades can apply emerging brain research to continue to build elementary-aged children's readiness for school, emotional resiliency, and abilities to be successful academically.
Recent improvements in neuroimaging, a relatively new discipline using various technologies to image the structure and function of the brain, allow us to better understand how the brain develops, and this affects our understanding of teaching and learning, specifically in the areas of executive function (EF) and self-regulation (SR). These increased understandings allow educational professionals to tailor instructional practices to best meet the needs of students, especially students living in poverty who are at greater risk for underperforming compared to their more resourced peers. To meet the needs of all our students, but especially our students living in poverty or other stressful environments, teachers offer learning experiences that engage children emotionally, socially, and cognitively in growth-promoting classrooms to increase children's chances for success in school and beyond. This paper highlights the salient connections between poverty and brain development, and then aligns neuroeducational insights with innovative, yet retrospective instructional strategies linked to the early childhood areas of language and literacy, dramatic and imaginary play, games and puzzles, and gross motor and musical movements.

The Connections Between Poverty and Brain Development

Self-regulation involves resisting impulsivity, delaying gratification, responding effectively and appropriately to our environments, and utilizing appropriate skills at appropriate times. Executive functions are domain-specific mental skills including task completion, response inhibition, attention control, attention shifting or cognitive flexibility, and working memory that advantage self-regulation (Shonkoff, 2017). Both occur largely in the prefrontal cortex of the brain and affect judgment, differentiation, anticipating outcomes, time management, attention

and switch focus, planning and organizing, remembering details, and social-emotional aptitude. Scientists assert that early childhood is a critical period for developing executive function skills critical for school readiness (Blair, 2016; Blair & Raver, 2015; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Lally & Mangione, 2017; Pakulak et al, 2017; Shonkoff, 2017). Increasingly, researchers continue to uncover poverty's impacts on executive function development (Blair & Raver, 2015; Fitzpatrick et al, 2014). Shonkoff (2011) emphasizes how school readiness and achievement gaps can be reduced with high-quality, research-based pedagogy and curriculum in conjunction with nurturing, supportive environments that reduce stress on developing brains. Existing neuroeducation research suggests a predictive relationship between executive function and to literacy and numeracy skill development (Shonkoff, 2011). Blair and Raver (2015) provide further evidence linking executive function as a predictive agent for academic achievement associated with socioeconomic status for children of poverty.

Teaching with Neuroeducation in Mind: Instructional Strategies

For the past decade, researchers increasingly focused on executive function and self-regulation as an essential underpinning for success in formal K-12 schooling. Indeed, "coordinating multiple, and sometimes competing, demands on cognitive activity, is one of the central hallmarks of readiness for the seismic shift in complexity of the learning tasks that will occur in early elementary school" (Moreno, Shwayder, & Friedman, 2017, p. 144). The strategies included here focus on building specific executive function skills, especially for children of poverty. Researchers in neuroeducation identify three main types of brain function that act as "the air traffic control system" of the brain (Center for the Developing Child, 2011; 2017). These primarily include working memory, cognitive flexibility, and inhibitory control, but also subsume decision-making, delaying gratification, planning, goal setting, rule following, and problem solving.

Working memory requires children to preserve information, work with this information, and use it at the appropriate time. Remembering an idea to share for turn-taking, retaining the options available when it is time to select a center activity, and following multi-step directions or procedures all require working memory (Gathercole & Alloway, 2007). Cognitive flexibility is the ability to be nimble with one's mind. This includes transferring easily between tasks or activities, employing different rules or procedures depending on the situation, and maintaining or shifting attention in response to various demands. Focusing on a task while ignoring distractions, sorting and classifying objects by color one time and shape the next, and transitioning when directed are all indicators of cognitive flexibility (Center for the Developing Child, 2017). Inhibitory control can be thought of as a combination of impulse control, planning, and considering possible outcomes. Waiting for a turn, anticipating potential consequences to choices, making a plan for play or learning and keeping that plan all require inhibitory control (Galpod, 2013).

While executive function can be negatively affected by stressful environments and a lack of quality interactions with caring adults (Lally & Mangione, 2017; Shonkoff, 2017), "growth-promoting environments" (Center on the Developing Child, 2017; Pakulak et al, 2017) can help children develop or strengthen their executive function. Predictable routines, familiar

procedures, adults who model pro-social-emotional behaviors and stress management techniques, gross motor development and exercise, creative play opportunities, scaffolding with a gradual increase of complexity and independence are all components of executive function-friendly classroom environments. Much of what supports executive function growth can be found in constructivist, discovery-based classrooms aligned with the respected theories of Montessori (1912), Piaget (1977), or Vygotsky (1978).

In recent decades, the elementary school focus collectively has shifted to an environment of increasing testing and decreasing play and autonomy. Neuroeducational findings demand reflection and a return to an early childhood environment in primary elementary grades reminiscent of the past that could significantly help students, especially those students living in poverty, experience greater academic success. Components of whole-child, constructivist classrooms often include language and literacy learning, dramatic or imaginary play, games and puzzles requiring logic and spatial awareness, gross motor play, and music and movement. Classroom games and learning experiences that can help support the development of working memory, cognitive flexibility, and inhibitory control are outlined below and are organized by areas of early learning classrooms.

Language and Literacy. The authentic foundational literacy experiences that occur in early childhood classrooms support the development of executive function (Center on the Developing Child, 2017; Moreno, Shwayder, & Friedman, 2017). Storytelling itself requires planning, elaboration, and organization. Reading stories to children using dialogic strategies and think-alouds, supporting them as they engage in their own writing at various developmental levels by encouraging planning, organization, and creativity, and encouraging bilingual storytelling all help support the development of working memory and cognitive flexibility. Adding elements of reader's theater, either from memory or a script, and using authentic student writing to develop personalized plays (Bodrova & Leong, 2007) can help develop inhibitory control.

Dramatic or Imaginary Play. Dramatic or imaginary play develop working memory, inhibitory control, and cognitive flexibility. Teachers can support children in building background knowledge vicariously through literature, multimedia, and real-life experiences. Student writing plans for imaginary play that function almost as scripts (Bodrova & Leong, 2007) blend emerging writing with planning, inhibitory control, problem solving, and language development. Stories that emanate from the circle area, classroom library, or small groups may translate into dramatic retellings. Children may also engage in thematic play, with toys, props, or costumes, to practice and reinforce concepts learned about home, community, and professions. While younger children may need more concrete representations for play, older children can move toward more abstract and child-made props, promoting cognitive flexibility (Center on the Developing Child, n.d. A). For example, younger children may use plastic or cardboard food props while older children may use blocks to represent merchandise in a store, which helps develop cognitive flexibility. Using housekeeping materials as part of play, like carefully pouring liquids from pitchers (Montessori Primary Guide - Introduction to Practical Life, n.d.), in dramatic play helps develop inhibitory control and can easily be integrated with other conceptual understandings like spatial awareness, mass, and volume.

Games and Puzzles. Although it may seem less than academic to the naïve onlooker, games and puzzles remain a smart choice for teachers. Whether used at circle time, in centers independently, with some teacher guidance and narrative talk, or in more formal small group instruction, games and puzzles, such as matching or classifying, can also help to improve working memory, inhibitory control, and cognitive flexibility. On the rug, teachers (or students) could offer a change to traditional rules to familiar games (or songs); this provides opportunities for cognitive flexibility and inhibitory control (Center on the Developing Child, n.d., A). For example, touching one's toes when you are actually asked to touch one's head, or not listening when "Simon Says," or putting a *Bingo* marker on something large when you hear a cue for something small strengthens children's cognitive flexibility and inhibitory control.
Puzzles, word games, brainteasers, matching or sorting games, and mazes of increasing difficulty require working memory, planning, and cognitive flexibility (Center on the Developing Child, n.d. B). Many games require working memory like the many iterations of *Memory* or the newer game, *Blink*. More complex card games, like *Go, Fish!* (Center on the Developing Child, n.d. B), require children not simply to match and remember, but to concentrate on multiple pieces of information such as who has which card and what cards are needed to make a match or a pattern. Some games, like *Quick Cups* and *See-It? Slam-It!*, require rapid responses that support inhibitory control and cognitive flexibility. Games like *Qwirkle*, *Rummikub*, and C*onnect Four* promote strategic and logical thinking that support all executive function domain areas (Center for the Developing Child, 2011). Montessori sensory activities (Montessori Primary Guide - Introduction to Sensorial, n.d.), and all kinds of activities that support sorting, classifying, and seriation of objects by attribute, can help support this type of cognitive functionality. Logic, reasoning, visual discrimination and guessing games like *I Spy* and *20 Questions* are also beneficial (Center on the Developing Child, n.d. B). For specific details regarding games aligning with current neuroeducational findings, Appendix A provides a helpful, annotated bibliography.

Gross Motor Play/Music and Movement. The more neuroscientists know about the brain, the more early childhood educators learn that exercise and movement help build cognition. Furthermore, play evidences the capacity to scaffold children's development in positive directions and potentially helps "prime neural mechanisms" (Hassinger-Das, Hirsh-Pasek, & Golinkoff, 2017, p. 49) which are important for healthy brain development. Gross motor movements that increase in complexity challenge children to develop working memory, cognitive flexibility, and inhibitory control. Songs like Hap Palmer's classic "Listen and Move," the camp favorite "Telephone," and "The Wheels on the Bus*"* have movements or actions that incrementally repeat to support working memory. Playing different genres of music and asking children to interpret it through movement and encouraging complex outdoor play that includes climbing, balancing, pedaling, and jumping are also good strategies. Planning obstacle courses or specific physical challenges, such as transferring water from one bucket to another using sponges, promote cognitive flexibility. Traditional dances and games like *Simon Says*, square dancing, or other dances requiring partner changes or shifting directions, and freeze dance develop working memory and inhibitory control (Center on the Developing Child, n.d. A). Montessori games such as *Walk the Line* do the same by requiring children to focus on balance and movement while ignoring a variety of distractions (Pugh, 2010). Games like *Duck, Duck, Goose* and *Red Rover* support working memory, fast-paced ball games like tether ball and dodge ball support inhibitory control, and organized sports and mindfulness activities help support

cognitive flexibility (Center on the Developing Child, n.d. B). Classics from Ella Jenkins like "Did You Feed My Cow?" and familiar tunes like "If You're Happy and You Know It," "Old MacDonald Had a Farm," and "Row, Row, Row Your Boat" that require partner singing, echoing, rounds, and parts support working memory development and inhibitory control. Complicated clapping rhythms like *Patty Cake* and *Miss Mary Mack* can help build all three highlighted areas of executive function.

Closing the Relationship Gap and the Play Gap Could Help Close the Achievement Gap

School readiness and achievement gaps may be reduced with high-quality, research-based pedagogy and curriculum in conjunction with a nurturing, supportive environment that reduces stress on developing brains (NAEYC, 2005; 2009; Shonkoff, 2011). Existing neurocognitive research suggests a predictive relationship between EF and SR to literacy and numeracy skill development (Shonkoff, 2011). Blaire and Raver (2015) provided evidence linking EF as a predictive agent for academic achievement and socioeconomic status for children of poverty. These same experts believe that growth-promoting environments in early elementary classrooms are ones that are language-rich, include purposeful play, and allow discovery and exploration with the support of peers and teachers scaffolding metacognitive development of skills that support SR and EF development.

Growth-promoting, brain compatible classrooms that utilize purposeful play, discovery-based, language-rich, child-directed learning using strategies like those outlined above need not sacrifice accountability, rigor, and standards-based education. Developmentally appropriate practice (DAP) is a long-standing and highly-respected early childhood education (ECE) approach that values meeting children where they are developmentally and socially with age- and stage-appropriate rich, engaging content. As the field of neuroeducation evolves, many parallels between DAP and the types of learning environments recommended by neuroscientists are aligning and being solidified. In the newly revised DAP position statement, NAEYC (2009) advocates for a blending of the best of both the ECE world and the K-12 world since kindergarten is uniquely positioned as a bridge between them. A comprehensive, holistic, and effective elementary curriculum diligently attends to academic and socio-emotional competencies. Today's early elementary classroom incorporates attention to robust content, learning progressions, quality systematic assessment, and effective curriculum and teaching (traditionally, the domain of the K-12 world) while also scaffolding and differentiating learning in a prosocial environment to support each student's unique needs (traditionally, the domain of the ECE world). To help mitigate the achievement disparities often associated with family income, ethnicity, and language background, young children require access to enriched, intensive learning experiences at an early age. Enabling and empowering teachers to ensure increased agency to make curricular decisions means that teachers recognize that purposeful play may be the right choice to meet individual needs. To be effective, highly competent teachers require high-quality teacher preparation and professional development (NAEYC, 2005; NAEYC, 2009) that empower teachers to make critical classroom decisions to include purposeful play that may run counter to current high stakes testing emphases (Boote, 2006).

Often at odds with the state-mandated standards approach which tends to reinforce instructional strategies perhaps more appropriate for older students (Goldstein, 2007a, 2007b; Graue, 2008), teachers in DAP settings including kindergarten and early elementary grades would do well to provide high-level, purposeful play opportunities (NAEYC, 2009). Many young children, especially children who are under resourced, do not spend time out of school engaging in this type of play (Bodrova & Leong, 1996). Because high-level, purposeful play affords so many socio-emotional and cognitive benefits, DAP purports that quality early childhood classrooms provide play-based learning opportunities supported by skilled facilitators (NAEYC, 2009). By incorporating rich learning activities, as described in the paper and additional website resources annotated in Appendix B, educators can start to advance academic equity. All children will benefit, but particularly children living in poverty.

Final Thoughts and Future Research

To be effective, elementary classrooms include environments of both emotional stability and intellectual novelty full of predictable routines, safe spaces, consistency, and respectful caring guidance (Lally & Mangione, 2017). Strategies to increase predictability and reduce stress can be used both in classrooms and encouraged with families to bridge caring home and school environments. Playful learning environments where children have choice and agency within safe, guided limits help to develop these important socio-emotional and cognitive skills (Hassinger-Das, Hirsh-Pasek, & Golinkoff, 2017; Jarrett & Waite-Stupiansky, 2009). These environments can impact a child's entire lifetime (Shonkoff, 2017). "Not only should play and games *not* be pushed out of the classroom to make room for more 'academic' learning, they need to be taken very seriously" (Bodrova & Leong, 2008, p. 58). A balanced approach tapping current neuroeducation advances and involving creative, guided, and independently directed movement and play in a supportive environment will help all children, but especially children living in poverty, to be more successful in navigating the rigorous demands of today's structured learning.

All of these suggested brain-compatible activities for the early elementary classroom, reinforced by today's neuroeducational research, harken back to a time before *No Child Left Behind* (2002) in early childhood classrooms. They are reminiscent, in fact, of the types of instructional strategies used almost 25 years ago. One could argue, as Bodrova, Leong, and Akhutina (2011) have, that innovative teaching, informed by our emerging understanding of educational neuroscience, supports a return to discovery-based, independent, autonomous, self-directed, constructivist, hands-on learning aligned with the theories of Montessori (1912), Piaget (1977), and Vygotsky (1978). Curricula such as *Tools of the Mind* (Bodrova & Leong, 2007) incorporate similar learning experiences intended to develop self-regulation and executive function while simultaneously building foundational literacy and early math skills. To support all children's development of executive function, it is critical teachers create learning activities "to be generalizable enough that [they] are not dependent on the implementation of a particular curriculum or intervention that emphasizes executive function" (Moreno, Shwayder, & Friedman, 2016, p. 144). Researchers, teacher educators, professional developers, and especially practitioners remain charged with identifying how self-regulation and executive function may innovate everyday teaching and learning experiences in early childhood education classrooms.

Many schools could benefit by incorporating these retrospective instructional strategies intended to close poverty-related school readiness and academic achievement gaps that are increasingly explained by differences in executive function skills (Blair & Raver, 2015; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Moreno, Shwayder, & Friedman, 2016; Shonkoff, 2011).

Future research is sought to align daily, granular practices that boost executive function and self-regulation skills, and to assess executive function and self-regulation capacities efficiently in the classroom. Additional short-term and long-term studies of the effectiveness of learning activities can deepen our understanding and allow educators to make research-informed decisions about emerging practice and policy for our early elementary classrooms. What is new is our increasing understanding of how critical brain development is, how toxic stress, scarcity, and poverty impede cognitive growth, and exactly how to support areas of impaired cognition in children who need it the most. In short, the early elementary classroom now can reap the benefits of concrete research findings and increasing neuroeducational evidence that older strategies are worth making new again to increase equity and achievement for students living in poverty.

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Appendix A
Annotated Bibliography of Commercial Games Referenced in Manuscript

Staupe, R. (1990s) *Blink* (Card game). El Segunda, CA: Mattel, Inc.

"How fast can you match? That's the key to BLINK. Shape, count, or color - any way you can match it, do it fast to get rid of your cards. You need a sharp eye and a fast hand to win this lightning-fast game!" (http://shop.mattel.com/shop/en-us/ms/mattel-games/blink-card-game-t5931) – Recommended age 6+

Connect 4 (Connection game) (1974). Pawtucket, RI: Hasbro.

"Challenge a friend to disc-dropping fun with the classic game of Connect 4! Drop your red or yellow discs into the grid and be the first to get 4 in a row to win. If your opponent is getting too close to 4 in a row, block them with your own disc! Whoever wins can pull out the slider bar to release all the discs and start the fun all over again!" (https://www.hasbro.com/en-us/product/connect-4-game:80FB5BCA-5056-9047-F5F4-5EB5DF88DAF4) - Recommended age 6+

Coffelt, D. M. (1984). *Go Fish!* (Card game). Berkeley, CA: Peaceable Kingdom.

"Swim with the sharks and lunch with the lobsters! Go Fish is a great way for young kids to learn how to play cards – how to hold them, how to deal, how to read the numbers, how to take turns. The game set includes instructions for a simple game and a challenging game." (https://www.amazon.com/Peaceable-Kingdom-Fish-Classic-Card/dp/B002BRSCJ6) – Recommended age 3+

Memory (Card game). Pawtucket, RI: Hasbro.

"Children learn about taking turns and matchmaking in this game as they try to make pairs of elated elephants, panting puppies, smiling suns, and other familiar objects. The 48 (cardboard) cards have lively, colorful drawings that make them easy to remember and a tray for storing them. Played alone, Original Memory is a quiet activity for developing concentration and memory. With more players, it's even more of a memory challenge to remember where the cards are that have already been turned over. And you have to wait your turn, which is sometimes harder than anything. The printed rules in the box set the tone for this child-friendly game: the youngest player always goes first. --*Lynne Sampson*" (https://www.amazon.com/Hasbro-Original-Memory-Card-Game/dp/B00000IWDD) - Recommended age 3+

Quick Cups (Board game). Toronto, ON: Spin Master.

"QUICK CUPS™ is the fast-paced family game of matching and stacking cups to a picture! Each player gets a set of five cups in five different colors. When a picture card is turned over, everyone races to line up or stack up their cups in the same color order as the picture. When the picture is horizontal, you line your cups up. When the picture is vertical, you stack them up. Finish first and ring the bell -- you just won the card! Win the most cards after all have been played, and you win the game! QUICK CUPS is match e'm up, stack 'em up fun!" (https://www.spinmaster.com/product_detail.php?pid=p10444) - Recommended age 6+

Ross, S. M. (2006). *Qwirkle.* Omaha, NE: MindWare.

"Mix, match, score and win! Qwirkle is a must-have for your next family game night. MindWare's best seller is a simple game of matching colors and shapes that requires tactical maneuvers, quick-thinking and a well-planned strategy. Players of this addictive game score points by building rows and columns of brightly-colored tiles that are either all the same color or all the same shape, without creating duplicates. Look for opportunities to score big by placing a

tile that touches multiple pieces with matching attributes; create a line of all six in a row, and you score a "Qwirkle". The player with the most points when the tiles run out wins! Qwirkle combines the game play of Dominoes and Scrabble and is the perfect combination of skill and chance! This easy-to-learn, yet challenging game for children and adults will have all three generations on the edge of their seat! Grab your family and friends and see for yourself why everyone is hooked on Qwirkle!" (http://www.mindware.orientaltrading.com/qwirkle-a2-32016.fltr?keyword=Qwirkle) - Recommended age 6+

Hertzano, E. (1977). *Rummikub* (Board game). New York, NY: Bello Games New York, Inc.

"It's no surprise that Rummikub is so popular--it has all the elements that make a great game: it's easy to learn and fast moving, it's different every time it's played, it combines luck and strategy, and it changes quickly so every player has a chance to win until the very end. And with more than 50 million units sold, Rummikub is one of the world's best-selling, and most-played, games. Players take turns placing numbered tiles in runs (consecutive numbers of the same color, like 2, 3, 4 in red) and groups (three or more of the same number in different colors, like a red 9, a blue 9, and a black 9), rummy style. It's easy to learn, but packed with strategy--the "board" changes all the time as players adjust the tiles on the table. The Joker tiles add to the fun; they can be any color or number. The object is to be the first player to play every tile on your rack. Players keep track of who wins each round--the player who wins the most rounds wins this time-tested tile game (there's also a point system for use as a tie-breaker). Rummikub is ideal for people of different ages to play together, and it's great for a game night too. When kids play, it reinforces STEM and STEAM concepts such as sequencing, pattern recognition, and planning skills. It's got lots of exciting moments, but it's also designed to bring people together, with plenty of opportunities for talking, chatting, and sharing with family and friends." (https://www.amazon.com/Rummikub-Original-Rummy-Tile-Game/dp/B00000IZJB) - Recommended age 8+

See-It? Slam-It! 2016). Victoria, BC: Outset Media.

"**See-It? Slam-It!** is a fast-paced family card game where players must shout out a word associated with a picture. There are three picture cards showing at all times. A letter card is flipped over and players race to spot something on any one of the cards beginning with that letter. See something!?! Then slam your hand down fast on the card before someone else spots a match. For example, the three picture cards shown are of pears, a cactus, and a shark jumping

out of a pail. You flip over the letter card and it's a "P". Now slam your hand quick on one of the picture cards and make a connection to the letter, "P". You could slam the cactus and say, "prickly"! BAM! There you go! You saw it, you slammed it. Now you know how to play See-It? Slam It! Get ready for a fun game of speed and observation."
(http://www.outsetmedia.com/games/see-it-slam-it) - Recommended age 7+

Appendix B
Helpful Website Resources for Early Elementary Implementation

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