JeuMETACOGITE, self-regulation and metacognition at school.

Project leaders: Anick Pelletier, LANOË Céline, LUBIN Amélie

The beginning of the 21th century has been marked by considerable progress towards the understanding of the processes involved in learning. These advances have paved the way for a new point of view in the field of education: this consists in taking into account the cognitive and neurocognitive functioning of the student to enable the construction of knowledge and school skills. One way to achieve this scientifically ambitious objective is to renew educational tools based on the most recent research. Learnings at school is an activity that is slow to acquire and that requires a significant cognitive and emotional regulation of the student's activity. The quality of this school-based learning depends in particular on the student's ability to mobilize these self-regulation (SR) processes (Gathercole et al., 2004; Lubin et al., 2016; Rossi, 2015; Roy, 2015).

Cognitive SR processes, also known as executive functions (EF), refer to a set of cognitive functions involved in the control and execution of goal-directed behaviors (Roy et al., 2012). During complex tasks, EFs make it possible to control and coordinate the cognitive actions and operations being resolved. They include, in a more or less consensual manner, cognitive skills of flexibility, inhibition, updating in working memory, goal-oriented planning, problem solving, attentive supervision, and hypothesis generation (Diamond, 2013; Miyake et al., 2000). EFs are involved in the control and regulation of behavior, including planning, comparing and selecting behavioral sequences for the pursuit of a goal. They are essential for academic learning (Molfese et al., 2010; Monette, et al., 2011, Rossi, 2015), including mathematical (Bull and Scerif, 2001; Lubin et al., 2016) and reading (Lubin et al., 2016; Nevo and Breznitz, 2011) skills. It is also known that low executive ability increases the probability of academic failure (Alloway et al., 2009). These cognitive AR processes are identified as cold components of executive functioning in that they do not involve, in the foreground, any particular emotional state, and rather bear a certain logical, abstract and decontextualized logic. Some emotional SR processes are also identified hot components of EFs, such as emotional decision-making and, more generally, social cognition (Roy et al., 2012).

All of these cold and hot SR processes are essential to academic success (Alexander, Entwistle & Kabbani, 2001; Blair & Diamond, 2008; Blair & Raver, 2015; Haelewyck & Palmadessa, 2007; Nader-Grobois, 2007; O'Shaughnessy et al., 2003). Thus, Nader-Grosbois (2007) distinguishes three self-regulatory strategies mobilized by the learner: (1) cognitive strategies, which include goal identification, planning, exploration of means, attention SR and self-evaluation; (2) socio-communicative self-regulatory strategies, which are distinguished by solicitations and responses, and the regulation of behaviour towards the environment; and, finally, (3) motivational and emotional self-regulatory strategies, which belong more to the personal sphere . We will be particularly interested in the cognitive and emotional SR strategies involved in learning as well as in the students' capacities to become aware of these strategies and to mobilize them appropriately in school contexts which are identified by metacognition (MC).

MC refers to a person's knowledge of his or her own cognitive processes and appears to be one of the most relevant indicators for promoting effective learning (Flavell, 1976; Veenman, Wilhelm & Beishuizen, 2004; Vukman & Licardo, 2010; Zohar & Barzilai, 2013). A distinction must be made, however, between metacognitive knowledge and metacognitive skills. Metacognitive knowledge is

defined by the declarative knowledge that a person has of him/herself as a learner and of the factors that influence his/her performance (Flavell, 1979). Metacognitive skills refer to the knowledge that a person needs to regulate and to the control of his or her own learning activities (Flavell, 1992), which makes them very similar to SR.

Brain imaging research underscores the interdependence of SR and MC in highlighting a common neural network including the prefrontal cortex, involved in both SR (Casey et al, 2005; Langner, Leiberg, Hoffstaedter, & Eickhoff, 2018) and MC (Clark & Dumas, 2016). The late maturation of the brain regions underlying them (Gotgay et al., 2004) explains their slow development from childhood to late adolescence (Diamond, 2013; Lockle & Schneider, 2006; Schneider, 2008).

Given the critical role of SR and MC in academic success, various types of educational programs have been designed and implemented in the classroom or in cognitive remediation in order to put them into practice. The results of these research works are indicative of the contrasting impacts depending on the practical processes, the targeted learning framework and the implementation contexts.

Some programs are based on repeated training of cognitive SR tests involving one or more EFs, in which possible transfer effects on tasks involving similar processes (near transfer) or on other tasks (far transfer) are measured. These studies have shown a near transfer effect (Blair, 2016; Diamond, 2013; Diamond et al., 2007; Diamond & Lee, 2011; Diamond & Ling, 2016; Kassai, Demetrovics & Takacs, 2019). The far transfer effects have yet to be widely demonstrated (Jacob & Parkinson, 2015; Kassai et al., 2019; Melby-Lervag & Hulme, 2013; Titz & Karbach, 2014).

Other programs, offering individual remediation for SR and MC in children with atypical development, appear to have more far transfer effects. Emotional SR and MC programs have an impact on children with behavioral and conduct disorders (Houssa, Volckaert, Nader-Grosbois & Noël, 2017) by significantly reducing their agitation behaviour and their lack of concentration and by promoting better emotional regulation and academic performance. Some programs combining cognitive RA and CD interventions also allow school-aged children with learning difficulties to acquire metacognitive strategies but also to transfer some of the strategies learned into problem-solving exercises (Bosson, 2008). Furthermore, metacognitive training programs have shown an improvement in school performance, particularly in children with intellectual deficiency (Büchel and Paour, 2005; Pennequin, 2011) and adolescents with conduct disorder (Pennequin, 2013). Finally, several remediation programs are available to children with ADHD or learning disabilities (Programme d'Intervention sur les Fonctions Attentionnelles et Métacognitives, PIFAM, Luissier, 2013; développement des habiletés exécutives, Gagné, 2016, 2018; enseignement explicite des habiletés métacognitives, Caron, 2016) and indicate significant positive outcomes from a clinical point of view that are, however, not systematically evaluated.

However, there are only a few programs that are implemented by teachers during school hours and made available to all their students in order to develop methodology and learning tools. On the one hand, a few, based on interventions associating cognitive AR and MC and carried out by the teacher with preschool (Cèbe, 1998; Rossi et al., 2012) and school-age students (Lubin et al., 2012), reveal transfer effects on learning. On the other hand, others aim to make students aware of these

tools of thought by sensitizing them to their organ of thought - the brain - and to the neural mechanisms that underlie the learning process. These pedagogical programs carried out in class on brain discovery, namely its functioning and its plasticity have shown a positive impact on students' motivation and academic performance (Blanchette Sarrasin et al., 2018; Lanoë et al., 2015).

In summary, intervention programs focusing solely on cognitive SR training do not seem to be sufficient to promote far transfer in academic learning. Programs that focus on both SR and MC seem to be more relevant for impacting academic learning. Nevertheless, to our knowledge, there has been no joint program on brain discovery, cognitive and emotional SR and MC that has been implemented by teachers in the classroom and made available to all students.

These programs would gain from being implemented in the classroom by combining learning by playing, which might then provide a learning base and serve as a pedagogical lever for improving the processes involved in learning. This concept, used in psychology and education sciences, would improve social competence as well as children's SR or ability to manage their behaviours and emotions (Tominey & McClelland, 2011; Weisberg, Hirsh-Pasek, Golinkoff, Kittredge, Klahr, 2016; Yogman et al., 2018). There are two types of play : free and guided, both of which are important for children's social and academic development (Hassinger-Das et al., 2017; Hirsh-Paseck, Gollinkoff & Eyer, 2003; Hirsh-Paseck et al., 2015; Singer, Golinkoff & Hirsh-Pasek, 2006).

Free play is a play based on the child's initiative, in which he/she creates his/her rules and uses toys independently. Guided play is a play where the adult shapes the play environment with a specific learning goal in mind. It is defined as a gaming activity in which the adult shapes the environment to optimize the child's learning. This refers to Vygotski's (1985) theoretical approach and its zone of proximal development, which stipulates that the most effective learning takes place within a social context in which the adult guides the child in his/her skills development.

The board game, when used with well-defined goals, belongs to this register of the play. The playful character of the game in relation to school work gives it a particular status. Some studies highlight the contribution of guided play, and in particular the use of board games, to school learning such as mathematics (Ramani & Siegler, 2011; Siegler & Ramani, 2008) or reading (Bergen & Mauer, 2000; Christie & Enz, 1992; Hassinger-Das et al., 2016). Nevertheless, its use is often limited to kindergarten. Yet its contributions are recognized in the remediation area, where the psychologist, the specialist in orthopedagogy or the specialized teacher often use it as a basis to work on certain functions. In this context, it is not a question of playing for the sake of playing, but of learning by playing. The board game is then merely a medium to put the targeted cognitive skills into action and allow a better piloting of these skills.

The objective of the "JEuMETACOGITE" project is to assess, in a classroom, the effects of a pedagogical program reinforcing SR capacities through a metacognitive approach based on board games among primary school students.

References

Alexander, K. L., Entwisle, D. R., & Kabbani, N. S. (2001). The dropout process in life course perspective: Early risk factors at home and school. *Teachers College Record, 103*, 760-822.

Alloway, T.P., Gathercole, S.E, Kirkwood, H.J., & Elliott, J.E. (2009). The cognitive and behavioural characteristics of children with low working memory. *Child Development, 80,* 606–621.

Bergen, D. & Mauer, D. (2000). Symbolic play, phonological awareness, and literacy skills at three age levels. In Roskos, K.A., Christie, J.F., eds. Play and Literacy in Early Childhood: Research from Multiple Perspectives (pp 45-62). New York, NY: L. Erlbaum.

Blair, C. (2016). The Development of Executive Functions and Self-Regulation: A Bidirectional Psychobiological Model. In K. D. Vohs & R. F. Baumeister (Eds.), *Handbook of Self-Regulation Third Edition: Research, Theory, and Applications*. New York: Guilford Press.

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology, 20(3)*, 899–911.

Blair C., Raver C.C. (2015). School readiness and self-regulation: a developmental psychobiological approach. *Annual Review of Psychology. 3, 66,* 711-31.

Blanchette Sarrasin J., Nenciovicia L., Brault Foisy L.M., Allaire-Duquette G. Riopel M., Masson S. (2018). Effects of teaching the concept of neuroplasticity to induce a growth mindset on motivation, achievement, and brain activity: A meta-analysis. *Trends in Neuroscience and Education. 12*, 22-31.

Bosson M. (2008). Acquisition et transfert de stratégies au sein d'une intervention métacognitive pour des élèves présentant des difficultés d'apprentissage. Thèse de Doctorat, Genève.

Büchel F.P, Paour J.L. (2005). Déficience intellectuelle : deficits et remediation cognitive. *Enfance, 3, 57*, 227-240.

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: inhibition, switching, and working memory. *Developmental Neuropsychology*, *19*, 273- 293.

Caron A. (2017). Pour une pédagogie exécutive de l'attention et de l'autocontrôle. *Approche Neuropsychologique des Apprentissages chez l'Enfant, 140*, 101-107.

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: what have we learned about cognitive development? *Trends Cogn Sci.*, *9*, 104- 110.

Christie, J.F. & Enz, B. (1992). The effects of literacy play interventions on preschoolers' play patterns and literacy development. Early Education and Development, 3, 205-220.

Cèbe S. (1998). Une intervention à visée cognitive en Grande section de Maternelle : ses effets de transfert sur l'apprentissage de la lecture à l'École Élémentaire. *Repères, recherches en didactique du français langue maternelle, 18,* 97-112.

Clark, I., & Dumas, G. (2016). The Regulation of Task Performance: A Trans-Disciplinary Review. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01862

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). The early years: preschool program improves cognitive control. *Science*, *318*, 1387-1388.

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*, 135- 168.

Diamond, A., & Lee, K. (2011). Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old. *Science*, *333*, 959- 964.

Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental Cognitive Neuroscience, 18,* 34-48.

Flavell, J. (1976). Metacognitive aspects of problem solving. In L. Resnick (Ed.), *The nature of intelligence* (pp. 231-236). Hillsdale, NJ: Erlbaum.

Flavell, J. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist, 34*, 906-911.

Flavell, J. (1992). Perspectives on perspective taking. In H. Beilin, & P. Pufall (Eds.), *Piaget's theory: Prospects and possibilities* (pp. 107-141). Hillsdale, NJ7 Erlbaum.

Gagné P.P. (2016). Les remédiations cognitives comme soutien aux élèves TDA. *Approche Neuropsychologique des Apprentissages chez l'Enfant,*93-100.

Gagné P.P., Cailleux V. (2018). Métaaction. Apprendre à scénariser des stratégies cognitives. Montréal. Chenelière Education.

Gathercole SE, Pickering SJ, Ambridge B, & Wearing H (2004). The structure of working memory from 4 to 15 years of age. *Dev Psychol* 40, 177-90

Gogtay, N., Giedd, J. N., Lusk, L., Hayashi, K. M., Greenstein, D., Vaituzis, A. C. (2004). Dynamic mapping of human cortical development during childhood through early adulthood. *Proceedings of the National Academy of Sciences of the United States of America, 101,* 8174–8179.

Haelewyck, M. & Palmadessa, S. (2007). Chapitre 11 Aide-moi à faire tout seul ! Les stratégies d'autorégulation mises en place par des élèves présentant un retard mental en situation d'apprentissage. Dans *Régulation, autorégulation, dysrégulation: Pistes pour l'intervention et la recherche* (189-201). Wavre, Belgique: Mardaga.

Hassinger-Das, B., Ridge, K., Parker, A., Golinkoff, R. M., Hirsh-Pasek, K., & Dickinson, D. K. (2016). Building vocabulary knowledge in preschoolers through shared book reading and gameplay. *Mind, Brain, and Education, 10,* 71–80.

Hassinger-Das, B., Toub, S.T., Zosh, J.M., Michnick, J., Golinkoff, R.M. & Hirsh-Pasek, K. (2017) More than just fun: a place for games in playful learning. Infancia y Aprendizaje. Journal for the study of Education and development, 40, 191-218.

Hirsh-Pasek, K., Golinkoff, R. M., & Eyer, D. (2003). *Einstein never used flashcards: how our children really learn–And why they need to play more and memorize less.* Emmaus, PA: Rodale Books.

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. *Psychological Science in the Public Interest, 16,* 3–34.

Houssa M., Volckaert A., Nader-Grosbois N., Noël M.P. (2017). Differential Impact of an Executive-Function and a Social Cognition Training on Preschoolers with Externalizing Behavior Problems. *Journal of Behavioral and Brain Science, 7,* 598-620.

Jacob, R. & Parkinson, J. (2016). The potential for school-based interventions that target executive function to improve academic achievement: a review. *Review of educational research, 25*, 3-7.

Kassai, R., Futo, J., Demetrovics, Z., & Takacs, Z. K. (2019). A meta-analysis of the experimental evidence on the near- and far-transfer effects among children's executive function skills. *Psychological Bulletin, 145(2*), 165-188.

Langner, R., Leiberg, S., Hoffstaedter, F., & Eickhoff, S. B. (2018). Towards a human self-regulation system: Common and distinct neural signatures of emotional and behavioural control. Neuroscience & Biobehavioral Reviews, 90, 400- 410.

Lanoë, C., Rossi, S., Froment, L., & Lubin, A. (2015). Le programme pédagogique neuroéducatif « À la découverte de mon cerveau »: quels bénéfices pour les élèves de l'école élémentaire? *ANAE, 134*, 55-62.

Lubin, A.*, Lanoë, C.*, Pineau, A. & Rossi, S. (2012). Apprendre à inhiber : une pédagogie innovante au service des apprentissages scolaires fondamentaux (mathématiques et orthographe) chez des élèves de 6 à 11 ans. *Neuroéducation, 1,* 55-84.

Lubin, A., Regrin, E., Boulc'h, L., Pacton, S., & Lanoë, C. (2016). Executive functions differentially contribute to fourth graders' mathematics, reading and spelling skills. *Journal of Cognitive Education and Psychology, 15,* 444-463.

Lockl, K., & Schneider, W. (2006). Precursors of metamemory in young children: the role of theory of mind and metacognitive vocabulary. *Metacognition and Learning, 1,* 15–31.

Luissier F. (2013). PIFAM : Programmes d'Interventions sur les Fonctions Attentionnelles et Métacognitives. Hogrefe.

Melby-Lervåg M., & Hulme C. (2013). Is working memory training effective? A meta-analytic review. *Developmental. Psychology, 49,* 270-291.

Monette, S., Bigras, M., & Guay, M.-C. (2011). The role of the executive functions in school achievement at the end of Grade 1. *Journal of Experimental Child Psychology, 10*, 158-173.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. Cognitive Psychology, 41(1), 49–100.

Molfese, V. J., Molfese, P. J., Molfese, D. L., Rudasill, K. M., Armstrong, N., & Starkey, G. (2010). Executive function skills of 6–8year olds: Brain and behavioral evidence and implications for school achievement. *Contemporary Educational Psychology*, *35*, 116- 125

Nader-Grosbois, N. (2007). Régulation, autorégulation, dysrégulation : Pistes pour l'intervention et la recherche. Wavre, Belgique : Mardaga.

Nevo, E., & Breznitz, Z. (2011). Assessment of working memory components at 6years of age as predictors of reading achievements a year later. *Journal of Experimental Child Psychology*, *109*, 73- 90.

O'Shaughnessy, T. E., Lane, K. L., Gresham, F. M., & Beebe-Frankenberger, M. E. (2003). Children Placed at Risk for Learning and Behavioral Difficulties: Implementing a School-Wide System of Early Identification and Intervention. *Remedial and Special Education*, *24*, 27- 35.

Pennequin V., Sorel O., Nanty I., Fontaine R. (2011). Métacognition et déficience intellectuelle chez l'enfant et l'adolescent : effet d'un entraînement sur la résolution de problèmes. Enfance, 2, 225-244.

Pennequin V., Lunais M. (2013). La métacognition chez les adolescents présentant des troubles de la conduite et du comportement : humeurs et expériences métacognitives. Enfance, 4, 303 à 322.

Ramani, G. B., & Siegler, R. S. (2011). Reducing the gap in numerical knowledge between low- and middle-income preschoolers. Journal of Applied Developmental Psychology, 32, 146–159.

Rossi, S. (2015). La mémoire chez l'enfant. Transmettre des outils cognitifs pour apprendre. *Education Canada, 55,* 38-40.

Rossi, S., Lubin, A., Lanoë, C., & Pineau, A. (2012). Une pédagogie du contrôle cognitif pour l'amélioration de l'attention à la consigne chez l'enfant de 4-5 ans. *Neuroéducation, 1,* 29-54.

Roy, A. (2015). Approche neuropsychologique des fonctions exécutives de l'enfant : état des lieux et éléments de prospective. *Revue de Neuropsychologie, Neurosciences Cognitives et Cliniques, 7*, 245-256.

Roy A, Le Gall D, Roulin JL, & Fournet N. (2012). Les fonctions exécutives chez l'enfant : approche épistémologique et sémiologie clinique. *Rev Neuropsychol, 4*, 287-297

Schneider, W. (2008). The Development of Metacognitive Knowledge in Children and Adolescents: Major Trends and Implications for Education. *Mind, Brain, and Education*, *2*(3), 114- 121.

Siegler, R. & Ramani, G.B. (2008) Playing linear numerical board games promotes low-income children's numerical development. *Developmental Science, 11,* 655-661

Singer, D.G., Golinkoff, R.M., Hirsh-Pasek, K. (2006). *Play = Learning: How Play Motivates and Enhances Children's Cognitive and Social-Emotional Growth*. New York: Oxford University Press.

Titz C., & Karbach J. (2014). Working memory and executive functions: effects of training on academic achievement. *Psychological Research, 78*, 852-868.

Tominey, S. L., & McClelland, M. M. (2011). Red light, purple light: Findings from a randomized trial using circle time games to improve behavioral self-regulation in preschool. *Early Education & Development, 22*, 489–519.

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*, 89- 109.

Vukman, K. B., & Licardo, M. (2010). How cognitive, metacognitive, motivational and emotional self-regulation influence school performance in adolescence and early adulthood. *Educational Studies*, *36*, 259- 268.

Weisberg, D.S., Hirsh-Pasek, K., Golinkoff, R.M., Kittredge, A.K. & Klahr, D. (2016). Guided play: principles and practices. *Current Directions in Psychological Science, 25*, 177–182.

Yogman, M., Garner, A., Hutchinson, J., Hirsh-Pasek, K. & Golinkoff, R.M (2018). The Power of Play: A Pediatric Role in Enhancing Development in Young Children. *Pediatrics, 142: e20182058*.

Zohar, A., & Barzilai, S. (2013). A review of research on metacognition in science education: current and future directions. *Studies in Science Education*, *4*, 121- 169.