

DO DEFICITS IN SPECIFIC DOMAINS IN EXECUTIVE FUNCTION PREDICT THE RELATION BETWEEN THEORY OF MIND AND SYNTAX UNDERSTANDING IN CHILDREN WITH AUTISM?

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Abstract

Theory of mind, executive function and language could be three overlapping cognitive variables in children development. A large literature in psychology and developmental sciences support this assumption. Results in the perspective of this hypothesis come from two lines of research which grew up separately for a long time: studies on the theory of mind - executive function link and theory of mind – language link, in children development. The actual challenge is whether the relationship of these three cognitive processes may implicate the reality that one should be an explanatory factor of the two others correlation. Thus, we conduct an experience in the aim to verify if executive function as a general cognitive domain is a predictor of the developmental theory of mind-syntax understanding relationship, in children with autism. A large matching age sample of children is recruited to participate in the experience. We used both first order and second false belief tasks, three EF tasks assessing inhibition, cognitive shifting and planning, and two tasks of syntax in the experimental material. We expect having results allowing to describe the predictive and explanatory links between executive function, syntax understanding and theory of mind. We also expect to obtain results explaining the relation of planning tasks with first and second order false belief tasks. We wish discussing the pattern of inhibition and cognitive shifting in the perspective of the cognitive complexity and control theory. Results of planning – theory of mind relationship is expected to discuss the effect of age in processing false belief tasks. The sense of syntactic understanding variable will be discussed in the results patterns for both children with autism and typically developing control group, in order to verify the consistency of our results with the literature about findings on syntactic processing in children with autism.

Keywords: *Theory of mind, executive function, syntax understanding, autism, children development.*

Ability of theory of mind (ToM) emerge in children around of the age of 4 years old (Perner, 1999, 2000; Wimmer & Perner, 1983). ToM refers to a core of competences allowing to impute mental states to self and others, in order to predict behaviors about a specific context (Baron-Cohen et al., 1985; Wimmer & Perner, 1983). In fact, understanding the development of ToM leaded researchers to question other cognitive processes, supposed having considerable implication in ToM development. Cognitive functions, like executive function (EF) and language have been question in ToM development according to the fact they involve the same period of development than ToM abilities (Perner, 1998; Russell et al., 1991). Questions regarding the relationship between ToM, EF, and language abilities generated a literature divided in two main research lines, in children development. One line sought to investigate the possibility of a prediction link between ToM and EF (Benson et al., 2013; Carlson, 2005; Devine & Hughes, 2014; Pellicano, 2007). The other line concentrated more interest in understanding the nature of the ToM-language relationship in children development (J. De Villiers, 2000; J. de Villiers, 2007; J. G. De Villiers & De Villiers, 2000; Tager-Flusberg, 2000; Tager-Flusberg & Sullivan, 1995).

In this communication, we debate the ToM, EF and language relationship as a unique research problem in atypical children development. We want to deepen the relation between these three cognitive variables in order to clarify whether EF might be a potential predictor for the developmental link between ToM and language notably syntax processing, or if EF process explain only the ToM development. Our focus is on children with autism, as the development and links between these processes may be different from those observed in typically developing children and these differences could explain at least part of difficulties encountered by children with ASD.

Results obtained in the literature showed that EF skills have large implication in ToM development in children with autism (Hala & Russell, 2001; Hughes & Russell, 1993; Pellicano, 2007, 2010). Thus, results of a longitudinal study by Ozonoff and McEvoy (Ozonoff & McEvoy, 1994) showed significant correlation between ToM and EF, in autistic children. According to several researchers, the correlation between ToM and EF in autism is discussed in the perspective of a more primary deficit in EF which has significant implication in the ToM operations (Devine & Hughes, 2014; Hughes & Russell, 1993; Pacherie, 1997). Results from multiple regression analyses supported the hypothesis that EF could be an important predictor for ToM development in children with autism, but not validated the opposite possibility (Pellicano, 2007, 2010). In typically developing children, the role of inhibition as a predictor of ToM was described, with a clear developmental effect in the EF-ToM correlation (Carlson & Moses, 2001). These results have shown that 4 years old participants outperformed 3 years old participants in both EF and FB tasks. Other results in autism allowed to document that EF processes implicated in both ToM deficits and in behavioral autistic feature expressions, in children with autism (Joseph & Tager-Flusberg, 2004; Lukito et al., 2017). In this view, a 12 years longitudinal study revealed that better relationship between EF and ToM was associated with fewer autistic traits (Kenny et al., 2019). Indeed, researchers supposed that inhibition and cognitive flexibility are two critical executive factors having more implication in ToM when considering the structure of false belief (FB) tasks (Benson et al., 2013; Carlson, 2005; Fujita et al., 2022; Russell et al., 1991). The implication of working memory had been shown by other results, in both autistic and typical children (Keenan et al., 1998; Polyanskaya et al., 2021). In other papers, a statistical significant correlation between scores of FB tasks and executive planning tasks was found in typical and atypical participants (Kouklari et al., 2018; Pellicano, 2007).

A large number of results support the hypothesis that language could be an explanatory factor for ToM development (M. C. Burnel et al., 2017; J. de Villiers, 2007; Durrleman et al., 2017; Hale & Tager-Flusberg, 2003). In this view, a link between understanding certain structures of language and perform FB tasks was found in children with autism (Tager-Flusberg & Sullivan, 1995; Ziatas et al., 1998). Results have shown that understanding syntax is a predictor for ToM development in typical and autistic preschool age children (Lind & Bowler, 2009; Paynter & Peterson, 2010; Tager-Flusberg, 2000). Conclusions about the relationship of ToM and syntax understanding led to certain consensus on the fact that children with autism use their knowledge of syntax as a compensatory strategy to achieve FB tasks without developing maturity of ToM (Fisher & Happé, 2005; Happé, 1995; Tager-Flusberg, 2000). Indeed, results from several papers showed that complement sentence structures might be an effective predictor for achieving FB tasks in the group of autistic children (J. de Villiers, 2007; J. G. De Villiers & De Villiers, 2000; J. G. de Villiers & de Villiers, 2014; J. G. de Villiers & Pyers, 2002). A significant correlation between morphosyntax task and verbal FB tasks was found in children with autism (Durrleman et al., 2016). Schroeder and colleague's results demonstrated that embedded clause constructions should be a predictor for autistic children performance in metarepresentational tasks (Schroeder et al., 2021). In this view, other results showed that comprehension of relative clauses allowed children with autism performing FB tasks (Durrleman et al., 2016, 2018). Also, it has been found that complement of cognitive verbs were significantly correlated to verbal FB tasks in children with autism (M. C. Burnel et al., 2017).

To go forward in the debate, some researchers wanted to know more on the hypothetic possibility that EF as a more general cognitive domain, predict the relation of ToM and syntax processing. In this way, results obtained by Burnel and his colleagues have shown that syntax was a predictor of ToM in typically developing children, but not EF (M. Burnel et al., 2021). In fact, this question was asked in a first paper published by Carlson and colleague, in the perspective of general language abilities (Carlson et al., 2002). The importance of this question is associated in the idea that these three cognitive functions refer to the same critical period in the development of children.

About our experience, the goal is to investigate the relationship between ToM, EF, and language as one and unique problem. Indeed, there is very few researchers who approached the question in this perspective. Results obtained do not allow until now clear explanation about which really predicted the ToM development, between EF and language. In this view, if certain results obtained in autistic children and in typically developing children (M. Burnel et al., 2021) showed the effect of syntax processing as a predictor of ToM, while those obtained by Polyanskaya and colleague (Polyanskaya et al., 2021) described a double profile: in typically developing children the significant predictor of ToM was working memory EF, and in children with autism syntax understanding was found as a predictor of ToM. The first remark is there is very little research on this extension of the debate interesting to know between EF and syntactic language, if one of these two variables predicts the relation of ToM with the other. The second remark is an inconsistency of results to answer the new concerns concerning the relation of ToM with the two other variables. Thus, our specific objective is to verify if particular domains in EF, like inhibition, cognitive flexibility, and planning predict deficit patterns in ToM in children with autism. We hypothesize that EF is a predictor of ToM development in children with autism. This experience is an occasion for us to question

the relation between EF and ToM in the perspective of two micro-problems in the literature. In one side, the role of inhibition and cognitive flexibility in coordinating conflicting rules (cognitive complexity and control (CCC) theory), and on the other side, the correlation between FB tasks and planning tasks.

Currently, our experience has as a status of ongoing study. Recruitment of a large sample of participants is in progress. The methodology part should allow to answer an important question regarding previous results obtained specifically on the relation of ToM, EF and syntax understanding in autistic and typical children. So, the sample size may be a crucial factor explaining certain result profiles, in previous papers interest to describe the link between these three cognitive variables. In this view, we recruited French speaking participants aged between 4 and 7 years old, with a diagnostic of autistic spectrum disorder (ASD) in IME (Institut Médicaux Educatifs) at Tours and at Paris Île de France.

We used several cognitive measures to evaluate skills related to general ability of language, ToM, EF, and syntax understanding. Indeed, to assess ToM abilities, three tasks of FB were chosen in the NEPSY-II (Korkman, Kirk, Kemp, 2012). The first task is an unexpected-contents false belief, the second is a type of perception knowledge, and the third is an appearance-reality task. Three tasks are used to measure ability of EF, one measure inhibition process from NEPSY-II (Korkman, Kirk, Kemp, 2012). The dimensional card changes sorting (DCCS; Zelazo, 2006) is used to evaluate cognitive flexibility, and the tower of London (TOL; Shallice, 1982) allowed to evaluate planning skills. Language abilities are measured by two vocabulary tasks: reception and production lexicon, chose in ELO test (Khomsy, 2001). We used two tasks of syntax from the CELF-5 (Wiig, Semel, Wayne & Secord, 2019) test to assess syntax and morphosyntax skills. All tasks were chosen according to the literature and the age criteria linked to the standardization of the tests.

We expect having results justifying our hypotheses. Results expecting should show significant correlation between EF and ToM in both groups of participants. The regression analyses must show that EF predict significantly ToM in autistic children. We hope obtaining results justifying a significant correlation between TOL test and the FB task – perception knowledge. Syntax understanding will not be expecting as a predictor of the ToM-EF relationship.

The results will be discussed in the perspective of previous results in the literature. Deficits pattern in the correlation between inhibition and cognitive flexibility with ToM will be an important aspect of discussion. We consider that the CCC theory is important to know more about the correlation between inhibition and cognitive shifting and ToM abilities, in autism. We discuss also results allowing to understand whether EF is a predictor of the relation between ToM and syntax understanding, in children with autism and in typically developing participants. Our interest is to present our results in this scientific event and give possibilities to other researchers to debate with us about and on specific methodological elements of the experience.

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