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Working memory predicts changes in children's theory of mind during middle childhood: A training study

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ABSTRACT

The present study examined the role of working memory (WM) in theory of mind (ToM) changes that occur in middle childhood using a training design. The main aim was to investigate whether the extent to which children benefited from ToM training was predicted by their WM. Eighty-six children (*M* age = 9.67 years; *SD* = 7.38 months) were assigned to either a ToM (N = 46) or a control condition (N = 40). The groups were equivalent at pre-test for age, family, socio-economic background, vocabulary, reading comprehension, WM, and ToM. Findings indicated that: i) the training promotes ToM, and ii) individual differences in WM moderated improvement in children's ToM. These results are consistent with the emergence account, according to which WM helps the development of ToM skills.

Research in theory of mind (ToM), defined as the ability to make inferences about people's mental states and to use these inferences to explain others' behavior (Wimmer & Perner, 1983), has recently expanded to include the period of middle childhood (Hughes, 2016). This expansion of research on ToM into middle childhood raises important new questions about the developmental changes in ToM and on the mechanisms underlying these changes. Current research is only beginning to consider these issues and a number of questions are still open. Addressing this gap, the study herein was designed to investigate the role of working memory (WM) in ToM changes during middle childhood using a training design. The present study takes a completely new approach to the issue of mechanisms underlying ToM changes. First, it focuses on an understudied developmental period in the ToM research area, namely middle childhood. Second, it adopts a training design that has the benefit of inducing a change (rather than simply observing it) by experimental manipulation and allows theoretical claims to be made about the nature of change. More precisely, the main aim of the current study was to investigate whether individual differences in WM moderate the benefits of ToM training.

WM is the ability to consider and manipulate pieces of information during a short period of time (Baddeley, 1992) and is a core component of the more general construct of executive functions (EF) (Brocki & Bohlin, 2004). We target WM for two main reasons. First, existing research suggests that the structure of EF gradually separates with age (Lee, Bull, & Ho, 2013; Shing, Lindenberger, Diamond, Li, & Davidson, 2010), encouraging researchers to examine single subcomponents when investigating older children. Second, a recent longitudinal study shows that the developmental link between EF and ToM in middle childhood may be specific to WM (Lecce, Bianco, Devine, & Hughes, 2017).

From a methodological point of view, the present research built upon studies conducted by Lecce and colleagues' that have showed positive effects of a conversation-based ToM training in primary school (Lecce, Bianco, Devine, Hughes, & Banerjee, 2014). Lecce and colleagues' intervention program is, to date, the only training specifically designed to increase ToM in typically developing children during middle childhood. It produces beneficial effects not only at post-test, but also two months later and did not simply teach children that mental states are relevant, rather, it helped children to make accurate judgments about them on the basis of

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contextual information (Bianco, Lecce, & Banerjee, 2016). This is crucial for the present study, given that a growing number of researchers (Apperly, 2012; Devine & Hughes, 2013; Lagattuta, Elrod, & Kramer, 2016) draw attention to the increasing ability of children (during middle childhood) to *use* their understanding of mental states in a flexible and appropriate way. This developmental period seems to be characterized by an increase in the ability to simultaneously infer a variety of mental states in complex social scenarios and in the awareness of the links between multiple mental states (Amsterlaw, Lagattuta, & Meltzoff, 2009; Bender, Pons, Harris, & de Rosnay, 2011; Lagattuta, 2014), rather than by the acquisition of new conceptual insight about the nature of mental states. In line with an existing study showing that Lecce et al.'s training is beneficial not only when it is run by researchers (Lecce et al., 2014), but also when it is implemented by a trained regular class teacher (Bianco & Lecce, 2016), in the present study the training activities were administered by children's regular class teachers. This allowed us to focus on the school environment that is crucial for children's development in middle childhood and reproduce typical social experiences that are known to contribute to individual differences in ToM development (Banerjee, Watling, & Caputi, 2011) in real life. Differently from Bianco and Lecce's research (Bianco & Lecce, 2016), in the present study the (expected) positive effects of the training were evaluated using a ToM task that varies in modality from the training activities: the Triangle task. It requires children to apply their mental state understanding to explain a character's behaviour in situations involving surprise, persuasion and mocking. Interestingly, the Triangle task shows convergent validity with the Strange Stories task (Devine & Hughes, 2016) and constructs validity, in that individual differences at age 10 are significantly associated with individual differences in children's false belief understanding at age 6 (Devine, White, Ensor, & Hughes, 2016). Given existing evidence, we expected that the ToM training, as run by teachers, has a positive impact on the Triangle task.

1. ToM and WM in middle childhood

The literature on WM and ToM in middle childhood shows a significant correlation between these two variables (Cantin, Gnaedinger, Gallaway, Hesson-McInnis, & Hund, 2016), even when age (Williams, Moore, Crossman, & Talwar, 2016) and gender were controlled for (Lagattuta et al., 2016). Although these results are interesting they tell us very little about the *role* that WM plays in ToM *development*. To answer this question, longitudinal studies are needed. To date, only three studies with such a design have been conducted in middle childhood. In the first one, Austin, Groppe, and Elsner, 2014 examined the relations between attention shifting, WM, inhibition and performance on a cartoon sequencing ToM task in a sample of children aged between 6 and 11 years over a 12-month period. They found a weak, but statistically significant, longitudinal association between early WM (and shifting) and later ToM. In the second study, Devine et al. (2016)) examined the links between ToM and EF over a 4-year period and reported no significant developmental relation between these two constructs. Two features of this study are relevant. First, EF was examined as a composite measure including WM, inhibition and shifting, therefore, no conclusion upon the specific role of WM in ToM development can be drawn from this study. Second, the extended interval between time points and the use of different measures at each wave might have attenuated any developmental influence of EF on ToM. These issues were addressed in a recent study conducted by Lecce, Bianco, et al. (2017). It examined the developmental relations between WM, inhibition and ToM, using a three-wave cross-lagged longitudinal study. Results showed that, in a sample of children followed from age 9.5 to age 10.5, individual differences in WM (but not in inhibition) were significantly linked to later individual differences in ToM (even when the effects of verbal ability and gender were controlled). Crucially, there was no significant relation between early ToM and later WM. Lecce and colleagues' study, thus, shows that WM is one of the mechanisms underlying the development of ToM in middle childhood. However, due to its longitudinal design, this study did not allow us to reach any conclusion on what are the developmental factors upon which WM has an impact. Addressing this gap was a key goal of the current study, in which we examined the role of WM in children's ability to capitalize on mental state conversations. Numerous authors have highlighted participation in conversations about mental states as an important influence on children's development of ToM (Dunn & Brophy, 2005; Nelson, 2005; Turnbull & Carpendale, 1999) and support of this position comes from longitudinal studies (Ensor, Devine, Marks, & Hughes, 2014) and metanalysis (Tompkins, Benigno, Lee, & Wright, 2018). However, to date, no one has yet investigated the role of WM in learning from mental states conversions. We expected that children who are better in WM capitalize more on the conversation-based training program and report higher level of ToM at post- test than children with low WM. Conversations, indeed, unfold rapidly over time and children are likely to need good WM skills in order to hold information in mind while processing the input that comes from new conversational turns.

2. The present study

The main goal of the present study was to investigate the relationship between ToM and WM in middle childhood. We addressed this issue using a training methodology as it permits us to *induce* ToM changes and examine development while it happens (for a meta-analysis on ToM training see Hofmann et al., 2016). At the same time, the training design allows us to control for potentially confounding variables, and it is a rigorous way to examine mechanisms underlying changes in the trained skill. The present study has two main aims. The first was to test the positive effect of a conversation-based ToM training when implemented by regular class teachers on a ToM transfer task. More precisely, in order to grasp genuine and meaningful ToM improvement (rather than superficial learning strategies), we evaluated the efficacy of the training program using a ToM-transfer task that differs, in type and modality,