Cognitive and Affective Theory of Mind in Mild Cognitive Impairment and Parkinson's Disease: Preliminary Evidence from the Italian Version of the Yoni Task

Journal:	*Developmental Neuropsychology*
Manuscript ID	Draft
Manuscript Type:	Original Article
Keywords:	Theory of Mind, Mild Cognitive Impairment, Parkinson's Disease, Ageing, Social Cognition

Cognitive and Affective Theory of Mind in Mild Cognitive Impairment and Parkinson's Disease:
Preliminary Evidence from the Italian Version of the Yoni Task

Text words count: 6.062

Number of Figures: 1

Number of Tables: 4

1. Introduction

Theory of mind (ToM) is a widely investigated construct in neuropsychology as well as in developmental and clinical psychology. It was originally described by Premack and Woodruff (1978) as the ability to infer and to represent the mental states of self and others (intentions, emotions, desires, and beliefs) and to understand and predict one's own and other people's behaviour on the basis of such mental representations. The increasing number of studies in this field have highlighted that ToM may be considered a complex, multidimensional psychological construct requiring the integration of several components, such as the attribution of intentions vs. emotions and the level of complexity of such inferences (first- and second-order level of attribution). Brothers and Ring (1992) distinguished between "cold" and "hot" aspects of ToM, later termed "cognitive" and "affective" ToM, respectively (Wang & Su, 2013). Cognitive ToM concerns the ability to understand the intentions, beliefs, and thoughts of the self and others. It can be evaluated through several tasks, such as the conventional first-order (Baron-Cohen, Leslie, & Frith, 1985; Wimmer & Perner, 1983), and second-order (Baron-Cohen, 1989; Perner & Wimmer, 1985) False Belief tasks, the cognitive subcomponent of the Faux Pas Recognition test (Stone, Baron-Cohen, & Knight, 1998) and the Strange Stories task (Happè, 1994). On the other hand, affective ToM concerns reasoning about the affective states, emotions or feelings of self and others. It is traditionally assessed using the Reading the Mind in the Eyes test (Baron-Cohen et al., 2001) and the affective subcomponent of the Faux Pas Recognition test (Stone, Baron-Cohen, & Knight, 1998).

A different paradigm introduced by Shamay-Tsoory and Aharon-Peretz (2007) systematically examined the dissociation between the cognitive and affective components of this construct at different inferential levels. The Yoni task is designed as a computerized task that evaluates the ability to judge first- and second-order affective versus cognitive mental state attributions based on simple verbal instructions and eye-gaze cues involving minimal language and executive demands (Shamay-Tsoory & Aharon-Peretz, 2007). The Yoni task was first used to investigate cognitive and affective dimensions of ToM in patients with localized brain lesions (Shamay-Tsoory & Aharon-Peretz, 2007), people with schizophrenia (Shamay-Tsoory, Aharon-Peretz, & Levkovitz, 2007), and criminal offenders (Shamay-Tsoory et al., 2010). These studies have produced evidence of a partial dissociation between affective and cognitive ToM based on partially distinct anatomical substrates. Specifically, the Ventromedial Prefrontal Cortex (vmPFC) (Sebastian et al., 2011; Shamay-Tsoory et al., 2005), the Amygdala (Völlm et al., 2006), the Inferior Frontal Gyrus (IFG) (Bodden et al., 2013; Dal Monte et al., 2014), and the Anterior Cingulate Cortex (ACC) (Bodden et al., 2013) have been found to be important for affective ToM, whereas the Dorsolateral Prefrontal Cortex (DLPFC) (Kalbe et al., 2010; Xi et al., 2011) and the posterior temporo-parietal regions (Corradi-Dell'Acqua, Hofstetter, & Vuilleumier, 2014; Van Overwalle & Baetens, 2009) have been found to play a key role in cognitive ToM tasks.

Given the distinction between cognitive and affective ToM and the involvement of specific brain areas underlying such different facets of mentalizing, we can assume the existence of different patterns of ToM impairment according to the specific neurodegenerative condition. In particular, the extent of ToM deficits may depend on various elements, such as the topographical distribution of the brain damage and the different stages of the disease. For example, the partial dissociation between cognitive and affective subcomponents of ToM was observed in Alzheimer's Disease (AD), a neurodegenerative condition which progressively leads to severe cognitive impairment and dementia. In this case, the neuropathological process affects, in the early clinical stage, the temporo-parietal regions involved in cognitive ToM reasoning. With the progression of the disease, the cortical degeneration involves also the pre-frontal regions, with the engagement of the affective component of ToM (Kemp et al., 2012). However, concerning the latter dimension, the results appear controversial. While the majority of the studies highlight a significant impairment in the cognitive dimension of ToM, in particular in those tasks with a high cognitive load such as second-order false belief tasks, it has also been suggested that patients with AD show impaired affective ToM.

Notably, only a few studies have investigated ToM in people in a pre-dementia stage, i.e., in people with Mild Cognitive Impairment (MCI), who are at increased risk for developing AD. In fact, MCI represents a prodromal clinical phase which refers to the transition from a healthy condition to an early AD condition (Petersen, 2004; Petersen et al., 2009). People with MCI show mild cognitive deficits in a single cognitive domain (usually memory) or even in multiple cognitive domains. However, their general cognitive functioning and their autonomy in daily life seem to be preserved. Studies by Baglio et al. (2012), Moreau et al. (2015), and Poletti and Bonuccelli (2013) reported a decline of both cognitive and affective ToM in people with MCI, while Dodich et al. (2016) did not find any ToM impairment in these patients. Collectively, these findings suggest that ToM impairment may arise early in people with MCI, but the results are quite controversial given the high variability of the tasks used to evaluate ToM. Therefore, further research is needed to better define the specific pattern of ToM difficulties in this clinical population, and to examine its possible relationship with deficits in cognitive functions.

A possible way to reach this goal would be to compare the ToM functioning of individuals diagnosed with MCI, predominantly typified by cognitive symptoms but in absence of dementia, to that of individuals with a neurodegenerative disease characterized mainly by motor symptoms and in the absence of severe cognitive impairment, such as the early stage of Parkinson's Disease (PD). It has been demonstrated that people with Parkinson's Disease (PD) show cognitive ToM deficits, in both the early and moderate stage of the disease. On the contrary, affective ToM seems to be preserved at the very early stage of the disease – less than five years of disease duration (Poletti et al., 2012; Bora et al., 2015). According to the current model of ToM processing in PD, cognitive and affective subcomponents of ToM may be associated to different frontostriatal circuitries, which are affected in people with PD in relation to the stage of the disease (Bodden et al., 2010). In particular, at early stages PD affects the head of the caudate nucleus, an area belonging to the Dorsolateral Frontostriatal circuitry (DLFS) and involved in cognitive ToM tasks. With the progression of the disease, the depletion of dopamine also affects the Orbital Frontostriatal circuitry (OFS), with the involvement of the affective sub-components of ToM.

Considering that the ToM profile of individuals with PD is relatively characterized as compared to that of MCI, in the current study we sought to compare ToM abilities in these two populations. It was reasoned that a comparison between two non-demented populations, i.e. MCI and early PD, could be helpful in characterizing the different profile of ToM functioning in relation to different neuropathological processes, also in the early stage when social cognitive impairment might be subtle and hardly to detect (Moreau et al., 2015). Deficits in cognitive and/or affective subcomponents of ToM might be a core feature of the early stages of such two neurological disorders, with a significant impact on daily living of patients, especially on their quality of life and social interactions (Henry et al., 2016; Yu & Wu, 2013).

To the best of our knowledge, no study so far has explored affective Vs. cognitive ToM functioning among patients with MCI using the Yoni task, and no studies have directly compared these two dimensions of ToM functioning in MCI and PD, two neurodegenerative conditions without severe cognitive impairment and dementia in the early stage. To this end, we investigated both cognitive and affective dimensions of mentalizing ability by using for the first time the computerized Italian version of the Yoni task (Shamay-Tsoory & Aharon-Peretz, 2007), together with a ToM battery that includes both cognitive and affective paper-pencil tasks commonly used in the research with adults and elderly individuals (Castelli et al., 2010). We hypothesized that people with MCI and PD would exhibit different, specific patterns of ToM impairment according to the different pathological process involved in these two neurodegenerative diseases.

2. Methods/Design:

2.1 Participants and clinical assessment

A total of 48 participants were consecutively recruited from the Don Carlo Gnocchi Foundation, IRCCS S. Maria Nascente in Milan (Italy). Participants included 16 outpatients diagnosed with amnestic Mild Cognitive Impairment [aMCI group: mean (SD) age: 75.88 (3.65) years; range 67-80 years; male:female ratio 8:8; mean (SD) education: 11.81 (2.40) years], 14 outpatients with Parkinson's disease [PD group: mean (SD) age: 68.21 (7.96) years; range 52-78 years; male:female ratio 13:1; mean (SD) education: 14.21 (3.44) years] and 18 healthy controls [HC group: mean (SD) age: 74.06 (3.39) years; range 69-80 years; male:female ratio 8:10; mean (SD) education: 12.00 (3.24) years]. Table 1 shows the demographic and clinical characteristics of the samples in more detail.

The inclusion criteria for people with aMCI were the following: 1) diagnosis of mild AD or MCI due to AD, according to the recommendations of the National Institute on Aging (Albert et al., 2011; McKhann et al., 2011;) and the DSM 5 diagnostic criteria (American Psychiatric Association - APA 2013); 2) normal global cognitive function, as determined by both the CDR scale (Morris, 1993; CDR with at least a 0.5 in the memory domain) and the Mini Mental State Examination score (MMSE score $\geq$ 24; Folstein, Robins, & Helzer, 1983), corrected for gender, age and years of education according to Italian normative data (Measso et al., 1993); 3) memory complaint, confirmed by an informant; 4) abnormal memory function, documented by an extensive neuropsychological examination ; 5) no impairment in functional activities of daily living as determined by a clinical interview with the patient and the informant; 6) absence of cerebral vascular disease, as evidenced by Magnetic Resonance Imaging, or psychiatric illnesses, with particular attention to excluding participants with a history of depression (Hamilton Depression Rating Scale score ≤ 12; Hamilton, 1960); 7) age over 65 years; and 8) school attendance ≥3 years.

The inclusion criteria for the PD group were: 1) diagnosis of probable PD, according to Gelb's clinical diagnostic criteria (Gelb, Oliver, & Gilman, 1999); 2) Mini Mental State Examination score within the normal range (MMSE cut-off score 23.80; Folstein, Folstein, & McHugh, 1975) corrected for gender, age and years of education according to Italian normative data (Measso et al., 1993); 3) scores on Hoehn & Yahr (H&Y; Hoehn & Yahr, 1967) less than 2.5; 4) absence of psychiatric and other neurologic illnesses, in particular, visual hallucinations, severe depression or autonomic failure; and 5) antiparkinsonian treatment at a stable dosage during the three months prior to study entry.

The group of healthy controls (HC) consisted of age-matched volunteers with MMSE scores greater than or equal to 26 (Folstein, Folstein, & McHugh, 1975) who attended the Don Carlo Gnocchi Foundation. They were screened according to their clinical history in order to exclude major systemic, psychiatric or neurological illnesses.

Exclusion criteria for all participants were: 1) the presence of visual or auditory deficits; 2) a positive history of psychiatric disorders or behavioral problems; 3) the presence of other neurological conditions, cardiovascular diseases or cerebrovascular diseases; 4) a MMSE (Mini Mental State Examination, Folstein, Folstein, & McHugh, 1975) score ≤23.80, in order to exclude participants with dementia.

The study conformed to the ethical principles of the Helsinki Declaration (1975, revised in 2008), with approval from the local ethics committee (Don Carlo Gnocchi Foundation, Milan). Informed written consent was obtained from all participants before the study began.

2.2 Neuropsychological and Theory of Mind assessment

Participants underwent a conventional neuropsychological assessment and a traditional paper-pencil ToM evaluation. In addition, a computerized task (the Yoni task) was used to assess affective and cognitive dimensions of ToM.

2.2.1 Neuropsychological assessment

During the neuropsychological examination, we administered the Montreal Cognitive Assessment test (MoCA; Santangelo et al., 2015) as a measure of global cognitive level. According to the theoretical model proposed by Santangelo and colleagues (2015), the total raw score of the MoCA test was divided into 12 subtasks exploring the following cognitive domains: Memory (score range 0-5), Visuo-Spatial Abilities (score range 0-4), Executive Functions (score range 0-4), Attention (score range 0-6), Language (score range 0-6) and Temporal/Spatial Orientation (score range 0-6). The total score of the MoCA test was also considered (score range 0-30). Adjusted and equivalent scores for the total MoCA score and for each cognitive domain subscores were provided according to the normative data in the Italian population sample (Santangelo et al., 2015).

2.2.2 Paper-pencil ToM tasks

ToM reasoning was assessed with a conventional paper-pencil battery specifically designed for research on adults and older individuals (Baglio et al., 2012; Castelli et al., 2010, 2011). For a detailed description of the tasks, please refer to Castelli et al. (2010).

The battery included:

- The *Deceptive Box Task* (Perner, Leekam, & Wimmer, 1987), which assesses the first level of false belief understanding (first-order false belief task). A closed box of candies is shown to the participant, the content of which has been previously substituted with staples. The examiner asks the participant what the closed box contains; then, the box is opened, the real content is shown and the box is closed again. At the end, the participant is asked to predict what another person would say if shown that closed box (first-order false belief question), to justify this answer, and to say what he/she had thought before discovering the real content (first- order own false belief question). Two control questions are also provided. Each question is scored 1 if the answer is correct and 0 if the answer is wrong (range 0-5).

- The *Look-Prediction* and the *Say-Prediction* tasks (Astington, Pelletier, & Homer, 2002; Liverta Sempio et al., 2005; Sullivan, Zaitchik, & Tager-Flusberg, 1994), which assess the second level of false belief understanding (second-order false belief tasks). The participant has to predict where a character in the story thinks another character would look for a hidden object (look-prediction) or what a character thinks the other one would say about a hidden object (say-prediction). Both tasks require participants to answer a total of five questions: two control questions (one memory item and one reality item) and three mentalistic questions (a first-order false belief question, a second-order false belief question and justification of the second-order false belief question). Each question is scored 1 if the answer is correct and 0 if the answer is wrong (range 0-5).
- The *Reading the Mind in the Eyes test* (RME test, Baron-Cohen et al., 2001), which assesses affective ToM. The test consists of 36 pictures of the eye region taken from different human faces. Participants have to infer what the character is feeling and choose a word that describes the character's mental state from four mental states written under each picture. In addition, the Gender Test was used as a control condition in order to test basic visual face discrimination ability, such as gender attribution. Each item is scored 1 if the answer is correct and 0 if the answer is wrong (range 0-36);
- A selection of four stories from the *Strange Stories* task (Happè, 1994; Happè, Brownell, & Winner, 1999; Italian translation by Mazzola and Camaioni, 2002) to assess a more advanced level of ToM reasoning about the social world and a selection of four physical stories used as a control condition. Each question received a score of 0 for wrong answers, 1

for partially correct/incomplete answers and 2 for correct answers (range 0-2 for each question). The global scores of the four "ToM stories" and of the four physical stories ranged from 0 to 8.

2.2.3 Yoni task

Cognitive and affective ToM abilities were assessed with the Italian translation of the *Yoni task* (Shamay-Tsoory & Aharon-Peretz, 2007). The task consists of 98 trials, each showing a face named "Yoni" ("Gianni" in the Italian version of the task) and four colored pictures surrounding the face, one in each corner of the screen, and referring to various semantic categories (for example, fruit, animals, chairs, means of transport) or faces. The participant is required to choose the correct image to which Yoni is referring based on a sentence that appears on the top of the screen and on some available cues, such as Yoni's eye gaze or facial expression or the eye gaze/facial expression of faces around him. Participants were instructed to choose the answer they thought to be correct by pointing to it with the computer mouse as fast as they could. Only one of the four alternatives is correct. The items differ in the complexity of the meta-representation they require, i.e., first- or second-order levels, and in the assessment of affective ToM (*Yoni likes*…), cognitive ToM (*Yoni is thinking* of…) or a physical (control) condition (*Yoni is close to*…). First-order cognitive and affective ToM items require participants to infer Yoni's mental state. In particular, in the cognitive condition both Yoni's facial expression and the sentence at the top of the screen are emotionally neutral (for example, "*Yoni is thinking of…*"), while in the affective condition, all cues provide relevant affective (both positive and negative) information (for instance, "*Yoni loves…"/"Yoni doesn't love…*"). In the second-order items, participants must understand the interaction between Yoni's mental state and each of the four images around him (in the second-order items, the four stimuli always consist of faces). For example, the sentence "*Yoni is thinking of the chair that….wants*" requires a second-order cognitive inference, while the sentence "*Yoni loves the animal that…loves*" requires a second-order affective inference. The items in the physical condition only require participants to think about the physical attributes of the character. These items were added in order to ensure that participants understood the instruction and were not responding automatically only to the eye gaze. Following Shamay-Tsoory & Aharon-Peretz (2007), the performance was rated for accuracy. Each item was scored 1 if the answer was correct and 0 if the answer was wrong. Thus, the total score on the Yoni task (Yoni TOT) ranged from 0 to 98. For each participant, the scores gained from each sub-category were summed in order to obtain four sub-totals: the total of first-order cognitive items (COG1, range 0-12), the total of second-order cognitive items (COG2, range 0-24), the total of first-order affective items (AFF1, range 0-12) and the total of second-order affective items (AFF2, range 0-36). No participants were excluded from the study because of an accuracy rate lower than 50% on the physical condition.

Please insert Figure 1 about here

2.3 Statistical analysis

All statistical analyses were conducted using the IBM SPSS Statistics software, version 22. A *p*-value < 0.05 was considered statistically significant. Group comparisons of demographic variables of the three groups were computed using analyses of variance (ANOVA). Bonferroni *Post-hoc* tests were also computed to compare each diagnostic group with the HC group.

Given the non-normal distribution of several variables, the Kruskal-Wallis H. test and the *Post-hoc* analyses corrected for multiple comparisons were used to: 1) compare scores obtained from the three groups both in the neuropsychological and in the ToM assessment (Tables 2-4); 2) compare the Reaction Times (RTs) within each group in the Yoni task according to the type of judgment (cognitive Vs. affective) and to the level of ToM reasoning (first- and second-order).

3. Results

3.1 Participants and clinical assessment

Table 1 shows the demographic data of the three samples. According to the specific clinical and epidemiological features of the diagnostic groups, age differed significantly between groups (F=8,73(2), *p*=.001, η^2=.28). In particular, the MCI group was older than the PD group (*p*=.001) and the PD group was younger than the HC group (*p*<.05). Instead, the three groups were comparable for the level of education, as we found no significant differences in the level of education among the groups (F=2.84(2), *p*=.069, η^2=.11).

The PD group scored between stages 1 and 2.5 on the Hoehn and Yahr (H&Y) scale (1967), indicating that participants were at a mild stage of the disease. None reported any cognitive problems or any evidence of deficits in their daily living activities. None of the patients reported changes in medication during the period of at least three months before enrollment and none was taking any additional psychotropic drug. Patient mean (SD) on the Unified Parkinson's Disease Rating Scale (UPDRS) evaluated immediately before the study began was 20.14 (15.17), and scores ranged from 4 to 44.

Please insert Table 1 about here

3.2 Neuropsychological assessment

All patients scored within the normal range on the total score of the MoCA test according to the equivalent scores (Santangelo et al., 2014) (Table 2). However, a significant difference emerged between groups on the global cognitive level assessed with the MoCA test (X^2=14.32, *p*=.001). In particular, the MCI group scored lower compared to the HC group (*p*=.001), while no significant differences emerged between the PD group and the HC group and between the MCI group and the PD group (Table 2)

As regards the single cognitive domain subscores, significant differences emerged among groups in the Executive Functions subscore (X^2= 7.59; *p*<.05), in the Memory subscore (X^2= 6.15; *p p*<.05) and in the Language subscore (X^2=8.05, *p*<.05). Post hoc tests revealed that the PD group obtained significantly lower performances in the Executive Functions subscore compared to the HC group (*p*=0.04), and that the MCI group scored lower compared to the HC group both in the Memory subscore (*p*=0.041) and in the Language subscore (*p*=0.02).

Please insert Table 2 about here

3.3 Paper-pencil ToM tasks

All participants exhibited good performance on the control tasks, i.e., the gender test and the physical stories. Two participants of the PD group who scored 0 on both the control questions of the Look-Prediction and on both the control questions of the Say-Prediction tasks were excluded from the analysis of those tests.

Our results show no significant differences among groups in the Deceptive Box task, in the Look-Prediction task and in the Say-Prediction task (Table 3). Notably, we found significant between-group differences in the most advanced ToM tasks, i.e. in the RME test (X2=11.71, p<.005) and in the Strange Stories task (X2=6.87, p<.05). In particular, pairwise comparisons revealed that the MCI group had lower performance than the HC group both on the RME test (p<.005) and on the Strange Stories task (p<.05), while no significant differences emerged between the two clinical groups (MCI and PD) and between the PD group and the HC group (Table 3).

Please insert Table 3 about here

3.4 Yoni task

3.4.1 Accuracy

No differences emerged between groups for the control items (physical condition) of the Yoni task (Table 4). However, a significant between-group difference emerged on the total score of the Yoni task (TOT/98, X^2=8.95, p<.05). In particular, the MCI group scored lower compared to the HC group (p<.05), while no differences emerged between the PD group and the HC group and between the two clinical groups.

While no between-group differences emerged on the first-order affective items (AFF1), we found significant between-group differences on the second-order affective items (AFF2, X^2=6.46, p<.05). In particular, the MCI group scored lower compared to the HC group (p<.05), while no significant differences emerged between the two clinical groups and between the PD group and the HC group.

As for the first-order cognitive items (COG1), we found a significant difference across groups (X^2=12.50, p<.005). In particular, the MCI group exhibited significantly lower performance compared to both the HC group (p<.005) and the PD group (p<.05), while no differences emerged between the PD group and the HC group. The results obtained for second-order cognitive items (COG2) are similar to those for second-order affective items reported above. Significant differences emerged between the groups (X^2=7.26, p<.05), with the MCI group scoring lower than the HC group (p<.05), while no significant differences emerged between the two clinical groups and between the PD group and the HC group.

3.4.2 Reaction Times (RTs)

Our results showed no significant differences in the RTs across groups, both in the affective/cognitive first-order items (AFF1, p=.39; COG1, p=.11), and in the affective/cognitive second-order items (AFF2, p=.14; COG2, p=.30) of the Yoni task.

Please insert Table 4 about here

4. Discussion

The aim of the present study was to characterize ToM functioning among two non-demented neurodegenerative diseases characterized by different neuropathological processes at early stages: the MCI group, predominantly typified by cognitive symptoms, and the PD group, primarily characterized by motor symptoms. Both clinical conditions were also compared to a group of healthy control participants (the HC group). We administered the Yoni task to evaluate both cognitive and affective, first- and second-order dimensions of ToM, in conjunction with a paper-pencil ToM battery commonly used to evaluate ToM in the life-span.

Our results showed that, on the paper-pencil ToM tests, all groups scored above the cut-off. More specifically, the performances on the Deceptive Box Task (first-order false belief task), the Look-Prediction task and the Say-Prediction task (both first- and second-order false belief tasks) were similar for all three groups, while some differences emerged in the more advanced ToM tasks. The MCI group scored lower compared to the HC group on the RME test and on the Strange Stories task. These tasks imply higher cognitive load to be performed, especially high verbal and memory load, which may be impaired in people with MCI. These results add further evidence to the state-of-the-art literature about ToM functioning in people with MCI, which is still quite controversial. In fact, our results on the RME test are in line with Poletti and Bonuccelli (2013), who reported low performance among people with MCI in inferring affective mental states as assessed with the RME test. Yet, these results are not in line with previous results obtained by Baglio et al. (2012), who found no impairments on an RME test administered in a reduced version for a fMRI paradigm. With respect to the Strange Stories task, our results are not in line with the previous results of Baglio et al. (2012) who found no impairment in aMCI in this task that examines the social implications of ToM reasoning. Probably, this puzzling picture can be explained referring to two elements. The first concerns the intrinsic variability of the clinical samples due to the presence of different diagnostic criteria, which are all scientifically grounded but not univocal. The second element refers to the high variability of the ToM tasks used in each study. In fact, various types of tasks are used to measure the same construct (for example, false belief reasoning), and the same task can be adapted according to the research paradigm (for example, paper-pencil vs. functional magnetic resonance imaging paradigm). The still controversial picture about ToM functioning among MCI populations also emerges from two recent studies with different ToM tasks. Moreau et al. (2015) found ToM impairments in the very early stages of MCI, even in real social interaction evaluated through video clips and on the Referential Communication task (Champagne-Lavau et al., 2009). On the other hand, Dodich et al. (2016) found that the MCI group had no impairments in ToM competence as evaluated by the Story-Empathy task, a non-verbal task measuring the ability to infer the intentions and emotions of others (Dodich et al., 2016).

In contrast with the conflicting results of ToM abilities in MCI the pattern of ToM abilities in PD is relatively established. Therefore, comparing MCI with PD group both on classical paper-pencil ToM tasks and on the Yoni task may help to clarify the pattern of ToM impairment among people with MCI. In line with previous studies (see Poletti et al., 2012 for a review), we show here that the PD group exhibits impairment on the more advanced ToM tasks (the RME test and the Strange Stories task), scoring between healthy elderly people and people with MCI. In fact, no differences emerged on either task between the MCI and the PD groups and between the PD group and the HC group. Thus, it also seems that people with PD show initial decay on advanced ToM tasks that evaluate the emotional components of ToM compared to the HC group, although the difference is not significant.

A better understanding of ToM functioning in MCI and PD is offered by the results of the Yoni task, which allows us to analyze both the complexity of ToM reasoning (first-and second-order) and the cognitive vs. affective dimensions of this construct. First, our results showed that people with MCI scored lower on the global score of the Yoni task compared to the HC group. In order to better assess where the MCI group fails, we considered the different components of the Yoni task. We found no significant difference among groups on the first-order affective items (AFF1), indicating that all patients were not impaired in this basic condition. This result can be explained in relation to the brain areas affected in both neurodegenerative diseases, and according to the stages of the diseases. In fact, both MCI and PD were at the early stage of the disease, therefore we can assume that the pre-frontal regions have not yet been affected by the disease, thus leaving the affective condition substantially preserved.

On the contrary, in the first-order cognitive condition (COG1), the MCI group exhibited the worst performance compared to the HC and the PD groups, while no significant difference emerged between the HC and PD groups. This result is quite interesting, given that people with MCI showed no impairment in the classical paper-pencil first-order false belief tasks. So, it seems that the Yoni task is able to detect early ToM impairment at the first-order levels of cognitive ToM reasoning, whereas classical paper-pencil false belief tasks are not able to detect such impairments. Moreover, the performance in the Yoni task indicated a decrease in the first-order cognitive scores only in the MCI sample, which is characterized predominantly by cognitive symptoms. On the second-order cognitive and affective items (COG2 and AFF2) we found a pattern of results similar to those on the Eyes Test and the Strange Stories test, with a decrease in ToM functioning observed among people with MCI and an initial decay in PD patients. These results seem particularly interesting because they offer the possibility to define the pattern of ToM impairment in the MCI group and the PD group at different levels. In fact, the MCI group showed the worst performance on the first-order cognitive items compared to both the HC and the PD groups, and a lower performance on the second-order cognitive and affective items compared to the HC group only. Thus, the Yoni task highlighted the decay of both the basic level of cognitive ToM reasoning and of the more complex ToM inferences (both cognitive and affective second-order levels of reasoning) among MCI patients, while the first level of affective ToM seems to be preserved. The Yoni task also appears to enable detecting an initial decay of advanced ToM performance in the PD group. So far, only Bodden et al. (2010) have investigated affective and cognitive dimensions of ToM in PD using the

Yoni task. They showed that PD patients exhibited low scores on both the affective and cognitive second-order ToM subscales, and that such impairment was not related to cognitive deficits. In the present study, the performance of the PD group on the Yoni task was not significantly different from that of the HC group. The performance of the PD group also did not differ significantly from that of the MCI group, indicating that the PD patients were showing reduced performance in this task, scoring between people with MCI and healthy control participants. The absence of significant differences between the PD group and the HC group could be explained by different clinical and epidemiological features of the two samples. Our PD sample was at a mild stage of the disease, scoring between stages 1 and 2.5 on the Hoehn and Yahr (H&Y) scale (Hoehn & Yahr, 1967), while the PD sample in Bodden's study was at a mild to moderate stage of the disease, with an H&Y median of 2.5, ranging from 1 to 3. However, it is important to point out that the level of accuracy on both the affective and cognitive items of the Yoni task in our study and in the research of Bodden et al. (2010) was well above the cut-off, so the performance of both the PD groups on the Yoni task was substantially preserved.

The selective impairment of the cognitive dimension on one side and of the second-order level of ToM reasoning on the other side could be interpreted in the light of cognitive demand involved in those tasks. In fact, even though the strong debate in the literature regarding the relationship between ToM and executive functioning still has some discrepancies, it seems that the typical decline in ToM due to aging could be mediated by alterations in executive functions (Kemp et al., 2012). This point may be more relevant in neurodegenerative pathologies, where the progression of the disease mainly affects the brain structures involved in high cognitive functions. In the present study, the pattern of ToM decay in MCI and the initial ToM impairment in PD could be partially interpreted in the light of the neuropsychological profile of each clinical group. Our neuropsychological assessment provides a picture of cognitive functioning which is congruent with the specific phenotypes of the two groups at the early stages of the disease. In fact, although all participants were above the cut-off on the global cognitive task, we found significant differences between groups both in the total score of the MoCA test and in the specific cognitive domains. In particular, the significant decrease of ToM performance observed in people with MCI could be interpreted in the light of an initial decline in the global cognitive level, in particular in the memory function and language skills compared to healthy controls. Furthermore, the PD group showed worse performance only in the "Executive Functions" subscore of the MoCA test compared to the healthy controls and this might explain the selective, early decrease in the performance of the more advanced ToM tasks, in which the executive functioning might play a major role.

5. Conclusion

Deficits in social cognition represent a core feature of many neurodegenerative disorders and may have a significant impact on mental health and wellbeing (Henry et al., 2016). For this reason, its assessment in the clinical setting has gradually gained importance in addition to the classical neuropsychological assessment. In fact, an assessment of ToM for Major Cognitive Disorders was introduced in the DSM-V (2013), and Adenzato & Poletti (2013) have warmly suggested that mentalizing tasks should be introduced into standard neuropsychological assessments.

At the same time, it is important to notice the great variety of ToM tasks that are usually employed to test ToM in neurodegenerative pathologies, thus leading to contradictory findings. The present study has offered preliminary evidence of the capacity of the Yoni task to detect different patterns of ToM deficits among people with MCI and to highlight an initial decay in ToM functioning among people with PD. The advantage of the Yoni task is that it provides an opportunity to highlight different levels of ToM deterioration at an earlier stage, i.e., in the absence of dementia, across different neurodegenerative pathologies.

6. Limitations of the study

The present study represents a preliminary investigation of affective and cognitive ToM in pre-demented populations with the Yoni task. The significant age differences between the MCI group and the PD group may constitute a possible limitations of this study. This difference may have influenced the comparison between the two clinical groups, especially on the ToM tasks where adjusted scores according to normative data are not provided. However, such differences could be explained in light of the different clinical features of these two neurodegenerative pathologies in their early stages, and particularly the mean age of onset. In fact, both clinical conditions are age-related, but the mean age of onset varies significantly: the mean age of onset for PD is estimated to be in the early-to-mid 60s (Inzelberg, Schechtman, & Paleacu, 2002), while MCI appears to become more prevalent in individuals aged 70 years and older (Petersen et al., 2009). Future studies should expand the sample size in order to further strengthen this pattern of results and to provide a more robust knowledge of ToM changes in age-related neurodegenerative pathologies, which in turn could pave the way for devising possible interventions to enhance ToM functioning across the life-span.

References

Adenzato M, Poletti M (2013) Theory of mind abilities in neurodegenerative diseases: an update and a call to introduce mentalizing tasks in standard neuropsychological assessments. Clin Neuropsych 10: 226-234.

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, B., Feldman, H. H., Fox, N. C., ... & Snyder, P. J. (2011). The diagnosis of mild cognitive impairment due to Alzheimer’s disease: Recommendations from the National Institute on Aging-Alzheimer’s Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia, 7*, 270–279. http://dx.doi.org/10.1016/j.jalz.2011.03.008

American Psychiatric Association (2013). *The diagnostic and statistical manual of mental disorders: DSM 5*. USA, Bookpoint.

Astington, J. W., Pelletier, J., & Homer, B. (2002). Theory of mind and epistemological development: The relation between children's second-order false-belief understanding and their ability to reason about evidence. *New Ideas in Psychology, 20,* 131–144. http://dx.doi.org/10.1016/S0732-118X(02)00005-3

Baglio, F., Castelli, I., Alberoni, M., Blasi, V., Griffanti, L., Falini, A.,…& Marchetti, A. (2012). Theory of Mind in amnestic Mild Cognitive Impairment: An fMRI study. *Journal of Alzheimer's Disease, 29*, 25–37. http://dx.doi.org/10.3233/JAD-2011-111256

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30*, 285–297. http://dx.doi.org/10.1111/j.1469-7610.1989.tb00241.x

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*, 37–46. http://dx.doi.org/10.1016/0010-0277(85)90022-8

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The ''Reading the Mind in the Eyes'' test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, 42*, 241–251. http://dx.doi.org/10.1111/1469-7610.00715

Bodden, M. E., Kübler, D., Knake, S., Menzler, K., Heverhagen, J. T., Sommer, J., ... & Dodel, R. (2013). Comparing the neural correlates of affective and cognitive theory of mind using fMRI: Involvement of the basal ganglia in affective theory of mind. *Advances in Cognitive Psychology, 9*, 32–43. http://dx.doi.org/10.2478/v10053-008-0129-6

Bodden, M. E., Mollenhauer, B., Trenkwalder, C., Cabanel, N., Eggert, K. M., Unger, M. M., ... & Kalbe, E. (2010). Affective and cognitive theory of mind in patients with Parkinson's disease. *Parkinsonism & Related Disorders, 16*, 466–470. http://dx.doi.org/10.1016/j.parkreldis.2010.04.014

Bora, E., Walterfang, M., & Velakoulis, D. (2015). Theory of mind in behavioural-variant frontotemporal dementia and Alzheimer's disease: a meta-analysis. *Journal of Neurology, Neurosurgery & Psychiatry, 86*, 714–719. http://dx.doi.org/10.1136/jnnp-2014-309445

Brothers, L., & Ring, B. (1992). A neuroethological framework for the representation of minds. *Journal of Cognitive Neuroscience, 4*, 107–118. http://dx.doi.org/10.1162/jocn.1992.4.2.107

Castelli, I., Baglio, F., Blasi, V., Alberoni, M., Falini, A., Liverta-Sempio, O.,… & Marchetti, A. (2010). Effects of aging on mindreading ability through the eyes: An fMRI study. *Neuropsychologia, 48*, 2586–2594. http://dx.doi.org/10.1016/j.neuropsychologia.2010.05.005

Castelli, I., Pini, A., Alberoni, M., Liverta Sempio, O., Baglio, F., Massaro, D., ... & Nemni, R. (2011). Mapping levels of theory of mind in Alzheimer's disease: a preliminary study. *Aging & Mental Health, 15*, 157–168. http://dx.doi.org/10.1080/13607863.2010.513038

Champagne-Lavau, M., Fossard, M., Martel, G., Chapdelaine, C., Blouin, G., Rodriguez, J. P., & Stip, E. (2009). Do patients with schizophrenia attribute mental states in a referential communication task? *Cognitive Neuropsychiatry, 14*, 217–239. http://dx.doi.org/10.1080/13546800903004114

Corradi-Dell'Acqua, C., Hofstetter, C., & Vuilleumier, P. (2014). Cognitive and affective theory of mind share the same local patterns of activity in posterior temporal but not medial prefrontal cortex. *Social Cognitive and Affective Neuroscience, 9*, 1175–1184. https://doi.org/10.1093/scan/nst097

Dal Monte, O., Schintu, S., Pardini, M., Berti, A., Wassermann, E. M., Grafman, J., & Krueger, F. (2014). The left inferior frontal gyrus is crucial for reading the mind in the eyes: brain lesion evidence. *Cortex, 58*, 9–17. http://dx.doi.org/10.1016/j.cortex.2014.05.002

Dodich, A., Cerami, C., Crespi, C., Canessa, N., Lettieri, G., Iannaccone, S., ... & Cacioppo, J. T. (2016). Differential impairment of cognitive and affective mentalizing abilities in neurodegenerative dementias: Evidence from behavioral variant of frontotemporal dementia, Alzheimer's disease, and mild cognitive impairment. *Journal of Alzheimer's Disease, 50*, 1011–1022. http://dx.doi.org/10.3233/JAD-150605

Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198. http://dx.doi.org/10.1016/0022-3956(75)90026-6

Folstein, M. F., Robins, L. N., & Helzer, J. E. (1983). The Mini-Mental State Examination. *Archives of General Psychiatry, 40*, 812–812. http://dx.doi.org/10.1001/archpsyc.1983.01790060110016

Gelb, D. J., Oliver, E., & Gilman, S. (1999). Diagnostic criteria for Parkinson disease. *Archives of Neurology, 56*, 33–39. http://dx.doi.org/10.1001/archneur.56.1.33

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery and Psychiatry, 23*, 56–62. http://dx.doi.org/10.1136/jnnp.23.1.56

Happé, F. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of Autism and Developmental Disorders, 24*, 129–154. http://dx.doi.org/10.1007/BF02172093

Happé, F., Brownell, H., & Winner, E. (1999). Acquired 'theory of mind' impairments following stroke. *Cognition, 70*, 211–240. http://dx.doi.org/10.1016/S0010-0277(99)00005-0

Henry, J. D., Von Hippel, W., Molenberghs, P., Lee, T., & Sachdev, P. S. (2016). Clinical assessment of social cognitive function in neurological disorders. Nature Reviews. Neurology, 12(1), 28.

Hoehn, M. M., & Yahr, M. D. (1967). Parkinsonism: Onset, progression and mortality. *Neurology, 17*, 427–442. http://dx.doi.org/10.1212/WNL.17.5.427

Inzelberg, R., Schechtman, E., & Paleacu, D. (2002). Onset age of Parkinson disease. *American Journal of Medical Genetics*, *111*, 459 – 460. http://dx.doi.org/10.1002/ajmg.10586

Kalbe, E., Schlegel, M., Sack, A. T., Nowak, D. A., Dafotakis, M., Bangard, C., ... & Kessler, J. (2010). Dissociating cognitive from affective theory of mind: a TMS study. *Cortex, 46*, 769–780. http://dx.doi.org/10.1016/j.cortex.2009.07.010

Kemp, J., Després, O., Sellal, F., & Dufour, A. (2012). Theory of Mind in normal ageing and neurodegenerative pathologies. *Ageing Research Reviews, 11*, 199–219. http://dx.doi.org/10.1016/j.arr.2011.12.001

Liverta Sempio, O., Marchetti, A., Castelli, I., Lecciso, F., & Pezzotta, C. (2005). *Mentalizzazione e competenza sociale. La comprensione della falsa credenza nello sviluppo normale e patologico.* Milano: Franco Angeli.

Mazzola, V., & Camaioni, L. (2002) (Unpublished results). *Strane Storie: Versione italiana a cura di Mazzola e Camaioni*. Roma: Dipartimento di Psicologia dinamica e clinica, Università La Sapienza.

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Kawas, C. H., ... & Mohs, R. C. (2011). The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia, 7*, 263–269. http://dx.doi.org/10.1016/j.jalz.2011.03.005

Measso, G., Cavarzeran, F., Zappala, G., Lebowitz, B. D., Crook, T. H., Pirozzolo, F. J., ... & Grigoletto, F. (1993). The mini-mental state examination: normative study of an Italian random sample. *Developmental Neuropsychology, 9*, 77–85. http://dx.doi.org/10.1080/87565649109540545

Molenberghs, P., Johnson, H., Henry, J. D., & Mattingley, J. B. (2016). Understanding the minds of others: A neuroimaging meta-analysis. *Neuroscience & Biobehavioral Reviews, 65*, 276–291. http://dx.doi.org/10.1016/j.neubiorev.2016.03.020

Moreau, N., Rauzy, S., Bonnefoi, B., Renié, L., Martinez-Almoyna, L., Viallet, F., & Champagne-Lavau, M. (2015). Different patterns of theory of mind impairment in mild cognitive impairment. *Journal of Alzheimer's Disease, 45*, 581–597. http://dx.doi.org/10.3233/JAD-143021

Moreau, N., Viallet, F., & Champagne-Lavau, M. (2013). Using memories to understand others: The role of episodic memory in theory of mind impairment in Alzheimer disease. *Ageing Research Reviews, 12*, 833–839. http://dx.doi.org/10.1016/j.arr.2013.06.005

Morris, J. C. (1993). The Clinical Dementia Rating (CDR): current version and scoring rules. *Neurology,43*, 2412–2414. http://dx.doi.org/10.1212/WNL.43.11.2412

Perner, J., Leekam, S.R., & Wimmer, H. (1987). Three-year olds' difficulty with false belief: The case for a conceptual deficit. *British Journal of Developmental Psychology, 5*, 125–137. http://dx.doi.org/10.1111/j.2044-835X.1987.tb01048.x

Perner, J., & Wimmer, H. (1985). "John thinks that Mary thinks that..": Attribution of second-order beliefs by five- to 10-year-old children. *Journal of Experimental Child Psychology, 39*, 437–471. http://dx.doi.org/10.1016/0022-0965(85)90051-7

Petersen, R. C. (2004). Mild cognitive impairment as a diagnostic entity. *Journal of Internal Medicine, 256*, 183–194. http://dx.doi.org/10.1111/j.1365-2796.2004.01388.x

Petersen, R. C., Roberts, R. O., Knopman, D. S., Boeve, B. F., Geda, Y. E., Ivnik, R. J., …& Jack, C.R. (2009). Mild Cognitive Impairment: Ten years later. *Archives of Neurology, 66*, 1447–1455. http://dx.doi.org/10.1001/archneurol.2009.266

Poletti, M., & Bonuccelli, U. (2013). Alteration of affective Theory of Mind in amnestic mild cognitive impairment. *Journal of neuropsychology, 7*, 121–131. http://dx.doi.org/10.1111/j.1748-6653.2012.02040.x

Poletti, M., Enrici, I., & Adenzato, M. (2012). Cognitive and affective Theory of Mind in neurodegenerative diseases: neuropsychological, neuroanatomical and neurochemical levels. *Neuroscience & Biobehavioral Reviews, 36*, 2147–2164. http://dx.doi.org/10.1016/j.neubiorev.2012.07.004

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences, 1*, 515–526. http://dx.doi.org/10.1017/S0140525X00076512

Sandoz, M., Démonet, J. F., & Fossard, M. (2014). Theory of mind and cognitive processes in aging and Alzheimer type dementia: a systematic review. *Aging & Mental Health, 18*, 815–827. http://dx.doi.org/10.1080/13607863.2014.899974

Santangelo, G., Siciliano, M., Pedone, R., Vitale, C., Falco, F., Bisogno, R., ... & Trojano, L. (2015). Normative data for the Montreal Cognitive Assessment in an Italian population sample. Neurological Sciences, 36(4), 585-591.

Sebastian, C. L., Fontaine, N. M., Bird, G., Blakemore, S. J., De Brito, S. A., McCrory, E. J., & Viding, E. (2011). Neural processing associated with cognitive and affective Theory of Mind in adolescents and adults. *Social Cognitive and Affective Neuroscience, 7*, 53–63. http://dx.doi.org/10.1093/scan/nsr023

Shamay-Tsoory, S.G., & Aharon-Peretz, J. (2007). Dissociable prefrontal networks for cognitive and affective theory of mind: A lesion study. *Neuropsychologia, 45*, 3054–3067. http://dx.doi.org/10.1016/j.neuropsychologia.2007.05.021

Shamay-Tsoory, S.G., Aharon-Peretz, J., & Levkovitz, Y. (2007). The neuroanatomical basis of affective mentalizing in schizophrenia: Comparison of patient with schizophrenia and patients with localized prefrontal lesions. *Schizophrenia Research, 90*, 274–283. http://dx.doi.org/10.1016/j.schres.2006.09.020

Shamay-Tsoory, S.G., Harari, H., Aharon-Peretz, J., & Levkovitz, Y. (2010). The role of the orbitofrontal cortex in affective theory of mind deficits in criminal offenders with psychopathic tendencies. *Cortex, 46*, 668–677. http://dx.doi.org/10.1016/j.cortex.2009.04.008

Shamay-Tsoory, S. G., Tomer, R., Berger, B. D., Goldsher, D., & Aharon-Peretz, J. (2005). Impaired "affective theory of mind" is associated with right ventromedial prefrontal damage. *Cognitive and Behavioral Neurology, 18*, 55–67. http://dx.doi.org/10.1097/01.wnn.0000152228.90129.99

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10*, 640–656. http://dx.doi.org/10.1162/089892998562942

Sullivan, K., Zaitchik, D., & Tager-Flusberg, H. (1994). Preschoolers can attribute second-order beliefs. *Developmental Psychology, 30*, 395–492. http://dx.doi.org/10.1037/0012-1649.30.3.395

Van Overwalle, F., & Baetens, K. (2009). Understanding others' actions and goals by mirror and mentalizing systems: a meta-analysis. *Neuroimage, 48*, 564–584. http://dx.doi.org/10.1016/j.neuroimage.2009.06.009

Völlm, B. A., Taylor, A. N., Richardson, P., Corcoran, R., Stirling, J., McKie, S., ... & Elliott, R. (2006). Neuronal correlates of theory of mind and empathy: a functional magnetic resonance imaging study in a nonverbal task. *Neuroimage, 29*, 90–98. http://dx.doi.org/10.1016/j.neuroimage.2005.07.022

Wang, Z., & Su, Y. (2013). Age-related differences in the performance of theory of mind in older adults: A dissociation of cognitive and affective components. *Psychology & Aging, 28*, 284–291. http://dx.doi.org/10.1037/a0030876

Wimmer, H. & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13*, 103–128. http://dx.doi.org/10.1016/0010-0277(83)90004-5

Xi, C., Zhu, Y., Niu, C., Zhu, C., Lee, T. M., Tian, Y., & Wang, K. (2011). Contributions of subregions of the prefrontal cortex to the theory of mind and decision making. *Behavioural Brain Research, 221*, 587–593. http://dx.doi.org/10.1016/j.bbr.2010.09.031

Yu, R. L., & Wu, R. M. (2013). Social brain dysfunctions in patients with Parkinson's disease: a review of theory of mind studies. Translational neurodegeneration, 2(1), 7.

Tables

		aMCI (n=18)	PD (n=14)	HC (n=18)	Pvalue[a] (ALL)
***Age** (years)*	*Mean(SD)*	75.88 (3.65)	68.21 (7.96)	74.06 (3.39)	0.001*
***Education** (years)*	*Mean(SD)*	11.81 (2.40)	14.21 (3.44)	12.00 (3.24)	0.069
***Gender** (M:F)*		8:8	13:1	8:10	-
MMSE	*Mean(SD)*	28.21 (1.56)	29.50 (0.10)	29.35 (1.20)	0.014#
H&Y	*Median(range)*	-	1.00 (1.00,2.50)	-	-
UPDRS	*Mean(SD)*	-	20.14 (15.17)	-	-

Table 1: Demographic and clinical characteristic of the sample.

* Significant differences between the MCI group and the PD group and between the PD group and the HC group.
# Significant differences between the MCI group and the PD group and between the MCI group and the HC group

	aMCI (n=18)	*PD (n=14)*	*HC (n=18)*	Pvalue[a] (ALL)	Pvalue[b] (MCIvsHC)	Pvalue[c] (PDvsHC)	Pvalue[d] (MCIvsPD)
Neuropsychological tests							
MoCa total score	23.91 (22.60,25.22)	25.29 (23.84,26.30)	27.08 (25.02,29.14)	.001	.001	.112	.397
Domain subscores							
Memory	0.00 (0.00,3.00)	2.50 (1.00,4.00)	3.00 (2.00,4.00)	.046	.041	1.00	.461
Visuo-spatial abilities	3.56 (3.01,4.00)	3.65 (2.62,3.90)	3.96 (3.64,4.00)	.051	-	-	-
Executive functions	3.15 (2.77,3.84)	3.09 (2.79,3.74)	3.82 (3.35,4.00)	.019	.082	.031	1.00
Attention	5.89 (5.27,6.00)	5.89 (5.46,5.89)	5.98 (5.89,6.00)	.184	-	-	-
Language	4.91 (3.88,5.74)	5.39 (5.09,5.79)	5.88 (5.29,5.93)	.019	.019	.195	1.00
Visual-spatial Orientation	6.00 (6.00,6.00)	6.00 (5.98,6.00)	6.00 (6.00,6.00)	.509	-	-	-

Table 2: Neuropsychological tests. Group characteristics and non-parametric comparisons. Scores were reported as median and interquartile range. Scores are adjusted for age and educational level.

Pvalue[a] test for overall comparison (MCI vs HC vs PD) ; Pvalue[b] test for MCI vs HC; Pvalue[c] test for PD vs HC; Pvalue[d] test for MCI vs PD. Group comparisons were computed with the Kruskal-Wallis H. test; pairwise comparisons were computed with Bonferroni *post hoc* test.

	aMCI (n=18)	PD (n=14)	HC (n=18)	Pvalue[a] (ALL)	Pvalue[b] (MCIvsHC)	Pvalue[c] (PDvsHC)	Pvalue[d] (MCIvsPD)
Paper-pencil ToM tasks							
Deceptive Box task	5.00 (5.00,5.00)	5.00 (5.00,5.00)	5.00 (5.00,5.00)	1.00	-	-	-
Look-Prediction task	3.00 (3.00,3.00)	3.00 (2.50,3.00)	3.00 (3.00,3.00)	.118	-	-	-
Say-Prediction task	2.00 (1.00-3.00)	1.00 (1.00,2.50)	3.00 (1.00,3.00)	.070	-	-	-
RME test	19.50 (16.25,21.00)	21.00 (18.00,25.25)	26.00 (21.25,27.25)	.003	.002	.136	.660
Strange Stories task	5.00 (4.25,5.75)	7.00 (4.50,7.00)	7.00 (5.00,8.00)	.032	.028	1.00	.351

Table 3: Paper-pencil ToM tests. Group characteristics and non-parametric comparisons. Scores were reported as median and interquartile range. Scores are adjusted for age and educational level.

Pvalue[a] test for overall comparison (MCI vs HC vs PD) ; Pvalue[b] test for MCI vs HC; Pvalue[c] test for PD vs HC; Pvalue[d] test for MCI vs PD. Group comparisons were computed with the Kruskal-Wallis H. test; pairwise comparisons were computed with Bonferroni *post hoc* test.

	aMCI (n=18)	PD (n=14)	HC (n=18)	Pvalue[a] (ALL)	Pvalue[b] (MCIvsHC)	Pvalue[c] (PDvsHC)	Pvalue[d] (MCIvsPD)
Yoni task							
AFF1	12.00 (11.00,12.00)	12.00 (11.00,12.00)	12.00 (11.00,12.00)	.559	-	-	-
AFF2	24.50 (19.25,30.00)	28.00 (24.75,32,25)	30.00 (27.50,32.25)	.040	.037	1.00	.298
COG1	11.00 (9.50,12.00)	12.00 (11.75,12.00)	12.00 (12.00,12.00)	.002	.002	1.00	.027
COG2	16.50 (13.00,17.75)	20.50 (16.75,22.25)	21.00 (14.00,23.00)	.026	.041	1.00	.091
Total Score	76.00 (67.00, 84.75)	83.50 (80.75,90.50)	88.50 (79.75,92.00)	.011	.016	1.00	.059

Table 4: Yoni task. Group characteristics and non-parametric comparisons. Scores were reported as median and interquartile range. Scores are adjusted for age and educational level.

Pvalue[a] test for overall comparison (MCI vs HC vs PD) ; Pvalue[b] test for MCI vs HC; Pvalue[c] test for PD vs HC; Pvalue[d] test for MCI vs PD. Group comparisons were computed with the Kruskal-Wallis H. test; pairwise comparisons were computed with Bonferroni *post hoc* test.

Figure

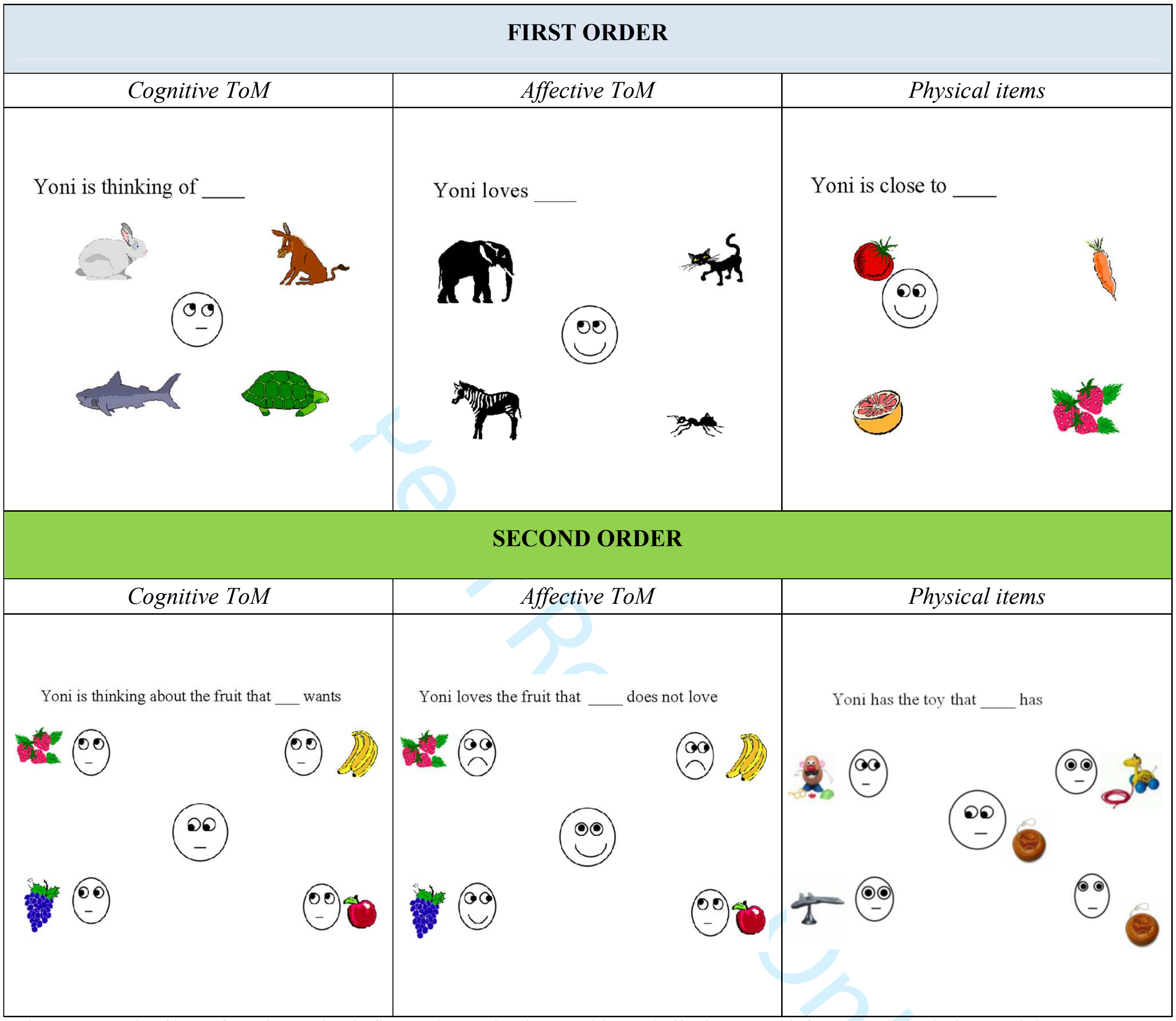

Figure 1: Sample of items from the Yoni task: first- and second-order, cognitive and affective mental inference and physical (control) items.