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# Positive and Negative Consequences of Making Coffee among Breakfast Related Irrelevant Objects: Evidence from MCI, Dementia, and Healthy Ageing

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**Abstract**

**Objectives:** Previous studies have reported impairments in activities of daily living (ADL) performance in the presence of irrelevant but physically/functionally related objects in dementia patients. The aim of the present study was to increase our knowledge about the impact of the presence of contextually related non-target objects on ADL execution in patients with multi-domain mild cognitive impairment (MCI) and dementia. **Methods:** We compared ADL execution in patients with MCI, dementia, and healthy elderly participants under two experimental conditions: One in which the target objects were embedded with *contextually related* non-target items that constituted the object set necessary to complete two additional (but unrequired) ADL tasks related to the target task, and a second, *control* condition where target objects were surrounded by isolated objects (they never constituted a whole set needed to complete an alternative ADL task). **Results:** Separate analysis of ADL errors associated with the target task *versus* errors involving the non-target objects revealed that, although the presence of contextually related objects facilitated the accomplishment of the target task, such a condition also led to errors involving the use of irrelevant objects in dementia and MCI. **Conclusions:** The presence of contextually related non-target items produces both positive and negative effects on ADL performance. These types of non-target objects might help to cue the retrieval of the action schema related to the target task, particularly in patients with MCI. In contrast, the presence of these objects might also lead to distraction in dementia and MCI. (*JINS*, 2017, *23*, 481–492)

**Keywords:** Activities of daily living (ADL), Dementia, Mild cognitive impairment (MCI), Executive functions, Memory, Everyday function

## INTRODUCTION

Patients with dementia and multi-domain mild cognitive impairment (mdMCI) often show functional deficits when they complete simple everyday activities such as meal preparation (American Psychiatric Association, 2000; Giovannetti, Libon, Buxbaum, & Schwartz, 2002). Many studies have demonstrated that the decline in everyday functioning increases as the patients deteriorate in terms of their cognitive abilities (Arrighi, Gelinas, McLaughlin, Buchanan, & Gauthier, 2013; Mioshi, Hodges, & Hornberger, 2013; Padilla, 2011; Rodriguez-Bailon, Montoro-Membila, García-Morán, Arnedo-Montoro, & Funes, 2015; Suh, Ju, Yeon, & Shah, 2004).

Regarding the relationship between cognition and function, one critical aspect still not fully understood is how the presence of other objects not necessary for the task at hand might influence the correct execution of activities of daily living (ADL). This appears to be a critical issue, as everyday environments are typically composed not only of the target items necessary for the task but also irrelevant non-target objects, which sometimes have a high semantic, functional, and/or physical relationship with the target items.

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However, to our knowledge, there has been only one study directly aimed at testing the influence of irrelevant items and their nature in patients with dementia, and we are not aware of any study addressing this issue in MCI. A study by Giovannetti and colleagues focused on the impact of physical and functionally similar non-target objects on ADL in patients with dementia (Giovannetti et al., 2010). Their patients were tested with the Naturalistic Action Test (NAT; Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002) and were asked to make coffee with milk, wrap a gift, or prepare a packed lunch. The results revealed that patients with dementia committed more errors involving the non-target objects (i.e., touching and using non-target items) and took longer to complete the task in the condition where non-target objects were functionally/physically related to the target objects than for a condition where they were not related. The authors suggested that these results could be due to the executive failures typically present in these patients. Nevertheless, although their manipulation had a considerable impact on errors related to the use of non-target items, it did not increase the number of errors related to the target items.

Apart from the functional and physical properties, the semantic or contextual relationships among objects might also be very important in ADL performance, as most of our actions toward target objects take place in specific locations at given times of the day where other non-target items are typically present. For example, we brush our teeth in the presence of objects designed to carry out other "personal care" related tasks such as hair grooming. A large body of research based on the contextual cueing paradigm (Chun & Jiang, 1998) has found benefits on object and scene perception and memory when contextual cues are present in healthy participants, compared to situations where these types of cues are absent. These studies show that humans learn configural associations among objects that typically co-occur in the same spatio-temporal coordinates, and the storage of this information enhances the ability to find, recognize, or remember these objects whenever they appear in contexts in which they have previously been encountered. This ability is present in both healthy young participants (Galleguillos & Belongie, 2010; LaPointe, Lupiáñez, & Milliken, 2013; Palmer, 1975; Sun, Simon-Dack, Gordon, & Teder, 2011) and healthy elderly people (Remy et al., 2013). However, these studies typically used basic computer-based tasks requiring simple key press responses.

Only a very small set of studies have addressed this issue within the context of ADL tasks, and have instead focused on the performance of patients with acquired brain damage (Humphreys & Forde, 1998; Morady & Humphreys, 2009; Niki, Maruyama, Muragaki, & Kumada 2009; Schwartz et al., 1998, 1999). The general hypothesis in these studies was that the presence of these types of irrelevant items would increase the competition for selecting the appropriate target objects (Moores Laiti, & Chelazzi, 2003). The fact that the executive system was altered in patients with stroke should have led them to experience increased difficulties in solving that competition and/or have left less resources available to support other aspects of executing the task, thus leading to a decline in ADL performance.

Of special interest were two studies where non-target items constituted the whole object set necessary to complete related non-target tasks (Morady & Humphreys, 2009; Niki et al., 2009). This kind of situation might require larger "doses" of executive control to reduce interference, not only at the level of object selection but also at the level of task or action schema selection (Cooper & Shallice, 2000; Niki et al., 2009). Results from these studies have suggested a decline in ADL performance with the presence of non-target items compared with the case in which they were absent (Humphreys & Forde, 1998; Niki et al., 2009). However, only subtle or even null differences have been reported when comparing contextually related *versus* non-related conditions in ADL execution (Morady & Humphreys, 2009; Niki et al., 2009). One potential reason for these mixed results might come from a lack of statistical power, given the relatively small sample of patients that were studied.

To the best of our knowledge, no studies have yet tested the influence of the presence of contextually related non-target objects on ADL execution in a large group of patients with multi-domain cognitive impairments such as MCI and dementia.

## THE PRESENT STUDY

The general aim of the present study was to increase our knowledge about the impact of the presence of contextually related non-target objects on ADL execution in patients with dementia and mdMCI. To address this question, we first needed to design a set of performance-based ADL tasks that were both appropriate for elderly Spanish participants and also sensitive to the initial stages of cognitive impairment. Second, we wanted to elucidate whether the presence of contextually related non-target objects enhances and/or disrupts performance on ADL execution. To test this, we based our methodology on the procedure used in previous studies with patients with stroke, creating a situation where non-target items constituted the object set necessary to complete related additional tasks (Morady & Humphreys, 2009; Niki et al., 2009).

According to these studies, one straightforward prediction is that the presence of irrelevant items contextually related to the target task could have opposing effects on ADL performance. On the one hand, based on the contextual cueing studies in healthy participants described above, we predict that the presence of contextual items might facilitate access or memory retrieval of the target task schema (i.e., reducing the errors toward target items). This benefit might be particularly present in patients with MCI and dementia, given their typical memory deficits. On the other hand, the presence of contextually related non-target objects, because of their strong association with the target items and the target task goal, could also lead to an increase in distraction-like behavior toward them. This pattern of distraction might be particularly present in patients with MCI and dementia, given the executive deficits typically observed in this population (Rainville, Lepage, Gauthier, Kergoat, & Belleville, 2012; Traykov et al., 2007).

Among the errors committed with contextually related non-target objects, we were particularly interested in analyzing tangential or utilization-like errors, that is, correct actions toward irrelevant items (e.g., cutting the oranges with a knife while the target task is to make coffee). This kind of error has been strongly linked to disinhibited behavior, particularly when the whole set of items needed to complete a competing irrelevant task are present, which might require additional "doses" of executive control, not only at the level of object selection but also at the level of task selection (Niki et al., 2009).

Third, we wanted to test whether any influence of the contextual manipulation might have differential effects among patient groups, that is, whether patients with MCI and dementia might be differentially affected by this critical manipulation when compared with healthy ageing participants. Finally, we wanted to explore the relationships between the neuropsychological variables of the sample and the ADL error categories.

## METHOD

### Participants

Twenty-nine patients with mdMCI and 31 patients with dementia (18, Alzheimer; 2, vascular dementia; 2, mixed dementia; and 9, behavioral variant-frontotemporal dementia, bvFTD) were recruited from the dementia outpatient program at San Cecilio Hospital (Granada, Spain). Diagnoses were made at an interdisciplinary team conference, based on clinical data and following standardized criteria. The diagnostic criteria for MCI (Albert et al., 2011) were the following: (1) presence of subjective complaints by either the patient or the informant; (2) objective evidence of impairment (greater than 1.5 sdt) in more than one cognitive domain (at least memory and executive deficits); (3) normal or minimal impairments in functional abilities; (4) level 2 or 3 on the Global Deterioration Scale (GDS); and (5) absence of dementia according to DSM IV criteria (American Psychiatric Association, 2000).

The scores of participants with MCI ranged between 20 and 30 on the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), with lower scores observed in individuals with lower education levels. Participants with dementia (i.e., Alzheimer's disease, vascular dementia, or bvFTD) met the criteria for dementia according to the DSM-IV. In particular, the criteria for Alzheimer's disease were impairments in memory in one or more domains of cognitive functioning, progressive decline in these functions with deficits in activities of daily living, and an insidious onset (McKhann et al., 2011). Regarding bvFTD, in addition to progressive decline in cognitive domains, it was necessary to observe three behavioral and cognitive symptoms related to personality, emotional blunting, loss of empathy, and/or executive deficits (Rascovsky et al., 2011).

Finally, the core criteria for vascular dementia were evidence of a cognitive disorder and a history of clinical stroke or vascular disease related to the cognitive deficits observed (Gorelick et al., 2011). The MMSE cutoffs for participants with dementia were between 14 and 27 points, depending on their educational level. A healthy aged-matched control group ($N = 27$) was recruited from the community. Healthy participants had neither cognitive nor functional deficits, as evaluated by an extensive neuropsychological protocol. All of these participants lived independently. The MMSE cutoffs for healthy elderly participants were between 28 and 30 points.

Exclusion criteria were the absence of long-standing psychiatric illness and motor/sensitive deficits. Moreover, participants had to be able to maintain their attention over time and to understand and follow different spoken instructions.

Medical reports of patients were obtained after they had given informed consent and the Ethics Committee of the hospital had authorized the research in compliance with the Spanish legislation on the protection of personal data (*Ley Orgánica de Protección de Datos de Carácter Personal 15/1999, 1999*). The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki.

## ADL TASKS AND CONDITIONS

### Procedure

Participants were tested individually in a room. They were placed in front of a table with a set of cooking objects, which were arranged on the surface to ensure that they could grasp every object on the table. In addition to target items, non-target objects were intermixed with these target items. For each participant and session, the objects were randomly positioned on the table at the beginning of the session. At the beginning of each task, the participants were asked to name all objects present on the table and to explain their function to test for low-level cognitive alterations such as perceptual disorders that could affect object recognition.

### Description of the ADL Tasks

Participants were then instructed to perform a given kitchen ADL, either to prepare a cup of coffee with milk and sugar or a piece of toast with butter and jam. These tasks were based on other kitchen tasks used in the NAT (Schwartz et al., 2002) but we used objects that are commonly used in Spanish culture. The required target task (coffee or toast) was counterbalanced among participants.

The exact instructions provided to participants were: "I will ask you to make a cup of coffee with milk and sugar/ toast with butter and jam. When you consider that the cup of coffee with milk and sugar/ toast with butter and jam is completed, please let me know.. We ensured that participants had understood exactly what they were required to do by asking them to repeat the instructions. External assistance from the evaluator was only given in cases of difficulties to complete an action due to

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motor problems, and only if the action step had already been initiated and the patient had requested help.

## Design

Each participant completed one task twice under two conditions, one under the *contextually related* condition (CRC) and another task under the *control* condition. For the CRC, all non-target objects constituted the object set necessary to complete two additional (but unrequired) ADL tasks related to the same spatio-temporal context, that is, tasks belonging to the category of "breakfast" (see Table 1 for details).

For the *control* condition, non-target items were also kitchen objects, but in this case, they were isolated items in the sense that they never constituted a whole set needed to complete an alternative ADL task. The number of objects in both conditions was matched (16 for each of the CRC and the *control* conditions). It is worth noting that this *control* condition was designed with the aim of simulating as closely as possible the real life conditions that might be present in the kitchen, where items needed to accomplish a given cooking task are typically surrounded by other objects not related to the task at hand. For details, see Table 1.

The order of the two conditions was counterbalanced across participants in each group. The performance of each participant was videotaped for later analysis.

## ADL Scoring Procedures

Errors made by the patients on ADL performance were classified according to the criteria established by Humphreys and Forde (1998) and Schwartz et al. (2002). Descriptions of each error category are explained in Table 2. First, we calculated the "Total error" score, which was the result of summing up all error types. Second, we adopted a similar distinction to the one described by Giovannetti et al. (2010) or Niki et al. (2009) where errors associated with the target items were used to calculate the "Target error score," whereas the errors associated with the non-target items were used to generate the "Non-target error score" (see Table 2).

## Inter-rater Reliability

Two raters independently coded video recordings of different error categories. Inter-rater reliability was assessed for 20% of the sample, selected randomly. Raters demonstrated that the intra-class correlation coefficient for test reliability was high, with an initial reliability estimate of more than 0.90 on all scoring measures. Any disagreements between the coders were resolved through discussion and re-assessment of the videotapes.

## Neuropsychological Assessment

Participants were evaluated by using a neuropsychological protocol to confirm the diagnosis at the time of ADL testing and the presence of multi-domain cognitive deficits in both groups. Language, memory, attention, and executive functions were evaluated to assess the cognitive state of all

**Table 1.** Tasks and objects in each experimental condition.

| *Contextually related* condition | | *Control* condition | |
|---|---|---|---|
| Target objects task | Non-target objects | Target objects task | Non-target objects |
| Target Task A: Coffee with milk<br>Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan, and Teaspoon. | Non-relevant task: Tomato toast<br>Objects: Tomato, Olive oil, Slices of bread, Toaster, Plate, and Knife.<br>Non-relevant task: Orange juice<br>Objects: Orange, Juice maker, and Glass. | Target Task A: Coffee with milk<br>Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan, and Teaspoon. | Objects: Whisk, Apple, Bowl, Banana Salt, Pâté, Grater, Platter, and Knife. |
| Target Task B: Toast with butter and jam<br>Objects: Butter, Jam, Slices of bread, Toaster, Plate and Knife. | Non-relevant task: Coffee with milk<br>Objects: Coffee bag, Milk, Cup, Sugar, Hotplate, Saucepan and Teaspoon.<br>Non-relevant task:<br>Orange juice<br>Objects: Orange, Juice maker and Glass. | Target Task B: Toast with butter and jam<br>Objects: Butter, Jam, Slices of bread, Toaster, Plate and Knife. | Objects: Tea bag, Juice pack, Salt, Fork, Ladle, Grater, Little jug, Whisk, Apple and Bowl. |

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**Table 2.** Descriptions of errors in performance-based tasks

Errors associated with the target objects:

- Perseverations: Some steps of the target actions were inappropriately repeated immediately.
- Repetitions: The participant repeated a target or non-relevant step inappropriately later in the sequence.
- Failures in Sequence: A participant failed to follow the conventional order of actions. Given the variability in the order of task performance across participants, we included only errors of this type in those cases where they were aberrant and prevented accomplishment of the task. These errors are fully described in Appendix 1.
- Action Additions: A participant added an action that cannot be interpreted as a task step. For example, when participants wanted to eat what they had prepared.
- Substitutions: A target object was used instead of a correct target object in order to complete the target action. For example, to use the cup as a pan for heating items on the hotplate.
- Manipulations/Toying behavior: A participant only lifted a target object and then set it down or fiddled with it.
- Tool omissions: Proper use of the tool was omitted. When patients fail in this category, they usually use any part of their body instead of the correct tool. For example, patients did not use the teaspoon to put sugar in the coffee.
- Omissions: Necessary steps to complete the target task were omitted. For example, omitting to heat the milk in order to prepare a cup of coffee.

Errors associated with non-target objects:

- Substitutions: A non-target object was used instead of a correct target object in order to complete the target action.
- Manipulations/Toying behavior: A participant only lifted a non-target object and then set it down or fiddled with it.
- Tangential Actions: When the patient performed an action correctly but from the non-relevant task. For example, when spreading butter on the toast or toasting the piece of bread when asked to make a coffee. We included in this category whether participants ate the non-target object.
- Perseverations: Some steps of non-relevant actions were inappropriately repeated immediately.
- Repetitions: The participant inappropriately repeated a non-relevant step later in the sequence.

participants, and MMSE was used to assess their global cognitive status. For naming performance, we used the 15-Item Boston Naming Test (Fastenau, Denburg, & Mauer, 1998; Mack, Freed, Williams, & Henderson, 1992). To evaluate short- and long-term memory, participants were assessed using Rey´s Auditory Verbal-Learning Test (Rey, 1964). Four measures of this test were used: the number of words recalled immediately in a free recall test (short-term memory), the number of words recalled in a long-term free recall test, the number of omissions, and the number of false alarms on a recognition test. The INECO Frontal Screening Test was used to evaluate executive functions (Torralva, Roca, Gleichgerrcht, Lopez, & Manes, 2009), and ideomotor apraxia was assessed using the Barcelona Test (Peña Casanova, 1990). Semantic fluency was evaluated with the animal category (Ardila, Ostrosky-Solis, & Bernal, 2006).

A small group of patients could not complete the whole evaluation battery due to low education level, fatigue, and lack of motivation. All the tests described above were performed by at least 80% of participants.

## Data Analyses

Group differences in age were analyzed by a one-way analysis of variance, years of education by non-parametric tests, and the percentage of male/female by a Chi Square Test. Differences in neuropsychological variables were analyzed using non-parametric tests due to the non-normal distribution of the scores.

Error ADL categories (with the sum of both conditions) were also explored with non-parametric tests (i.e., multiple between-group Kruskal-Wallis analyses and later Mann-Whitney *U* Tests for two-by-two group comparisons) because the scores were not normally distributed. In addition, comparisons between the two ADL conditions were conducted for each group using the Wilcoxon signed-rank test. Effect sizes were estimated calculating Cliff's Delta statistics (δ) in non-parametric analyses (Macbeth, Razumiejczyk, & Ledesma, 2011) and Cohen's d for parametric tests. Tangential steps were analyzed by a chi square test to determine if there were significant differences in the proportion of participants who committed this error type. Fisher's exact test was used to compare tangential steps between the two groups.

Finally, using the whole sample, Spearman correlation analyses were conducted between all neuropsychological measures and the ADL error categories, by first collapsing across both conditions, and then by focusing only on the contextually related condition. Finally, we tested for differences between tasks (coffee and toast) in the whole sample (by using Mann-Whitney *U* Test), and we did not find any, so we collapsed the data from these two tasks.

# RESULTS

## Demographic and Neuropsychological Results

The groups did not differ in terms of age ($F(2,84) = 2.65$; $p = .079$) or gender. The age of the patients with dementia did not differ from healthy participants ($p = 1.0$; d = .16) or from patients with MCI ($p = .32$; d = −.45). Similarly, we did

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**Table 3.** Demographic and neuropsychological results for the three groups

| | Healthy | | MCI | | Dementia | | Group differences | |
|---|---|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* | F (d.f)/ $\chi^2$ | |
| Age | 66.33 | 8.90 | 70.97 | 6.13 | 67.71 | 8.10 | 2.65(2,84) | $p = -.08$ |
| Years of education | 10.70 | 3.54 | 8.24 | 3.45 | 9.48 | 3.11 | 6.03 | $p = .05$ |
| Sex (%women) | 59% | | 45% | | 48% | | 1.26 | $p = .53$ |
| MMSE | 29.67 | .62 | 26.32 | 2.77 | 21.61 | 4.42 | 53.90** | Healthy > MCI > Dementia |
| Naming | 13.63 | 1.57 | 13.97 | 1.12 | 13.20 | 2.07 | 2.10 | n.s |
| Praxias | 3.96 | 0.19 | 3.79 | 0.49 | 3.33 | 0.92 | 12.53* | Healthy > Dementia |
| R-AVLT ST FRecall | 4.44 | 1.42 | 2.90 | 1.50 | 2.35 | 1.62 | 21.01** | Healthy > (MCI = Dementia) |
| R-AVLT LTF Recall | 8.07 | 3.35 | 3.21 | 2.74 | 1.42 | 1.69 | 43.47** | Healthy > MCI > Dementia |
| R-AVLT Omissions | 1.15 | 1.56 | 2.69 | 2.89 | 3.66 | 3.29 | 11.47* | Healthy > Dementia |
| R-AVLT False alarms | 1.33 | 1.41 | 5.90 | 6.64 | 11.03 | 9.73 | 26.15** | Healthy > MCI = Dementia |
| INECO | 24.20 | 2.50 | 15.37 | 5.87 | 10.41 | 6.49 | 47.97** | Healthy > MCI > Dementia |
| Semantic Fluency | 21.00 | 6.58 | 12.76 | 4.16 | 9.58 | 4.51 | 41.58** | Healthy > MCI > Dementia |

*$p < .005$.
**$p < .001$.
n.s = nonsignificant; MMSE = Mini-Mental-State Examination; R-AVLT STFRecall = Short Term Memory of Rey Auditory Verbal Learning Test. R-AVLT LTFRecall = Long Term Memory of Rey Auditory Verbal Learning Test. INECO = INECO Frontal Screening.

not find significant differences in age between patients with MCI and healthy participants ($p = .09$; d = .60). The MCI group had fewer years of education than both healthy participants and those with dementia ($Z = -2.33$; $p = .02$; $\delta = -.31$) but there were no statistical differences between groups after Bonferroni correction (see Table 3). Previous studies have demonstrated that everyday tasks of this sort are not affected by these demographic factors (Buxbaum, Schwartz, & Montgomery, 1998; Schwartz et al., 1998, 1999, 2002). However, to further ensure the absence of a relationship between age and the ADL score in our study, we carried out Spearman correlations between years of education and total errors, non-target errors and target errors in the whole sample. We did not find statistical correlations among these variables (r = –.185, $p = .09$; r = –.100, $p = .35$; r = –197, $p = .07$, respectively).

Patients with dementia showed poorer performance on all neuropsychological variables in comparison with both the healthy group and patients with MCI (see Table 3). The performance of the patients with MCI fell in between that of the dementia and healthy groups on almost all the neuropsychological tests, with the exception of naming, praxis, and memory omissions in which they did not differ from healthy participants. Therefore, the present group differences in neuropsychological variables were in agreement with the diagnostic criteria, and the multi-domain nature of cognitive deficits in each patient group.

## Results from Performance on the ADL Task

Data from one participant from the healthy group were not available for the CRC, due to technical problems at the time of recording. Similarly, one participant from the dementia group performed a previous non-comparable version of the *control* condition. Consequently, the set of data from these two participants were replaced by the mean of each group in the corresponding conditions.

### ADL Total Error Score

Regarding the analysis of total errors produced on the ADL task (summed across conditions), we found a main effect of group, $\chi^2(2, N = 87) = 23.12$, $p > .0001$. The participants with dementia committed more total errors than the healthy group ($Z = -4.532$; $p > .0001$; $\delta = .69$). Similarly, patients with MCI had a significantly higher number of total errors than the healthy groups ($Z = -3.01$; $p = .003$; $\delta = -.47$). Although patients with dementia made more errors in total than patients with MCI, the differences among groups did not reach significance after Bonferroni correction ($Z = -2.30$; $p = .022$; $\delta = .34$). Regarding the effect of condition, we did not find significant differences between them on the total error score ($Z = -.667$; $p = .505$).

### ADL Target Error Score

The analysis restricted to errors related to target items (summed across conditions) yielded a main effect of group $\chi^2(2, N = 87) = 24.22$, $p = .000$. Patients with dementia made significantly more target errors than both healthy participants ($Z = -4.70$; $p < .000$; $\delta = .69$) and patients with MCI ($Z = -2.50$; $p = .012$; $\delta = -.44$), Patients with MCI made significantly more errors than the healthy group ($Z = -2.83$; $p = .005$; $\delta = .37$).

Regarding the influence of the two ADL conditions on the target error score, we found a main effect of condition, that is, participants produced fewer errors with target items under the CRC compared with the *control* condition

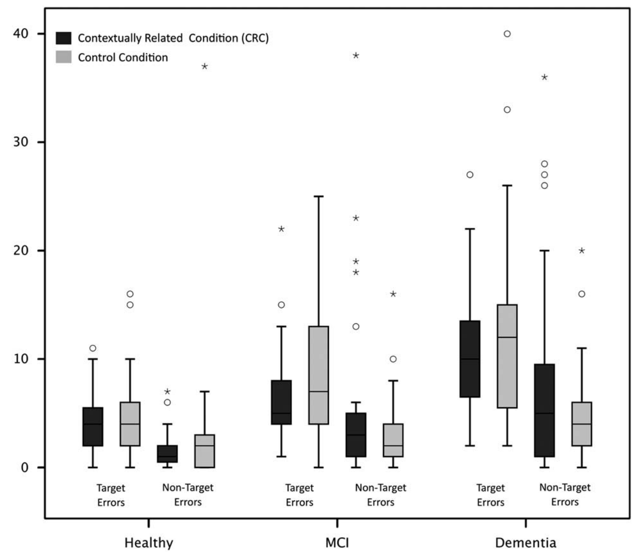


**Fig. 1.** Box plot with target and non-target errors for each group in the two conditions. Asterisks (stars) represent extreme outliers. Dots represent the conjunction of more than one extreme outlier.

(*Z* = –2.28; *p* = .023; δ = .10). Separate analyses for each group revealed that this reduction in target errors in the CRC was only present for group with MCI (*Z* = –2.24; *p* = .025; δ = .23), but did not reach significance for the group with dementia (*Z* = –1.03; *p* = .301; δ = 5.51 E-02) and had no effect at all in the healthy group (*Z* = –.34, *p* = .73; δ = 7.68E-02) (see Figure 1 and Table 4).

## ADL Non-target Error Score

Analysis of non-target errors (summed across conditions) also revealed a main effect of group $\chi^2(2, N = 87) = 11.81$, $p < .005$. Patients with dementia committed significantly more non-target errors than healthy participants (*Z* = –3.36; *p* = .001; δ = .51). The number of non-target errors made by patients with MCI fell in between those produced by the other two groups, but did not differ significantly from those produced by the dementia group (*Z* = –1.46; *p* = .14; δ = –.22) or from errors committed by the healthy group after Bonferroni correction (*Z* = –2.07; *p* = .038; δ = .32).

Analysis of the influence of the two ADL conditions on the non-target error score revealed that this manipulation had no influence (*Z* = –1.12; *p* = .261; δ = 5.12E-03). Separate analyses for each group revealed a null effect of the nature of non-target items on the healthy group (*Z* = –.719; *p* = .47; δ = 4.25E-02), and the MCI group (*Z* = –.85; *p* = .39; δ = –.04), while a marginally significant effect was observed for the dementia group (*Z* = –1.75; *p* = .08; δ = –.10).

## Analysis of Tangential Actions toward Non-target Items

As described above, we were particularly interested in analyzing group differences regarding this specific type of error toward non-target items, operationalized as steps "correctly" made with non-target objects, but tangential to the target task. Table 5 shows the proportion of participants that exhibit this type of error at least once in each group independently of the number of errors. For the *control* condition, the presence of

**Table 4**. Target and non-target errors for each group in the two conditions

| | | *Contextually related* condition | | *Control* condition | |
|---|---|---|---|---|---|
| | | Mean | *SD* | Mean | *SD* |
| Target errors (total) | Healthy | 4.30 | 3.48 | 4.89 | 3.90 |
| | MCI | 6.66 | 4.73 | 9.31 | 6.62 |
| | Dementia | 10.87 | 5.87 | 12.80 | 9.01 |
| Perseverations | Healthy | 0.00 | 0.00 | 0.04 | 0.19 |
| | MCI | 0.07 | 0.26 | 0.07 | 0.26 |
| | Dementia | 0.10 | 0.30 | 0.13 | 0.56 |
| Repetitions | Healthy | 0.23 | 0.58 | 0.11 | 0.42 |
| | MCI | 0.31 | 0.71 | 1.00 | 1.90 |
| | Dementia | 0.61 | 1.14 | 0.63 | 1.01 |
| Failures in sequence | Healthy | 0.00 | 0.00 | 0.00 | 0.00 |
| | MCI | 0.07 | 0.26 | 0.14 | 0.44 |
| | Dementia | 0.16 | 0.37 | 0.20 | 0.40 |
| Action additions | Healthy | 0.38 | 0.79 | 0.41 | 0.69 |
| | MCI | 0.52 | 0.78 | 0.59 | 0.95 |
| | Dementia | 0.65 | 0.80 | 0.67 | 1.04 |
| Substitutions | Healthy | 0.04 | 0.19 | 0.04 | 0.19 |
| | MCI | 0.03 | 0.19 | 0.21 | 0.49 |
| | Dementia | 0.26 | 0.44 | 0.27 | 0.44 |
| Man/Toying | Healthy | 3.19 | 3.30 | 4.12 | 3.92 |
| | MCI | 4.59 | 4.40 | 6.21 | 5.32 |
| | Dementia | 7.32 | 5.41 | 9.13 | 8.53 |
| Tool omissions | Healthy | 0.00 | 0.00 | 0.00 | 0.00 |
| | MCI | 0.28 | 0.45 | 0.21 | 0.41 |
| | Dementia | 0.13 | 0.34 | 0.13 | 0.43 |
| Omissions | Healthy | 0.46 | 1.11 | 0.18 | 0.79 |
| | MCI | 0.83 | 1.31 | 0.96 | 1.18 |
| | Dementia | 1.74 | 1.53 | 1.60 | 1.22 |
| Non-target errors (Total) | Healthy | 1.74 | 1.85 | 3.25 | 7.07 |
| | MCI | 5.69 | 8.65 | 3.59 | 3.80 |
| | Dementia | 8.74 | 10.31 | 4.70 | 4.35 |
| Substitutions | Healthy | 0.08 | 0.27 | 0.07 | 0.27 |
| | MCI | 0.07 | 0.26 | 0.14 | 0.35 |
| | Dementia | 0.42 | 0.72 | 0.50 | 0.76 |
| Man/Toying | Healthy | 1.65 | 1.84 | 2.85 | 5.42 |
| | MCI | 3.93 | 5.48 | 3.38 | 3.83 |
| | Dementia | 6.03 | 6.43 | 4.00 | 3.88 |
| Tangential steps | Healthy | 0.00 | 0.00 | 0.30 | 1.54 |
| | MCI | 1.55 | 3.40 | 0.07 | 0.37 |
| | Dementia | 1.84 | 3.30 | 0.20 | 0.75 |
| Perseverations | Healthy | 0.00 | 0.00 | 0.00 | 0.00 |
| | MCI | 0.00 | 0.00 | 0.00 | 0.00 |
| | Dementia | 0.03 | 0.18 | 0.00 | 0.00 |
| Repetitions | Healthy | 0.00 | 0.00 | 0.04 | 0.19 |
| | MCI | 0.14 | 0.52 | 0.00 | 0.00 |
| | Dementia | 0.42 | 1.06 | 0.00 | 0.00 |

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**Table 5**. Percentage of participants that exhibit tangential steps in each group and condition

| | Healthy (%) | MCI (%) | Dementia (%) |
|---|---|---|---|
| *Contextually related* condition | 0 | 24.1 | 34.4 |
| *Control* condition | 3 | 3.4 | 10 |

this type of error was rare and there were no differences among the groups ($\chi^2(2) = 1.47$; $p = .48$). For the CRC, the distribution of percentage of participants who committed tangential steps of the three groups differed significantly ($\chi^2(2) = 10.14$; $p = .006$). Interestingly, in this condition, none of the healthy participants produced tangential steps, whereas a large proportion of patients in the MCI and dementia groups did commit these types of errors in the CRC. Fisher's exact test revealed that patients with MCI and patients with dementia committed significantly more tangential steps than the healthy group ($p = .011$; $p = .001$, respectively). Non-significant differences for this type of error between patients with MCI and dementia ($p = .573$).

## Relationships between Neuropsychological Measures and ADL Error Types

We did not find (when collapsing both conditions *versus* focusing on the contextually related condition alone) any specific patterns indicating a relationship between neuropsychological variables and the various ADL error categories. Instead, we found that in both analyses, all neuropsychological measures (those used to measure global cognitive status, episodic memory, semantic memory, praxia, and executive functions) were associated with errors made toward target items, errors toward non-target objects, and tangential errors (see Appendix 2 and 3).

## GENERAL DISCUSSION

The aim of the present study was to test the impact of non-target objects constituting the whole set of items to complete contextually related tasks on ADL execution in dementia, mdMCI, and healthy ageing patients.

First, we found that the performance-based ADL tasks designed and used in this study were sufficiently sensitive to reveal functional differences between MCI, dementia, and healthy ageing participants within the context of an elderly Spanish sample. In agreement with several previous studies (Cooke, Fisher, Mayberry, & Oakley, 2000; Giovannetti et al., 2008, 2002), the total error score, the target error score, as well as the non-target error score allowed us to discriminate between patients with dementia and healthy participants.

Even more importantly, our measures were also sensitive to the initial stages of cognitive impairment, as revealed by a significantly larger ADL error score for MCI compared with healthy participants on both the total, the target error scores and the tangential steps. This is in agreement with a small set of recent studies identifying subtle differences between MCI and healthy participants (Gold, Park, Troyer, & Murphy, 2015; Schmitter-Edgecombe, McAlister, & Weakley, 2012; Schmitter-Edgecombe & Parsey, 2014; Seligman, Giovannetti, Sestito, & Libon, 2013).

The qualitative differences among these two groups found in our study might be related to the fact that the target ADL task was always performed in the presence of other non-target objects, which might have added a general source of "difficulty" in selecting the target from non-target items, and for this reason our tasks were more sensitive to capturing differences between patients with MCI and healthy participants.

Regarding the main manipulation of the contextual relationship between target and non-target items included in this study, we observed evidence of both positive and negative effects, although on different aspects of behavior.

## Positive Effects due to the Presence of Non-target Items for Completing Contextually Related Tasks

A main effect of non-target object type revealed that participants produced less ADL errors related to the target task when irrelevant items constituted the whole set needed to complete *contextually related* tasks compared with when the task was performed in the presence of isolated non-target objects (*control* condition).

This facilitation effect is wholly compatible with previous computer-based studies in elderly participants showing the benefits for object recognition or object memory when these objects are embedded in semantically coherent scenes as opposed to incongruent scenes (e.g., Remy et al., 2013). Our study adds to these findings by demonstrating that a further benefit of embedding objects in a semantically coherent context is to enhance real action in multistep ADL tasks in cognitively impaired participants. These positive effects might be due to the fact that the presence of contextually related non-target objects might provide more effective cues to retrieve the semantic knowledge and action schema about the target task, a process that may already be weak, even in MCI participants. This notion is supported by several memory studies showing a positive relationship between the use of semantic cues to codify and retrieve information from memory in both MCI (McLaughlin et al., 2014) and dementia patients in simple word list memory tasks (Oltra-Cucarella, Perez-Elvira, & Duque, 2014).

Analysis of each group revealed that this facilitation effect was particularly marked in patients in the initial stages of cognitive impairment (the MCI group), while it was only marginal for the more impaired dementia group, and non-significant for the healthy elderly group. The lack of a statistically significant facilitation effect in the latter group might be due to a ceiling effect, given the simple nature of the tasks used in the present study. More compelling was the finding that the facilitation effect of context (reduction of target errors) for patients with dementia was only marginal and failed to reach significance. This might be related to the fact that for these patients, given their severe and multiple cognitive alterations, the presence of a coherent context might not be sufficiently effective. Thus, their deficits in memory retrieval might be too large to benefit from the kind of contextual cues provided in the present study.

In fact, even if we made a greater attempt to recreate a real breakfast context similar to that encountered in their homes, our tasks took place in a laboratory setting with very specific instructions and with objects that were not the same as those with which the patients have direct experience in their everyday lives. Several studies have shown that patients with Alzheimer's and semantic dementia can show some benefits in naming, gesturing, and using individual objects when these items are familiar and they are tested in natural settings (Bozeat, Ralph, Patterson, & Hodges, 2002; Giovannetti et al., 2006; Snowden, Griffiths, & Neary, 1994; but see Chrysikou et al., 2011). However, these studies required isolated actions toward individual objects. Thus, future studies involving participants with dementia tested in natural settings with personalized objects might help to aid our understanding of this effect within the context of multistep ADL tasks.

### Negative Effects due to the Presence of Non-target Items Needed to Complete Contextually Related Tasks

When inspecting the non-target error score, we found a main effect of group, indicating that patients with dementia committed more errors with non-target objects than healthy participants, while the scores of patients with MCI fell in between these two groups. However, we did not find any significant group differences across the two conditions. Nevertheless, both dementia and MCI groups showed a tendency to commit more errors toward non-target items in the CRC than in the *control* condition, and such tendency was marginally significant in the case of patients with dementia. The lack of statistical significance could be related to a lack of statistical power due to our small set of tasks.

Future studies including a larger set of ADL tasks, and/or a more homogenous sample in terms of cognitive profile, might help to provide a more complete test of this potential negative influence of *contextually related* non-target objects on ADL performance. In addition, future studies could examine other, less conspicuous types of errors with non-target objects, such as those known as "microslips." This error category refers to the initiation of an overt error that is not completed (Seligman et al., 2013) and has been shown to be moderately linked to executive measures (Bettcher, Giovannetti, Macmullen, & Libon, 2008).

Nonetheless, when looking at tangential completed errors toward non-target items, we observed that both MCI and patients with dementia frequently committed this error, although primarily in the CRC. Interestingly, healthy elderly adults almost never produced this kind of behavior. Therefore, the presence of this kind of correct but tangential action might constitute a qualitative distinction between healthy and impaired ageing even at the early stages of the disease. This finding is in agreement with the initial hypothesis presented in the introduction. The CRC created in the present study might have introduced an additional source of competition, not only at the level of object selection (Moores et al., 2003) but also at the level of task or action schema selection (Cooper & Shallice, 2000; Niki et al., 2009), given the presence of the whole set of objects required to complete contextually related tasks.

The fact that the executive system was altered in these patients should have increased the difficulty to solve that competition and/or left less resources available to support other aspects of task performance, thus leading to more errors being committed toward these irrelevant items compared with those present in the *control* condition.

Finally, regarding the pattern of correlations between neuropsychological variables and ADL errors, we found that all neuropsychological tests, with the exception of naming, were associated with all error categories in ADL. This lack of specificity could indicate that the ADL error categories of interest in this study are actually dependent on the integrity of several cognitive processes. Alternatively, it is possible that the selected neuropsychological tests were not sufficiently specific with respect to the kind of cognitive deficits they isolate. Future studies should include other neuropsychological tests that help to identify more specific processes, particularly within the context of executive functions.

## CLINICAL IMPLICATIONS

The present findings offer potentially important information to guide the design of intervention programs in patients with dementia and MCI. The positive and negative effects we have described in this study that are produced by the presence of contextually related objects can occur at the same time in a patient. Thus, it is important that the professional is aware of the existence of both effects to either enhance or alleviate its effects depending on the degree of affectation (MCI or dementia). The results in this study suggest that, when patients are at the initial stages of damage (i.e., MCI), the presence of contextually related non-target objects produce more benefits than harm in ADL performance. However, in the case of patients with dementia, it appears that the opposite pattern occurs. Thus, these results can help us to suggest opposite intervention strategies for each group. Clearly, we need to be cautious when applying these recommendations individually, as the present results are based on observations of groups, which are heterogeneous in terms of cognitive profile.

Indeed, it is possible that different subtypes of MCI (amnesic, executive, or multi-domain) or dementia (e.g., Alzheimer's, bvFTD) could show different patterns of benefits/detriments when required to perform ADL in the presence of contextually related items. Although the current study was significantly underpowered for such an examination, exploratory analyses revealed that patients with bvFTD (only nine patients with dementia were bvFTD type), produced more errors with non-target objects than patients with other forms of dementia across conditions ($p = 0.78$, 20 *vs*. 10 errors for FTD *vs*. group with other types of dementia, respectively) particularly in the contextually related condition (7 for the non-bvFTD group, and 13 for the group with bvFTD, compared with the control condition, 4 *vs*. 7).

Regarding tangential actions, we observed that more than half of the patients with bvFTD committed this type of error (55.6%), compared with only 27% for patients with other dementias ($p = .10$). Taken together, these findings appear to be compatible with the notion that patients with bvFTD are more prone to disinhibited actions toward irrelevant items, which appears to be exacerbated in the contextually related condition. However, these results were only marginally significant and need to be further tested in future studies, preferably using a larger sample of participants for each subtype of dementia.

Finally, we can speculate as to whether the costs/benefits of asking a patient to perform ADL in the presence of contextually related items might also vary depending on the training stage at the time of observation. One possibility could be that for the initial training on ADL, for people that have stopped doing certain activities, we could offer contexts with objects semantically related that can elicit tasks to begin the recovery of the action pattern and the actions of target objects. However, we need to be aware of the high probability of committing tangential actions toward objects without a purpose, and use techniques that allow us to improve the organization of goals and the ability to achieve them, for example in combination with Goal Management Training (Levine et al., 2000).

This study also has some limitations. First, the allocation of non-target objects was not systematically randomized. Future studies should control this aspect of our experimental design. Another limitation refers to the way in which we addressed the educational level of the sample. Although this variable did not correlate significantly with the errors committed in the ADL tasks and is in agreement with previous studies (Buxbaum et al., 1998; Schwartz et al., 1999, 1998, 2002), we believe that it is important to control this aspect in future research to provide a more in-depth analysis of the impact of educational status on levels of self-sufficiency.

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### Supplementary material

To view supplementary material for this article, please visit https:/doi.org/10.1017/S135561771700025X

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