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The Closing-In Phenomenon in an Ecological Walking Task

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Abstract

Objectives: Alzheimer's disease (AD) patients may show the Closing-in (CI), a tendency to reproduce figures close to or superimposed on the model. AD patients with CI might manifest reduced functional independence compared to AD patients without CI, but no study directly assessed if CI can hamper common daily living activities. To address this issue here we investigated whether AD patients with CI veer their walking trajectory toward irrelevant objects more often than AD patients without CI. **Methods:** Fifty AD individuals, and 20 age- and education-matched healthy adults, underwent a graphic copying task to detect CI and a newly developed walking task to assess the tendency to veer toward irrelevant objects and to bump into them. All participants also completed a comprehensive neuropsychological battery to assess dementia severity; impairments in frontal/executive, visuo-spatial, visuo-constructional, and memory domains; and functional independence in daily living activities. **Results:** Graphic CI occurred in 34/50 (68%) AD patients (AD-CI group) who achieved significantly lower scores on frontal/executive abilities, and daily living functioning than AD individuals not showing CI. Most AD-CI patients (20/34; 58.8%) also showed at least one veering error in the walking task. Participants with CI and veering errors showed significantly poorer performance on Stroop test, and lower level of functional independence than AD individuals with CI in isolation. **Conclusions:** CI on graphic tasks can identify difficulties in walking and in complying with everyday activities in AD patients. These observations demonstrate the value of assessing CI in copying tasks. (*JINS*, 2018, *24*, 437–444)

Keywords: Frontal defect, Attention, Alzheimer's disease, Drawing, Walking, Closing-in

INTRODUCTION

Closing-in (CI) is the tendency to reproduce drawings in the space close to the model or to directly draw on the model in copying tasks (Mayer Gross, 1935). In recent years, CI has been extensively studied particularly in individuals with different forms of dementia (Trojano & Gainotti, 2016); CI has been observed in Alzheimer's disease (AD; De Lucia, Grossi, Fasanaro, Carpi, & Trojano, 2013; Grossi, Orsini, & De Michele, 1978; Grossi, De Lucia, & Trojano, 2015; Lee et al., 2004), vascular dementia (De Lucia, Grossi, & Trojano, 2014), and fronto-temporal dementia (Grossi, De Lucia, Milan, & Trojano, 2015) and, more recently, in Parkinson's disease with associated dementia (De Lucia, Grossi, Mauro, & Trojano, 2015; Poletti et al., 2012). Moreover, the phenomenon has been reported in individuals with neurodegenerative disorders without clinically relevant associated dementia (De Lucia et al., 2015), and in focal brain-damaged individuals (De Lucia, Grossi, & Trojano, 2016; Gainotti, 1972).

In all these neurological conditions, CI in copying tasks were due to frontal dysfunctions, confirming the idea that CI might represent a neuropsychological marker for frontal/executive dysfunctions (De Lucia et al., 2013). Indeed, visuo-constructional tasks involve several mental processes monitored by frontal/executive abilities. Figure copying entails visual attention, visuo-spatial analysis, and planning abilities, and requires continuous attentional switches from the model to the drawing hand (Gasparini et al., 2008). Impairments of frontal/executive functions might release a "default" attraction of the moving hand toward the focus of visual attention (the stimulus to be copied). Some authors, indeed, observed that the attraction of attention and action toward the model is boosted when participants' attentional resources are divided between two concurrent cognitive activities (Ambron, McIntosh, Allaria, & Della Sala, 2009; De Lucia et al., 2014; McIntosh, Ambron, & Della Sala, 2008).

Of interest, it has been recently observed that mild-to-moderate AD patients showing CI, and in particular those who overlap their copy onto the model (adherent-type of CI),

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manifested more severe loss of independence in the ability to carry out basic and instrumental activities of daily living with respect to patients with dementia not showing CI (De Lucia, Grossi, & Trojano, 2017). This finding suggested that CI in copying tasks could serve as an indirect index of a basic impairment of attention-action control in daily living activities. Walking is perhaps the most common and automatized activity of daily living, and yet requires cognitive control abilities whenever ecological conditions call for a concurrent secondary task, as in walking and avoiding hurdles or walking carrying a glass at home. All these common situations are considered rather unproblematic, but can constitute a risk for falling when attentional capacities are limited (Ruffieux, Keller, Lauber, & Taube, 2015; Wollesen, Voelcker-Rehage, Regenbrecht, & Mattes, 2016).

On this basis, the aim of the present study was to directly assess whether CI could manifest during walking. We hypothesized that, if CI results from a failure to inhibit automatic responses toward distractors, then veering of walking trajectories toward irrelevant objects should be significantly larger among individuals who exhibit CI, compared to individuals not showing CI. To test this prediction, we devised a simple walking task to be performed in presence of visual distractors.

METHOD

Participants

Participants for the present study were recruited from a continuous series of outpatients attending the Geriatric Center "Frullone" in Naples. In analogy with previous studies on CI (e.g., Ambron et al., 2009; De Lucia et al., 2013), we excluded patients with severe dementia. To qualify for the present study, participants had to meet the following inclusion criteria: (i) clinical diagnosis of probable AD according to the NINCDS-ADRDA diagnostic criteria (McKhann et al., 1984); (ii) mild to moderate level of AD severity, as characterized by a score ranging 0.5 to 2 points on the Clinical Dementia Rating scale (CDR; Hughes, Berg, Danziger, Coben, & Martin, 1982), and by a raw score ranging 10 to 23 on the Italian version of Mini Mental State Examination (Measso et al., 1993); (iii) formal education of at least 2 years; (iv) lack of concomitant severe organ insufficiency or neoplastic disease; (v) lack of walking difficulties as characterized by a raw score ranging 15 to 20 on the Assessment of Walking Skills (AWS) test (Della Sala, Spinnler, & Venneri, 2004), see below.

Fifty AD patients (36 females) with age ranging 53 to 76 years, and education ranging 5 to 17, met the above selection criteria.

We also enrolled a group of 20 healthy adults, age- and education-matched with the AD sample [9 female; age range: 55–71 years; education range: 5–17 years; Mini-Mental State Examination (MMSE) range: 26–30; Clinical Dementia Rating (CDR) scale: 0], with no previous history of neurological or psychiatric diseases, and without walking difficulties.

When necessary, participants were assessed while wearing their own glasses to ensure normal or corrected to normal visual acuity. No participants had clinically relevant visual field defects.

All participants gave their written informed consent to participate to the study. This study was conducted in accordance with the Ethical standards of Helsinki Declaration.

Preliminary Assessment of Walking Skills

Before entering the study, all participants underwent a preliminary evaluation of walking skills to avoid any abnormalities potentially interfering with performance on the walking task. To this aim, we used a dedicated task included in the AWS test (Della Sala et al., 2004). The task requires participants to immediately imitate motor actions demonstrated and verbally described by the examiner (i.e., "walk with right hand on stomach and left hand on back," or "walk with your hands behind the nape of your neck"). Two examiners are present during the task, one demonstrating the items and the other observing and recording participants' performance. The task includes 20 items (plus two practice trials). Each response is scored 1 point when accurate or 0 when it includes: (i) crossing of the legs while attempting to walk; (ii) inability to keep an upright stance; (iii) association with parasitic arm or trunk movements or bizarre leg movements; (iv) impaired balance; (v) lack of dexterity. The total score ranges 0 to 20 points.

Neuropsychological Assessment

In addition to the MMSE and CDR, all participants underwent several tests assessing frontal-executive abilities, visuo-spatial and visuo-constructional skills, and anterograde memory; two standard questionnaires assessed functional independence.

Frontal-executive abilities were evaluated by means of Frontal Assessment Battery (FAB; Appollonio et al., 2005), phonological verbal fluency test (Carlesimo, Caltagirone, & Gainotti, 1996), Stroop color-word test (Caffarra, Vezzadini, Dieci, Zonato, & Venneri, 2002a), attentional matrices (Spinnler, & Tognoni, 1987), and Trail Making Test (TMT; Giovagnoli et al., 1996). The FAB consists of verbal and nonverbal subtests and provides a global measure of frontal control abilities; the phonological verbal fluency test requires participants to produce in one minute as many words beginning with the letter "F", "A", and "S" as they can, and provides a measures of cognitive flexibility. The Stroop test consists of three sections requiring to name colors (naming task), to read words (reading task), and to inhibit reading of color-words and name the ink color in which each word is printed (interference task), and provides a measures of executive monitoring and inhibition of irrelevant responses. The attentional matrices consist of three matrices of digits on which participants are required to cancel target-digits ignoring distractor-digits, and provide a measure of visual attention. The TMT consists of two parts in which participants have to draw lines connecting numbers in ascending order (part A), and to connect numbers and letters in ascending

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order alternating the two series (i.e., 1-A-2-B-3-C; part B), and provides a measure of sustained and selective attention.

Visuo-spatial abilities were evaluated by means of the Corsi span forward (Spinnler & Tognoni, 1987), and the Clock drawing test (Mondini, Mapelli, Vestri, & Bisiacchi, 2003). Corsi span requires patients to reproduce block-tapping sequences of increasing length, and provides an index of working memory for visuo-spatial information. The Clock drawing task requires participants to complete a shape of a clock by putting in all the numbers and setting the hands for 2 and 45, and provides a measure of visuo-spatial skills, semantic knowledge, planning, and constructional abilities.

Visuo-constructional abilities were assessed by the immediate reproduction of Rey Complex Figure (Caffarra, Vezzadini, Dieci, Zonato, & Venneri, 2002b), and by the figures copying task (Spinnler & Tognoni, 1987). The two tasks require participants to copy an abstract complex model or seven arrays of black-and-white geometrical drawings (see below).

Anterograde memory was assessed in the verbal domain by immediate and delayed recall of a series of 15 words (Carlesimo et al., 1996) that provide two measures: immediate recall (range, 0–75) and delayed recall (range, 0–15). Anterograde memory in the visuo-spatial domain was assessed by delayed reproduction of the Rey Complex Figure (Caffarra et al., 2002b).

In all participants we also assessed daily living functioning by the Italian informant-based versions of the questionnaires for basic activities of daily living (BADLs; Katz, Downs, Cash, & Grotz, 1970), and instrumental activities of daily living (IADLs; Lawton & Brody, 1969). These questionnaires explore patients' functional level expressed as the number of activities performed autonomously by the participants.

Assessment of Closing-in in Copying of Geometrical Figures

To detect CI, we used Spinnler and Tognoni's copying test (1987) mentioned above. In this task, participants were shown with seven stimulus-sheets each including black-and-white geometrical figures (e.g., square, diamond, cube, triangle) centrally printed in the upper half of an A4 sheet of paper. Participants were explicitly required to reproduce the model in the lower half of the same sheet, centrally aligned with respect to participants' body midline.

For each graphic reproduction, we recorded presence and type of CI. Two types of CI were identified: adherent-CI, occurring when at least one element of the copy overlapped to at least one element of the model (i.e., a side of a square), and near-CI, occurring when any point of the copy was within 10 mm from the lower side of the model (De Lucia, Grossi, Fasanaro, Carpi, & Trojano, 2013). Number of near-CI, adherent-CI, and total CI was computed for each individual, independently from the accuracy score computed after Spinnler and Tognoni (1987).

Assessment of CI in a Walking Task

In a second session, performed 1 day later, the tendency to veer toward a salient visual stimulus was assessed in a walking task. The task was run in a dedicated space of the daily center "Frullone," a large rectangular empty room with white walls and light gray floor, and with one window in the upper half of the two longest sidewalls.

In the center of the room a walking path (800 cm long, and 325 cm wide) was marked by two parallel black lines (made by 10-cm-wide thin rubber adhesive tape) placed 50 cm from each other. On the four sides of the path, eight visual distractor-items were placed randomly (30 cm from the path; see Figure 1). The distractor-item consisted of rectangular red light cardboard boxes, 140 cm high, and 50 cm wide (the boxes were not anchored on the ground for safety reason).

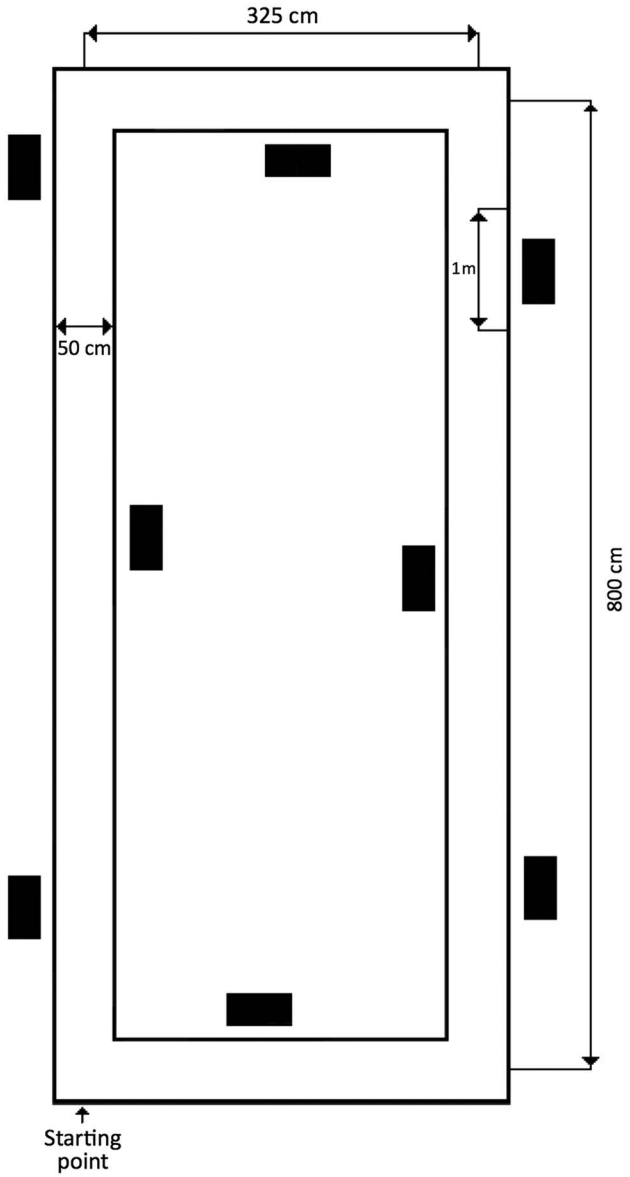


Fig. 1. The figure shows a representative example of the walking path used to assess closing-in in an ecological task. Participants were required to walk in the center of the path. The black rectangles depicted on each side of the path represent the red boxes used as distractor-items.

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Participants were explicitly required to walk at their own pace in the center of the path paying attention not to step on the parallel black lines; no explicit mention was made about the red boxes, and no time restriction was given. One examiner shadowed the participants (without providing any further instruction or cue) along the whole path to supervise task completion and avoid risk of falling.

On each trial, we recorded the number of relevant veering errors (defined as steps on the borders of the path placed in the area of each red box, or bumps into one box) in correspondence of the 8 red boxes. Number of total errors ranged 0 to 16, as all participants completed two trials, one in clockwise and one in anticlockwise direction.

Statistical Analyses

On the basis of presence of CI in the copying test, we divided participants into three groups: healthy adults (HA), AD individuals not showing CI errors (AD group), and AD individuals showing at least one type (near or adherent) of CI error (AD-CI group). Then, we ran a multivariate analysis of variance (MANOVA), to compare demographic data, neuropsychological scores and scores on daily living functioning scales in the three groups (HA, AD, and AD-CI). *Post hoc* analyses were performed by means of the Bonferroni-corrected *post hoc* comparisons, according to which the observed *p*-value is corrected by multiplying it by the number of comparisons; the *corrected p*-value is then evaluated against the conventional significance level of $p < .05$. In the present study, all significant tests had $p < .05$ after adjustment.

Number of participants showing veering errors in the walking task was compared between AD and AD-CI groups by chi-square analysis. Moreover, we compared AD-CI participants showing CI errors in copying of geometrical figures and veering errors in the walking task and AD-CI participants showing CI errors only in copying of geometrical figures by means of a second MANOVA with demographic data, neuropsychological scores and functional independence as the dependent variables. *Post hoc* analyses were performed by means of Bonferroni-corrected post hoc comparisons, setting the level of significance at $p < .05$.

All data analysis has been performed by Statistical Package for Social Science (SPSS, ver. 19.0; IBM, Armonk, NY).

RESULTS

No HAs produced CI in copying of geometrical figures test (HA group). Among AD individuals, 16/50 participants did not show CI (AD group), 34/50 (68%) participants produced 97 CI errors out of a total of 350 copies (AD-CI group). Among AD individuals showing CI, 4 produced near-CI in isolation, 19 produced adherent-CI in isolation, and 11 individuals exhibited both near-CI and adherent-CI.

Results from the first MANOVA analysis showed a main effect of the group (Wilks' $\lambda = .013$; $p < .001$; $\eta^2_p = .88$). AD-CI group individuals achieved significantly lower scores on frontal/executive abilities, and on daily living functioning than AD individuals. Moreover, both AD and AD-CI individuals scored significantly poorer than HAs on all the neuropsychological measures consistently with the clinical diagnosis (see Table 1).

In the walking task, no HA individuals veered their walking trajectory toward the distractors. Among AD group, veering errors were evident in 1/16 individual not showing CI in copying of figures, producing a total number of four errors. Most AD-CI individuals (20/34; 58.8%) also showed at least one veering error in the walking task, producing a total number of 174 errors. The difference in percentage of patients showing veering errors between the two AD groups (AD *vs.* AD-CI) was significant (chi-square = 6.138; df = 1; $p = .02$). All patients showing veering errors in the walking test also showed adherent-CI in the copying test (see Table 2).

Results from the second MANOVA showed no significant general effect (Wilks' $\lambda = .32$; $p = .21$; $\eta^2_p = .67$), but the analysis of the individual effects revealed that AD-CI participants who showed CI and veering errors had a significantly poorer performance on the Stroop-color word test, in terms of interference-time, and lower level of independence on both BADLs and IADLs questionnaires with respect to AD-CI individuals who showed CI in copying only (see Table 3).

DISCUSSION

In the present study, we explored the relationship between CI in a graphic copying task and the tendency to show comparable errors in an ecological task such as walking. We observed that most AD patients (58.8%) producing graphic CI also tended to veer their walking trajectory toward irrelevant visual distractors. Of interest, the strongest association was found between veering of walking trajectory and the adherent type of CI. Patients with graphic CI and veering errors in walking also manifested a more severe defect in tests requiring attention-executive monitoring and inhibition of responses toward irrelevant stimuli with respect to the remaining AD patients of the present sample. Thus, defective inhibition of automatically cued actions would release the tendency to veer walking trajectories.

Usually, frontal-attention processes carry out a high-level control during walking for monitoring all the environmental variables. When frontal/executive abilities are defective, visual distractors can trigger a tendency to veer toward them. Ambron, McIntosh, and Della Sala (2012), described a similar effect in pre-school age, as they found that children showing CI can manifest a stronger tendency to deviate their drawing productions toward visual distractors compared to children without CI. Of interest, these authors also observed that the tendency to veer toward the distractor was most evident in children producing adherent-CI compared to those showing near-CI only. Therefore, the present findings would reinforce the idea that CI in copying tasks and the tendency to approach toward visual distractors would arise from a failure of the frontal/executive control processes involved in the inhibition of actions automatically triggered by external cues (De Lucia et al., 2013; Kwak, 2004; Trojano & Gainotti, 2016).

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Table 1. Means (SDs) of demographic data, general cognitive functioning, overall dementia severity, and neuropsychological test scores in healthy adults without CI (HN), Alzheimer's disease individuals without CI (AD), and Alzheimer's disease individuals with CI (AD-CI). Summary statistics of the AD *vs* AD-CI comparisons are also reported (*p*-value and partial eta squared).

	Score range	HN ($N = 20$)	AD ($N = 16$)	AD-CI ($N = 34$)	*p*-Value	η^2_p
Demographic data						
Age	—	63.80 (3.86)	66.19 (5.75)	66.68 (4.70)	.75	.002
Education	—	11.10 (3.53)	9.38 (3.75)	9.18 (3.57)	.99	.000
General cognitive functioning						
MMSE	0–30	28.95 (1.14)	18.81 (3.10)**	17.74 (5.45)**	.48	.010
Overall dementia severity						
CDR scale	0–3	0.00 (0.00)	1.46 (0.12)**	1.47 (0.08)**	.99	.000
Frontal/executive abilities						
Frontal assessment battery	0–18	17.15 (0.58)	9.18 (2.19)**	7.24 (2.38)**	.008	.137
Phonological verbal fluency	—	39.70 (4.98)	27.19 (12.10)**	18.32 (7.56)**	.016	.114
Stroop test (interference – time)	—	18.05 (4.36)	156.47 (88.09)*	259.81 (76.59)**	.01	.118
Stroop test (interference – error)	—	0.43 (0.54)	17.31 (10.72)**	24.93 (15.38)**	.20	.033
TMT (B-A)	—	81.70 (32.07)	201.81 (103.70)**	322.18 (172.57)**	.01	.115
Attentional matrices	0–60	53.15 (4.15)	30.56 (6.54)**	20.12 (10.90)**	.001	.206
Visuo-spatial abilities						
Corsi span forward	—	5.30 (0.73)	4.00 (0.63)**	3.75 (0.95)**	.81	.001
Clock drawing test	—	9.40 (0.68)	6.13 (2.23)**	5.95 (3.15)**	.07	.065
Visuo-constructional abilities						
Rey Complex Figure – copying	0–36	34.00 (2.02)	16.36 (7.48)**	16.29 (8.36)**	.68	.003
Copying of geometrical figures	0–14	13.05 (1.05)	9.23 (2.15)**	8.01 (1.87)**	.82	.001
Anterograde memory abilities						
15-Word learning test – immediate recall	0–75	47.15 (6.51)	18.33 (3.19)**	17.48 (7.23)**	.41	.014
15-Word learning test – delayed recall	0–15	12.20 (1.57)	3.34 (2.61)**	2.06 (1.59)**	.13	.047
Rey Complex Figure – delayed recall	0–36	18.05 (3.94)	3.66 (4.36)**	2.83 (2.84)**	.69	.003
Activities of daily living						
BADLs	0–6	5.35 (0.48)	1.62 (1.02)**	0.85 (0.95)**	.01	.124
IADLs	0–8	6.75 (0.55)	1.75 (1.18)**	0.94 (1.04)**	.01	.111

Note. Summary statistics of the comparisons between the two groups are also reported (*p*-value and partial eta squared).
*Different from HA at corrected-$p < .05$.
**Different from HA at corrected-$p < .005$.

The present results, demonstrating that graphic CI is often associated with specific errors in walking, support the value of graphic CI in predicting loss of independence in basic and instrumental activities of daily living (De Lucia et al., 2017).

Table 2. Number of AD individuals showing veering errors in walking and/or CI in copying (the number of participants showing bumps into boxes/steps on the path errors is shown in parentheses)

	AD ($N = 16$)		AD-CI ($N = 34$)	
	No veering errors	Veering errors in walking	No veering errors	Veering errors in walking
No CI	15	1 (0/1)	0	0
Near-CI in isolation	0	0	4	0
Adherent-CI in isolation	0	0	0	19 (15/4)
Near-CI and adherent-CI	0	0	10	1 (0/1)

Note. AD = AD individuals not showing CI; AD-CI = AD individuals showing CI. No healthy individual produced CI or veering errors.

In this respect, adherent-CI seems to be directly related to impairments of abilities to monitor and inhibit attraction toward salient visual stimuli (De Lucia et al., 2013; McIntosh et al., 2008).

Attention skills are usually required to walk in daily living. Elderly individuals with reduced attention capabilities may fail in monitoring and planning their visual attention and action, and collide with objects (Vermeulen, Neyens, van Rossum, Spreeuwenberg, de Witte, 2011). Indeed, it has been observed that changes in executive functions, in particular initiation of action, self-awareness, planning, and inhibition of dominant responses and external distractors, can modify walking patterns even in healthy elderly individuals (Yogev-Seligmann, Hausdorff, & Giladi, 2008).

In everyday life, walking across a street is a voluntary motor action that uses frontal-executive cognitive system. Presence of distractors could represent a conflicting condition, since it would require to focus visual attention on the target and to inhibit the automatic action to veer toward it. CI in graphic tasks could help in predicting the potentially dangerous tendency to collide with distractors in walking.

The same reasonment applies to driving, which require frontal-executive functions, in particular selective attention, and judgement abilities (Carter et al., 2015). Indeed, in a

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Table 3. Means (*SD*s) of demographic data, general cognitive functioning, dementia severity, and neuropsychological test scores in Alzheimer's disease individuals showing closing-in (CI) in graphic task only, and Alzheimer's disease individuals with CI in graphic task and veering of walking trajectory errors in the walking task.

	AD participants with CI in copying only ($N = 14$)	AD participants with CI and veering errors ($N = 20$)	p-Value	η^2_p
Demographic data				
Age	66.45 (4.41)	67.00 (5.24)	.74	.003
Education	9.50 (3.81)	9.30 (3.34)	.87	.001
General cognitive functioning				
MMSE	18.60 (5.28)	16.50 (5.65)	.27	.037
Dementia severity				
CDR scale	1.35 (0.56)	1.64 (0.60)	.15	.062
Frontal/executive abilities				
Frontal assessment battery	7.50 (2.54)	6.86 (2.17)	.44	.018
Phonological verbal fluency	18.95 (11.67)	17.43 (11.78)	.71	.004
Stroop test (interference – time)	212.79 (86.45)	348.83 (74.70)*	.03	.129
Stroop test (interference – error)	26.36 (17.48)	36.45 (12.99)	.06	.105
TMT (B-A)	344.79 (150.16)	306.35 (198.28)	.54	.012
Attentional matrices	20.50 (10.82)	19.57 (11.40)	.81	.002
Visuo-spatial abilities				
Corsi span forward	3.63 (0.61)	3.40 (0.94)	.11	.036
Clock drawing test	4.75 (3.07)	3.96 (1.91)	.26	.044
Visuo-constructional abilities				
Rey Complex Figure – copying	17.43 (7.14)	16.20 (10.04)	.69	.005
Copying of geometrical figures	9.00 (1.71)	8.05 (2.12)	.18	.054
Anterograde memory abilities				
15-Word learning test – immediate recall	20.43 (7.18)	17.45 (7.73)	.26	.039
15-Word learning test – delayed recall	3.71 (2.36)	2.60 (2.16)	.16	.059
Rey Complex figure – delayed recall	4.75 (3.14)	2.97 (2.68)	.08	.089
Activities of daily living				
BADLs	1.35 (1.15)	0.50 (0.60)	.008	.200
IADLs	1.42 (1.34)	0.60 (0.59)	.02	.158

retrospective study on CI in AD, Ambron et al. (2009) envisaged that CI could manifest as a tendency to veer toward attention-requiring stimuli during driving. Automobile driving requires performing several competing tasks, including search and recognition of roadside targets and traffic signs, while simultaneously monitoring traffic with attention to avoid roadway hazards. A decline of frontal-executive functions would increase the rate of traffic accidents, especially in drivers with AD (Uc, Rizzo, Anderson, Shi, & Dawson, 2005). Indeed, it has been observed that drivers affected by AD showed more driving errors that normal individuals, and this phenomenon was related to severity level of AD (Martyr & Clare, 2012). Therefore, CI could serve as a marker of propensity to collide with salient visual cues during walking and driving. Moreover, this tendency to collide with stimuli could be modulated by higher frontal/attention load thus individuals showing more severe forms of CI could have high likelihood to collide with visual cues since their lower frontal control.

The two main limitations of the present study refer to the relatively small sample of AD patients, and to the fact that we only assessed walking as an instance of common daily living activities. Further studies should thus address generalization of the present findings, but we can conclude here that CI in AD patients can serve as an easy to detect and useful marker to identify subjects at a high risk for accidents in daily living.

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