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Comparing two different orientation strategies for promoting indoor traveling in people with Alzheimer's disease

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ABSTRACT

The present study compared two different types of orientation strategies: an assistive technology program (AT, i.e., remotely controlled sound/light devices) and a backward chaining procedure (BC) for promoting indoor traveling in four persons with moderate to severe Alzheimer's disease (AD). A social validation assessment of the two strategies was also conducted employing undergraduate students as raters. For three out of four participants, AT intervention was more effective than the BC procedure, whilst for the fourth participant the two types of intervention had a comparably satisfying efficacy. A doubly Multivariate Analysis of Variance on social validation assessment data provided generally more positive scores for the AT intervention. These results suggest that AT programs (a) can be valuably employed for restoring and maintaining independence in indoor traveling in people with moderate to severe AD, and (b) might be perceived as preferable to conventional teaching strategies within daily contexts.

1. Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative brain disorder that usually occurs in old age, and is marked by a decline in cognitive functions such as remembering, reasoning, and planning, and by a variety of behavioral and psychiatric symptoms, such as agitation, delusions and depression (Ferri et al., 2005; Mayeux, 2003). People suffering from AD often show disorders in spatial and topographical orientation, at first restricted to new and unfamiliar environments, and then extended to familiar ones (e.g., Caffò et al., 2012; Monacelli, Cushman, Kavcic, & Duffy, 2003), with negative implications on independence and self-confidence (Conde-Sala, Garre-Olmo, Turró-Garriga, López-Pousa, & Vilalta-Franch, 2009; León-Salas et al., 2013; McLaughlin et al., 2010; Passini, Pigot, Rainville, & Tetreault, 2000; Rainville, Passini, & Marchand, 2001).

Recently, Caffò et al. (in press) reviewed the strategies for reducing topographical orientation disorders in elderly people with dementia, specifically in persons with AD. Eight experimental studies published between 1981 and 2013 were analyzed and their approaches were classified as restorative or compensatory, depending on whether they relied or not on residual

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learning ability, respectively (Sitzer, Twamley, & Jeste, 2006). Studies based on compensatory strategies employed new ways of performing cognitive and behavioral tasks, which would bypass cognitive deficits. Specifically, they relied on the use of spatial cues (Namazi, Rosner, & Rechlin, 1991; Nolan, Mathews, & Harrison, 2001) as well as assistive technology (AT) programs (Lancioni et al., 2011; Lancioni, Perilli, et al., 2013). Studies based on restorative strategies, on the other hand, aimed to restore functioning in specific domains with the ultimate purpose of returning it to pre-morbid levels, or slowing the progression of the disease. Interventions employing restorative strategies included reality orientation (Hanley, 1981), errorless-based technique (Provencher, Bier, Audet, & Gagnon, 2008) as well as backward chaining programs (McEnvoy & Patterson, 1986; McGilton, Rivera, & Dawson, 2003).

Results of the studies reviewed suggested that it is possible to reduce spatial orientation disorders in dementia, and specifically in AD. In terms of the assessment of training efficacy, all the studies reported positive/mixed changes on spatial and topographical orientation abilities after the interventions. Both compensatory and restorative approaches seemed to be valuable in enhancing correct way-finding behavior, with various degrees of effectiveness. The best results were obtained with compensatory strategies, in particular with AT programs. These interventions proved to be highly effective in reducing spatial orientation disorders in AD, probably because they were aimed at supporting and recovering functional daily life ability without requiring effective learning skills. Restorative strategies, by contrast, showed partial results, especially at follow-up measurements. Studies using these strategies suggested that cognitive training programs may have only a modest impact on way-finding skills, slightly improving spatial and topographical memory functions in the short-term period.

While the results of the two approaches seemed clearly different, questions about participants' characteristics and experimental designs made it quite difficult to draw a definite conclusion about those approaches and their usability. Indeed, participants included in the intervention programs had different levels of cognitive functioning, ranging from mild to extremely severe (i.e., Mini Mental State Examination from 4 to 24), or not even specified (McEnvoy & Patterson, 1986). Moreover, six of the eight studies employed a single-subject design, while two studies employed a case–control design. A third question that was not really taken into account when evaluating the differences between the two approaches concerns their practicality in terms of environmental interference/disturbance and human and economic costs (Lancioni et al., 2011; Lancioni, Perilli, et al., 2013; Lancioni, Singh, et al., 2013).

The present study was aimed at pursuing within-subject comparisons between an assistive technology-based (AT) orientation program (i.e., a compensatory strategy) and a backward chaining (BC) program (i.e., a restorative strategy) with four participants with moderate to severe AD who traveled to indoor destinations. These comparisons were to shed some light on the first two questions stated above. The study also proposed a social validation assessment, in which psychology, nursing, and special education undergraduate students, were asked to rate the patients' travel performance on a number of questions related to practicality and affordability of the two program conditions (Callahan, Henson, & Cowan, 2008). This assessment was thought useful for a better appreciation of the third question mentioned above.

2. Method

2.1. Participants

The patients (Jenny, Woody, Michael and Marlon) were 81, 89, 67 and 83 years old, respectively. Jenny and Woody were deemed to function at the moderate level of Alzheimer's disease, while Michael and Marlon were diagnosed to be at a severe level of the disease. Their scores on the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975) were 12, 17, 6, and 10, respectively. None of them was depressed according to scores on the Hamilton Depression Rating Scale (Hamilton, 1960). Michael and Marlon received pharmacological treatment in the form of galantamine and rivastigmine, respectively. Jenny and Woody lived in a residential care facility, whilst Michael and Marlon attended a day center. All of them were involved daily in a supervised activity program and were able to walk without any support. They showed no hearing or vision loss and understood simple verbal instructions. Their spatial and topographical orientation abilities were very poor, and they failed to orient themselves even in very familiar environments and could not travel independently. Nonetheless, they seemed to be willing to travel from one room to another and to enjoy the opportunity to go for a little walk in the morning. This study was well accepted by the staff personnel of the facilities that the participants attended, and was formally approved by an Ethics Committee connected to those facilities. The patients' families had provided formal consent for their participation in the study.

2.2. Setting and sessions

Data were collected between February and May 2012. Two routes for each patient were arranged. For the patients of the residential care facility (Jenny and Woody), the first route started from the living room and ended inside their own bedroom; the second route corresponded to the reverse path, that is, from the bedroom to the living room. For the patients of the day center (Michael and Marlon), the first route started from the living room and ended in the coffee corner; the second corresponded to the reverse path, that is, from the coffee corner to the living room. The routes were approximately 18–20 m long, and matched in number of turns, since each route had two 90-degree turns. Each route was divided into five sections of the same length. Within each session, the patient was asked to reach the target destination to show the research assistant pictures and/or to meet people present there. All the patients were familiar with the rooms used as starting points and target destinations. A schematic map of the routes used with patients from residential care facility and from day center is provided in Fig. 1.

2.3. Orientation strategy with assistive technology

The orientation strategy conducted with AT was comparable to that used in Lancioni et al. (2011), Lancioni, Perilli, et al. (2013), and Lancioni, Singh, et al. (2013). The technology used during the intervention phase was a basic wireless doorbell system (JKB310P by JEIKO; www.jeiko.eu). The orientation system included a source at each of the five sections into which the route was divided, and a transmitter to be used by the research assistant to activate and deactivate each source. Every source (i.e., a box-like device of about 12 cm × 10 cm × 4 cm) was battery powered and could emit various sounds. Music sound was chosen in this study, as it was considered most suitable for the patient and the environment. Moreover, the sound emission was also combined with the presence of strobe light flashes that might represent additional (helpful) orientation cues for the patient (see Lancioni, Perilli, et al., 2013). The transmitter (i.e., a device of about 7 cm × 3 cm × 2 cm) allowed the research assistant to operate the sources from any position (i.e., without interfering with the patient).

At the start of each travel session, the patient was informed about the target destination he/she was supposed to reach, and then was asked to pay attention to the music, and to walk to the point the music came from. Immediately after that, the research assistant activated the first source. As soon as the patient arrived near to that music/source, thus completing the first route section, he/she was asked again to pay attention to the music and to walk toward the next point; again, the second music device was activated, and so on. This procedure was repeated until the last section was completed, and the patient reached the target destination, where he/she received social approval and positive physical contact, and met one or more persons present there. The research assistant intervened with guidance (and thus the specific travel/route section would be considered incorrect) if the patients took a wrong direction or stood still without moving for 20 s after the last of the three 5-s music cues available had occurred from a source. The three cues occurred at intervals of 20 s from each other (but the patient could travel the route section with only one or two of them).

2.4. Orientation strategy with backward chaining

The orientation strategy conducted with backward chaining was similar to that used in McEnvoy and Patterson (1986) and in McGilton et al. (2003). The orientation system included various familiar objects of the environment, such as chairs, large pictures, small furniture, colored pillars and automated doors, to serve as landmarks for each section of the route. Each travel session began from the last section of the route to be learned; at this stage the patient was provided verbal instruction about (a) the direction to follow to reach the target destination, (b) the landmark to pay attention to, and (c) the left/right position of the landmark in relation to him- or herself. As soon as the patient achieved independence in the last section of the route, he/she was brought to the start of the penultimate section, and was given verbal instruction about the path to follow, the landmarks (one per route section), and their left/right position. The same procedure was also applied when the first section of the route was included and the patient had to travel the entire distance. The participant received social approval and positive physical contact at her/his arrival at the target destination. The research assistant intervened with guidance (and thus the specific section of the route would be considered incorrect) if the patients took a wrong direction or stood still without moving for 20 s after the last of the three verbal-instruction instances available had occurred. The three verbal instruction instances were separated from each other by 20 s intervals (see Section 2.3).

2.5. Measures and reliability

The patients' performance on both intervention strategies was measured by recording (a) the number of route sections traveled correctly (i.e., without errors or pauses longer than 20 s), and (b) the number of music cues or verbal instructions provided for each route section. Inter-rater reliability was assessed in about 20% of the patients' travel sessions. Agreement on these two measures varied between 80 and 100% with means above 95%. No reliability measures were taken on the responses given by university psychology, nursing and special education students for the social validation assessment since they constituted permanent records.

2.6. Experimental conditions

The patients usually received two sessions per day, five days per week. An alternating treatments design was used with each participant to compare the orientation strategy with AT with the orientation strategy with BC (Barlow, Nock, & Hersen, 2009). The study started with baseline sessions on both routes. This was followed by intervention with one of the orientation strategies for one route and the other orientation strategy for the second route. The routes had the same length, the same number of sections and turns (i.e., five and two, respectively; see Fig. 1) and were considered to be of similar difficulty (see Section 2.2). Thirty-five intervention sessions for each strategy were conducted for Michael and Marlon and 40 intervention sessions for each strategy were conducted for Jenny and Woody. If one of the two orientation strategies produced a higher level of correct travel performance after 35–40 intervention sessions, its use was extended to the other route (i.e., the one previously associated with the lesser effective strategy, which was abandoned) according to a partial crossover procedure. If

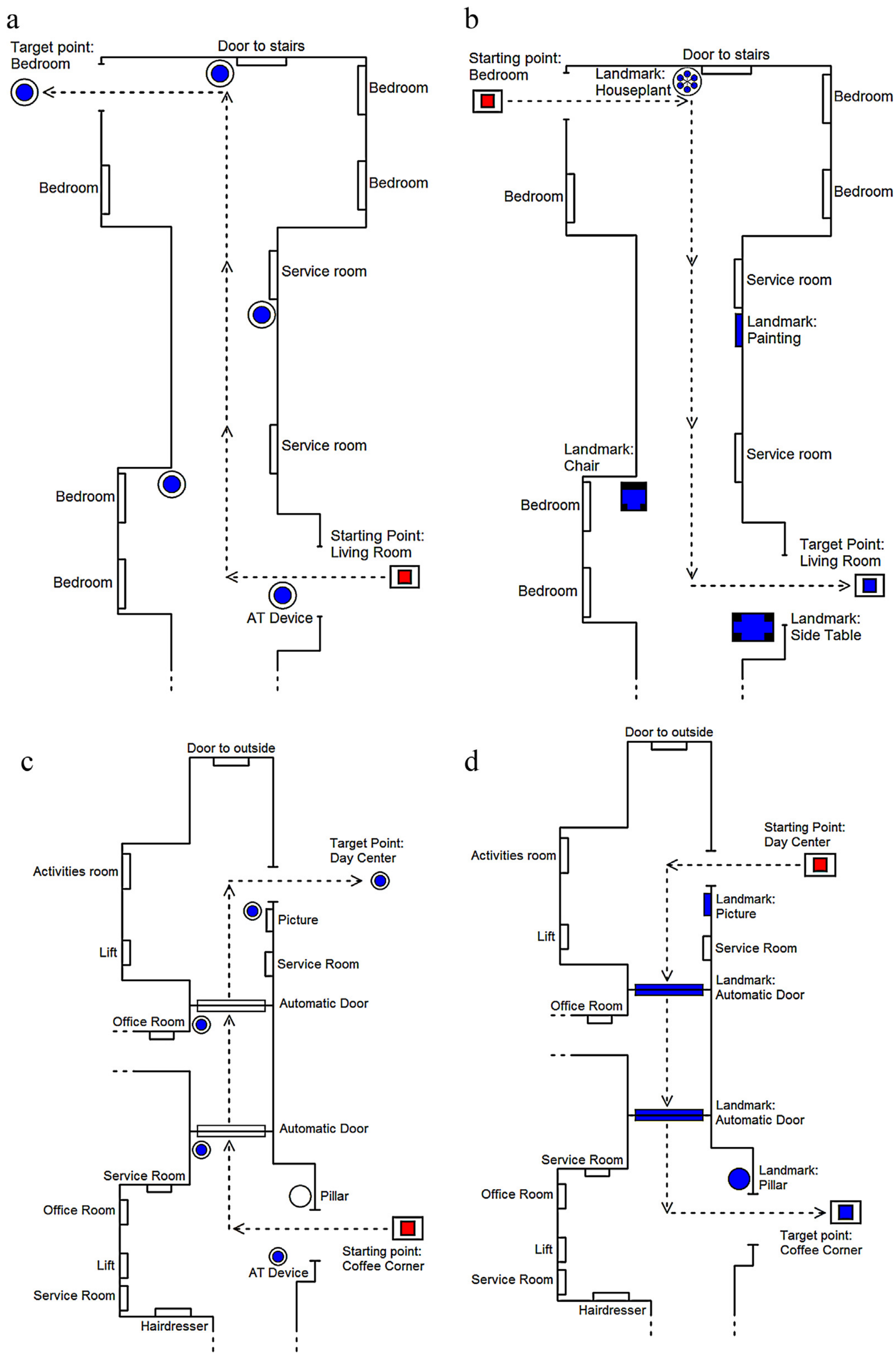

Fig. 1. The four images show the routes arranged for the patients from residential care facility (a. and b.) and from day center (c. and d.), respectively. Jenny and Woody traveled routes a. and b. with the help of AT orientation strategy and BC orientation strategy, respectively, during the baseline and intervention phases. During the partial cross-over phase, they traveled the route b. with the help of AT orientation strategy. Michael and Marlon traveled routes c. and d. with the help of AT orientation strategy and BC orientation strategy, respectively, during the baseline and intervention phases. During the partial cross-over phase, Michael traveled the route d. with the help of AT orientation strategy. During the cross-over phase, Marlon traveled the route d. with the help of AT orientation strategy and the route c. with the help of BC orientation strategy.

this orientation strategy produced a performance improvement with this other route also, the conclusion was that such orientation strategy was responsible for the differences in performance. The partial crossover procedure was to (a) identify the more effective orientation strategy, regardless of the route employed, and (b) avoid a second use of the seemingly less effective strategy to minimize frustration/failure. If the two orientation strategies produced the same levels of correct travel performance, a full crossover procedure was employed, that is, the route previously matched with the first orientation strategy was assigned to the second strategy, and vice versa.

2.6.1. Baseline

Five baseline sessions were carried out on the two routes for each patient. During the baseline sessions, patients were required to travel to the target destinations without any assistance from the AT or from the BC procedure. Information on the destinations to reach, corrective guidance, and travel consequences were as described in Sections 2.2–2.4.

2.6.2. Intervention with AT

Six familiarization (practice) sessions were carried out prior to the start of the intervention phase with AT, to ensure that the patients responded to the system's cues. These sessions were followed by 35–40 regular intervention sessions, during which the patients continued to receive the technology-based orientation cues, as described above. Prompting by the research assistant occurred as described above (see Section 2.3).

2.6.3. Intervention with BC

Six familiarization sessions were conducted prior to the start of the intervention phase with BC, to ensure that the patients could correctly recognize the landmarks and comprehend the verbal instructions. These sessions were followed by 35–40 regular intervention sessions. Prompting by the research assistant occurred as described above (see Section 2.4).

2.6.4. Crossover procedure

Thirty-five or forty partial crossover trials were carried out for Jenny, Woody and Michael, with the AT orientation strategy. The route previously matched with BC was now supported with AT. The BC orientation strategy was abandoned because of the poorer performance obtained with it. For Marlon, thirty-five crossover trials were carried out for each route. During those trials, the route previously matched with AT orientation strategy was supported with the BC strategy, and vice versa.

2.7. Social validation assessment

A social validation assessment of Woody, Michael and Marlon performance was carried out with three groups of 12 rehabilitation psychology, nursing and special education undergraduate students. No social validation assessment was carried out for Jenny, since the family did not give permission to record video-clips during the intervention sessions. The three groups represented convenience samples selected among students with an interest in the field of aging and disabilities. Each group was asked to rate the performance of one patient by watching two video-clips of that patient. For each group, six students (a) watched a video-clip showing the patient traveling to a destination with the help of the AT orientation strategy, (b), scored that clip according on a six-item questionnaire, (c) watched a video-clip of the patient traveling to a destination with the help of the BC orientation strategy, and (d) scored the clip on the aforementioned questionnaire. Each video-clip reported a typical/representative intervention performance for that patient. The other six students watched and scored the video-clips in the reversed order.

Table 1 shows the items of the questionnaire. Three items (i.e., items one, three and four) addressed the impact of the orientation strategies on the patients' comfortableness, competence and self-determination. The other three items (i.e., items two, five and six) concerned the impact of the orientation strategies on the environment, their functionality in terms of cost effectiveness, and the students' personal level of interest regarding the strategies. For each item, the students were asked to provide a score of 1–5, which represented least and most positive ratings, respectively.

3. Results

The four graphs of Fig. 2 summarize the baseline, intervention and crossover data of Jenny, Woody, Michael and Marlon, respectively. The black circles and empty diamonds represent mean percentages of correct travels over blocks of session for

Table 1
Social validation questionnaire items.

1. Do you think that the patient is comfortable (happy/relaxed) with this orientation strategy?
2. Do you think that this orientation strategy is generally respectful of the environment (without causing particular interference/disturbance)?
3. Do you think that this orientation strategy helps the patient to have a positive image (to appear competent)?
4. Do you think that this orientation strategy can help the patient maintain self-determination and continuity during travel?
5. Do you think that this orientation strategy can be recommended as cost-effective?
6. Would you personally find it interesting to implement this orientation strategy?

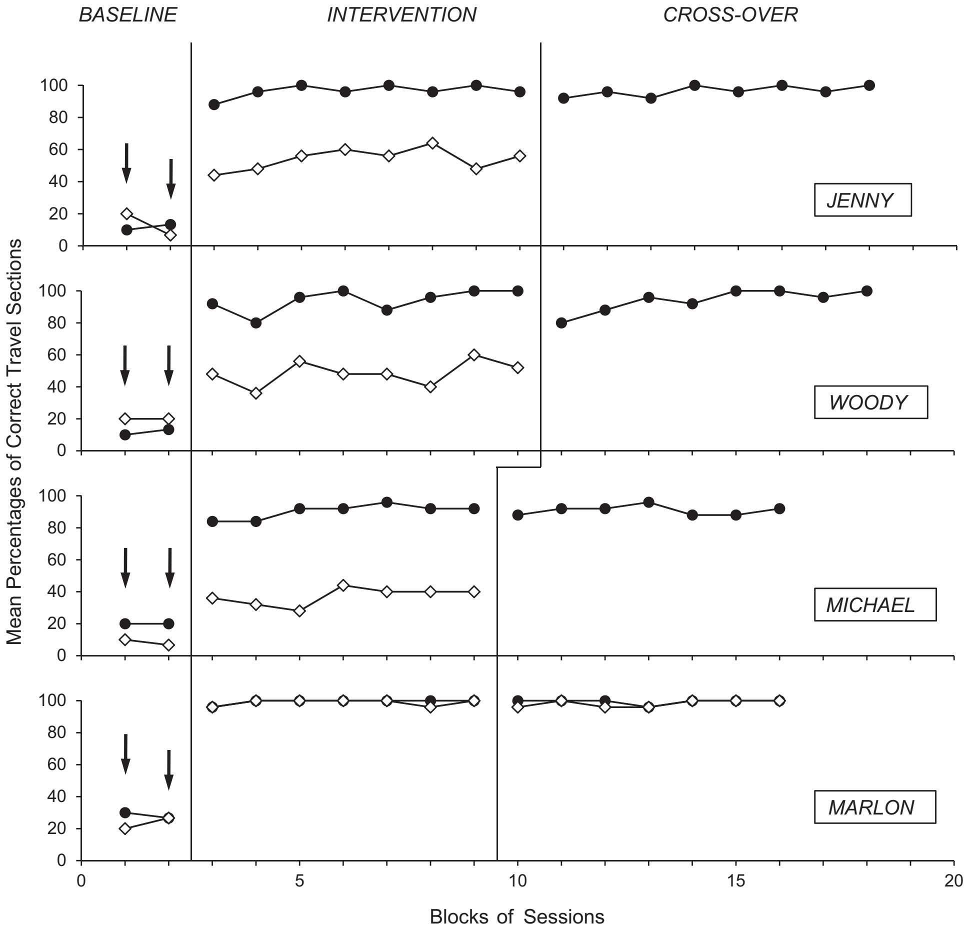

Fig. 2. The four graphs summarize the baseline, intervention and cross-over data of Jenny, Woody, Michael and Marlon. The black circles and empty diamonds represent mean percentages of correct travels over blocks of session for the intervention with Assistive Technology and with Backward Chaining, respectively. Blocks include five sessions except when arrows are present. In those cases, they include two to three trials.

the intervention with AT and with BC, respectively. Blocks include five sessions except when arrows are present. In those cases, they include two or three sessions. During baseline sessions, the participants' mean percentages of travel/route sections carried out correctly varied from below 10 to about 30. During the intervention with the AT, the participants' mean percentages of correct travel/route sections increased to mean levels exceeding 90. For three out of four patients (Jenny, Woody and Michael), the intervention with BC produced considerably lower percentages of correct travel/route sections (i.e., with means ranging from 37 to 54). The partial crossover procedure showed that the AT intervention was also highly effective with the route previously used with the BC intervention, and the percentages of correct sections increased to above 90. The last patient (Marlon), unlike the first three participants, had comparably successful performance (i.e., reaching nearly 100% correct levels) with the two intervention strategies. The crossover procedure (which reversed the combinations of strategies and routes for him) showed maintenance of the high levels of correct performance with both strategies.

The Kolmogorov–Smirnov test (Siegel & Castellan, 1988) showed that the levels of correct travel/route sections obtained with AT orientation strategy were significantly higher ($p < .01$) than those obtained with BC strategy during the intervention phase for Jenny, Woody and Michael, whilst no significant intervention differences were found between the two strategies for Marlon. The differences between intervention and crossover levels were not significant for any of the participants.

A doubly Multivariate Analysis of Variance (dMANOVA) was conducted to test the null hypothesis that there were no differences across interventions (within-subjects variable) for the three patients involved in the social validation (between-subjects variable), along the six dimensions of the questionnaire (dependent variables), and across the presentation order (i.e., video-clips order) as a control variable. Since the latter showed neither main nor interaction effects, it was removed from subsequent analysis. Follow-up univariate and multivariate analyses were conducted, as appropriate, to test for patients by intervention interactions and main effects on univariate measures.

The main multivariate effects of patients and interventions were both significant with $p < .001$. The interaction between patients and interventions was not significant. The mean ratings for the three patients were all significantly different, with $p < .05$ (Woody, $M = 3.47$ and SD = .91, Marlon, $M = 3.82$ and SD = .83, Michael, $M = 3.25$ and SD = .77).

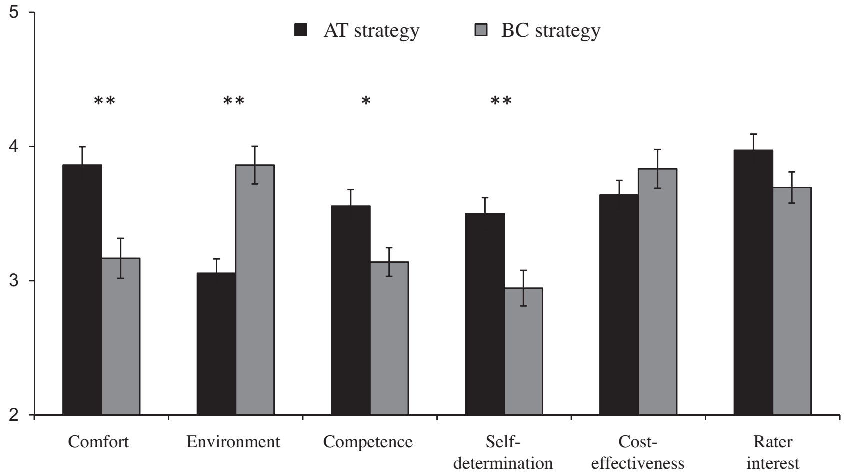

Fig. 3. Mean ratings (standard deviations in bars) on the questionnaire items for the two orientation strategies. Dark gray bars represent the ratings for the orientation strategy with AT, while light gray bars represent the ratings for orientation strategy with BC. *Significant with $p < .01$, **Significant with $p < .001$.

Fig. 3 reports the raters' mean scores and standard deviations on the questionnaire items for the two orientation strategies. The score differences between orientation conditions were statistically significant for four of the six items of the questionnaire; mean scores were higher for AT orientation strategy on items concerning comfort ($p < .001$), competence ($p < .01$), and self-determination ($p < .001$), whilst for BC orientation strategy the item regarding environmental noises/disturbances received more positive rating ($p < .001$). No differences were found with respect to cost-effectiveness and raters' interest to carry out training with one of the two strategies.

4. Discussion

The present study conducted a comparison between a compensatory and a restorative strategy, in order to reduce topographical disorientation deficit in four persons with AD. The results suggested that the orientation strategy with AT (i.e., compensatory) was highly effective in helping the four participants to reach the target destinations successfully, thus confirming previous findings by Lancioni et al. (2011), Lancioni, Perilli, et al. (2013), and Lancioni, Singh, et al. (2013). The orientation strategy with BC (i.e., restorative) showed to be less effective for three of the four participants and as effective as AT procedure for the fourth participant.

The social validation assessment showed that rehabilitation psychology, nursing and special education undergraduate students involved in rating the travel performance of three of the four patients provided generally more positive ratings for the patients' performance with AT orientation strategy on items regarding comfort, competence and self-determination, and more positive ratings for the patients' performance with BC orientation strategy on item concerning environmental disturbance. Comparably high ratings on items regarding cost-effectiveness and raters' interest were provided for both orientation strategies. Moreover, scores on the three patients (Woody, Michael and Marlon) showed differences compatible with levels of performances achieved in the intervention phases. Indeed, scores were generally higher for Marlon and Woody, and lower for Michael. This result confirmed the view that raters, who are not directly involved in research procedures, are able to detect even slight differences in performances and thus they could be considered as reliable and independent judges of rehabilitation efforts (Lancioni, Sigafoos, O'Reilly, & Singh, 2012).

By confirming the effectiveness of a program employing an assistive technology procedure, the data of the present study constitute positive evidence in support of compensatory intervention strategies. A rehabilitation program based on a relatively simple technology can offer patients with Alzheimer's disease who have lost the ability to orient and travel, even within indoor and relatively familiar environments, an opportunity to perform it again (Baldwin, 2003; Gibson, MacLean, Borrie, & Geiger, 2004; Lancioni et al., 2007; Marquardt & Schmieg, 2009; Marquardt et al., 2011; Petry, Maes, & Vlaskamp, 2005). The implications of this evidence within daily contexts could be quite straightforward in view of the fact that the technology as such is simple and easily usable (e.g., Perilli, Lancioni, Hoogeveen, et al., 2013; Perilli, Lancioni, Laporta, et al., 2013).

By contrast, a restorative strategy based on a backward chaining procedure showed to produce little improvements in the ability to travel and reach a destination. This result could be somewhat expected, since the participants recruited for the present study presented with moderate/severe Alzheimer's disease, and showed deficits in several cognitive domains (data obtained from chart review). The most relevant deficits which might have undermined the restorative training were (a) a poor working memory (that reduces the possibility of retaining the information about landmarks and route to follow), (b) a severe attention deficit (that interferes with information coding), (c) a severe deficit in basic spatial skills (that undercuts the sense of direction), (d) the inability to distinguish left from right, and (e) the inability to recognize landmarks.

A quite surprising result was obtained with the fourth participant (Marlon). Although he was deemed to function at a severe level of AD, he was fully able to orient following both intervention strategies. His visuo-spatial working memory was still functioning at a good level, so that he could profitably take advantage of the cues given in the backward chaining procedure. Moreover, unlike the other patients, he had a still intact ability to distinguish left from right, and to recognize every single landmark during the travel. This participant's performance may lead to two different considerations. First, it might be that he was within the moderate range of the disease rather than at the severe level of it, as suggested by his score on the Mini Mental test. Second, there might be situations in which the person's deterioration is not equally severe across domains. Some domains may prove more efficient for a longer time (Van Tilborg, Kessels, &Hulstijn, 2011).

In conclusion, the present study showed that compensatory strategies (particularly AT) are widely functional for counteracting topographical orientation disorders in persons with moderate to severe AD. The social validation data also emphasized the effectiveness of AT in ensuring the participants' competence, comfort and self-determination. Yet, AT was less preferred than BC when judged in terms of environmental disturbance. Taken together, these results might suggest that one should (a) try to use a restorative approach in the early stages of the disease (e.g., mild cognitive impairment and mild AD), in which general cognitive resources are supposed to be substantially preserved (Dechamps et al., 2011; Noonan, Pryer, Jones, Burns, & Lambon Ralph, 2012; Van Tilborg et al., 2011), and (b) shift to a compensatory strategy when the person shows more severe disorientation and loss of performance. New research would need to evaluate both of these strategies with additional patients to determine the generality of the present findings (Barlow et al., 2009). New efforts to improve the technology might also be considered critical. One could investigate whether AT strategies based on visual cues can be equally effective and environment friendly (i.e., less disturbing; Lancioni, Perilli, et al., 2013).

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