We wanted to thank the editor and anonymous expert reviewers for their thoughtful comments and suggestions on this MS which we feel have greatly improved the paper. Below please find our responses to your comments/suggestions in **bold**.

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**Editorial comments:**  
  
1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. **Ok.**

2. Please revise lines 32-33, 60-61, 70-71, 73-74, 107-109, [154-157 **this latter line is discussion of the algorithm and how to construct it]**, 207-211, and Figure 1 legend to avoid previously published text. **These are updated per request.**

3. Please adjust the numbering of the Protocol to follow the JoVE Instructions for Authors. For example, 1 should be followed by 1.1 and then 1.1.1 and 1.1.2 if necessary. Please refrain from using bullets, dashes, or indentations. **These changes have been made.**

4. JoVE cannot publish manuscripts containing commercial language. This includes trademark symbols (™), registered symbols (®), and company names before an instrument or reagent. Please remove all commercial language from your manuscript and use generic terms instead. All commercial products should be sufficiently referenced in the Table of Materials and Reagents. You may use the generic term followed by “(see table of materials)” to draw the readers’ attention to specific commercial names. Examples of commercial sounding language in your manuscript are: Excel, IBM SPSS, IBM Corp., etc. **These changes have been made.**

5. JoVE policy states that the video narrative is objective and not biased towards a particular product featured in the video. The goal of this policy is to focus on the science rather than to present a technique as an advertisement for a specific item. To this end, we ask that you please reduce the number of instances of " Ubisense" within your text. The term may be introduced but please use it infrequently and when directly relevant. Otherwise, please refer to the term using generic language. **We mention Ubisense with reference to the GUI (Smart Factory) and also in the table of materials. Otherwise, we refer to the RTLS in general.**

6. Please revise the protocol text to avoid the use of any personal pronouns (e.g., "we", "you", "our" etc.). **Personal pronouns have been removed from the MS.**

7. Please revise the protocol to contain only action items that direct the reader to do something (e.g., “Do this,” “Ensure that,” etc.). The actions should be described in the imperative tense in complete sentences wherever possible. Avoid usage of phrases such as “could be,” “should be,” and “would be” throughout the Protocol. Any text that cannot be written in the imperative tense may be added as a “Note.” Please include all safety procedures and use of hoods, etc. However, notes should be used sparingly and actions should be described in the imperative tense wherever possible. **These issues have been addressed in the protocol.**

8. Please note that your protocol will be used to generate the script for the video and must contain everything that you would like shown in the video. Software must have a GUI (graphical user interface) and software steps must be more explicitly explained ('click', 'select', etc.). Please add more specific details (e.g. button clicks for software actions, numerical values for settings, etc.) to your protocol steps. There should be enough detail in each step to supplement the actions seen in the video so that viewers can easily replicate the protocol. For example: Steps 8 and 8.1: As currently written, it is not clear how to smooth RTLS raw data. **Ok, and additional details have been provided.**

9. The Protocol should contain only action items that direct the reader to do something. Please move the discussion about the protocol to the Discussion. **Ok.**

10. After you have made all the recommended changes to your protocol (listed above), please highlight 2.75 pages or less of the Protocol (including headings and spacing) that identifies the essential steps of the protocol for the video, i.e., the steps that should be visualized to tell the most cohesive story of the Protocol. **Ok.**

11. Please highlight complete sentences (not parts of sentences). Please ensure that the highlighted part of the step includes at least one action that is written in imperative tense. **Ok.**  
12. Please include all relevant details that are required to perform the step in the highlighting. For example: If step 2.5 is highlighted for filming and the details of how to perform the step are given in steps 2.5.1 and 2.5.2, then the sub-steps where the details are provided must be highlighted. **Ok.**

13. Figure 1: Please label panels A and B. **Figure 1 is updated per request.**

14. References: Please do not abbreviate journal titles. **Ok.**   
  
**Reviewers' comments:**

**Reviewer #1:**  
  
Manuscript Summary:  
The manuscript is suitable for JoVE journal. Key steps of the protocol are presented adequately. However, more details can be included to clearly explain the protocol.  
  
Major Concerns:  
1. Line 191: description should be included to explain how the parameters (e.g. walking distance, sustained walking distance, etc.) calculated from the RTLS (line 143) can be linked or maybe used to measure gait and balance. This will show the relationship of the 2 key steps (line 98 and line 191) of the protocol. **Thank you for this comment. We introduce this idea in lines 97-100 and discuss gait and balance in terms of key factors associated with falls. We also point to the literature that has utilized a RTLS to measure cognitive impairment, gait and balance, alone and with paper and pencil tools (as this study does). Also, see lines 373-380.**   
  
2. Between line 121 and line 127, there should be description to highlight how the Ubisense sensors are connected to the POE switches. And if there are more sensors than the number of slots/ports in the switch, what can be done to synchronize them? More importantly, it should highlight the steps or important notes (if required) in saving the locations shown on the "Location Engine Configuration" onto the host computer desktop. **Thank you for these comments. Please see lines 136-143 for more information about the POE switches. The C: Ubisense software location is given to save the raw CSV files to the desktop, lines 265-266.**  
3. One of the previous works of Prof Kearns should be cited because he and other authors had demonstrated how ultra-wide band radio (Ubisense) is used for similar purposes. The title of the publication is "Ultra Wideband Radio: A Novel Method for Measuring Wandering in Persons with Dementia". Here is the link to the publication: <http://scholarcommons.usf.edu/mhs_facpub/141/>. **Thank you for this citation, it has been added on line 96.**  
  
Minor Concerns:  
1. Line 102: calibration is quite an important key step of Ubisense to ensure accurate tracking. Any highlighted lessons from this step can be very useful to readers or users who want to try the system. **Thank you for this comment. We added additional details about calibrating the system; see the installation and set up section throughout specifically lines 209-216.**

2. Line 107: should it be "based on x, y, and z coordinates" because in line 146 it mentions the raw location data are of x, y, z coordinates? In fact, the authors can share how the z coordinates are handled because sometimes the z (height) values are lower than their expected heights in my personal experience with Ubisense. **Thank you for this comment. The z coordinate has been used in previous work for fall detection but for the purposes of this project the z coordinate was not used. See: Bowen, ME, Craighead, J, Wingrave, C, Kearns, W. Real-Time Locating Systems (RTLS) to Improve Fall Detection. *Intl J Geron* 2010; 9(4): 464-471. doi:10.4017/gt.2010.09.04.005.00. We revised this section for clarity.**  
  
3. Line 113: Authors might share some reasons on why wrist tag is used instead of hang tag. One issue with the hang tag is Ubisense sensor's visibility because it can be blocked from the sensors when the tagged subject walks. Also, how the tag is handled when the resident goes to sleep or goes to bath/shower. **Thank you for this comment. The hang-tag, while made for human tracking, suffers from two issues: if put on backward, the antenna is boxed between the circuit board and the human body, which is about 98% water and attenuates the signal. The circuit board also attenuates the signal, albeit to a lesser degree, which affects RTLS accuracy. The compact tag has the benefit of being attached to an area of the body having a small cross sectional area and more limited absorption of radio frequency energy. A note about positioning each of these is discussed lines 216-218. We also discuss developing a protocol to remove a tag when bathing/showering (see lines 240-243) and also to check for water issues and a tag that is inactive (lines 318-319). We discuss how to turn the tag on for use lines 234-235. For this project, tags remain on the resident while sleeping, though this is optional.**

4. Line 164: is Smart Factory a program within Ubisense's Location Engine Configuration? Smart Factory program's introduction should be mentioned. **We minimize the mention of Ubisense and Smart Factory in this revision per editor request but we do introduce Smart Factory as the GUI line 149 and thereafter refer to it as just the GUI. Where applicable, figures note Smart Factory as well.**

5. Line 303: is the check of tag in Smart Factory done manually? If there is an algorithm to perform such checks, it should be mentioned. **In this project it is done manually in the GUI; however we discuss that there is a battery status tab in Smart Factory -- see lines 306-307.**   
  
6. With the recent case of data privacy protection in Europe, authors may consider to highlight the protection to ensure safety and privacy in storing a person's personal location data. **Thank you for this comment. We discuss protecting subject data with a key located on a secure server behind a firewall on a locked computer. We also bring attention to the idea of remote monitoring and the protection of human subject data and running the project though the institutional review board. Finally, we discuss how the x and y coordinates cannot be linked to a city/town, area, person, etc., lines 247-250 given that subjects have a unique ID.**  
  
  
**Reviewer #2:**  
  
Authors of the manuscript stated they discuss the use of a RTLS that measures walking activity and also gait quality and balance ability measures on older adults with cognitive impairment. Unfortunately, numerous systems have been developed, in the past few decades, to monitor human activities using RFID, UWB, Wi-Fi or Ultrasound, and so on. I am sorry I didn't find any novelty in the manuscript. Only a system has been described, which can be used to measure cognitive impairment, gait and balance.

**Thank you for this observation. There is heterogeneity in the RTLS field and multiple systems may theoretically be used for these purposes. However, the majority of these are engineering exercises which have never been field tested much less have made it to market, hence the paucity of longitudinal studies of human movement variability and its evolution over time.  Being able to monitor a single person in an enclosed space using Wi-Fi for a period of a few days is several orders of magnitude simpler than recording 50 individuals simultaneously for a period of 1 year. The logistics in terms of maintaining data flow and quality control, ensuring that noncompliance with protocol is corrected amicably not to mention the near real-time analysis and translation of findings for publication on an expanding body of information dwarf simple issues related to a laboratory demonstration of feasibility.  The choice of the Ubisense system was based upon several considerations, not the least of which was that it is in widespread use in industrial settings with proven reliability – 99.99 uptime.  While the system has been used to monitor worker productivity (BMW, Airbus, Aston Martin, Caterpillar and the petrochemical industry) its use as a practical tool for accruing longitudinal behavioral data on persons with mental health conditions, for example dementia, traumatic brain injury and the study of autism spectrum disorder is indeed quite novel.  Based on this comment we added information on the RTLS using UWB to measure walking activity compared to other infrared, RFID, or other systems. Please see lines 80-100 and also where we discuss limitations, lines 445-464.**

Additionally, I think it is not proper to contain abbreviations (e.g., RTLS and CI) in the Abstract. **Thank you, we have updated the abstract.**

**Reviewer #3:**  
  
First off, I think that the way the protocol is presented makes it really difficult to replicate in settings that may slightly differ from the one used (including tools). From reading the title "Using a real-time locating system to measure the walking activity of institutionalized older adults", it seems that I could use \*any\* RTLS to compute older adults' walking activity. This is far from the truth. As is, the paper describes a procedure on how to obtain walking activity with a particular proprietary technology i.e., Ubisense's RTLS. From the images and detailed click-by-click instructions, should one use a different version of the Ubisense software, not to mention other positioning system, this procedure could not be easily replicated.

**Thank you for these observations. There is heterogeneity in the field of RTLS technologies – and theoretically various systems and technologies may be used to track wandering behaviors. For example, there is the ultra-wideband (UWB) solution, which Ubisense, Inc., OpenRTLS, Inc. and Zebra, Inc. use, infrared + radio frequency, ultrasound and machine vision systems. However, this project requires a tracking technology that is small and unobtrusive, wireless, capable of wide-area tracking, with no line of sight issues and accuracy to within 20cm and there are few (if any) other systems that fulfill these requirements. For example, infrared + radio frequency technology relies on creating “zones” which detail when a person passes through them, but is not specific enough to determine wandering behaviors except within a meter or two, which is far too gross for these purposes. That is, though we would understand when a person crossed from one zone to another (for example, room to room), we would not have the precision to understand what happened in that room – how many miles walked, time spent walking, etc. Ultrasound and machine vision have  issues with identification and reflections and machine vision systems have good resolution but cannot differentiate subjects without resorting to using an RFID tag to make up for the inadequate capabilities of current AI. With UWB, the Ubisense system has a wider range and spatial resolution on the order of 20cm, versus 1 meter or more for other systems making it the most precise. Thus, smaller “zones” are available for study much in the sense that a stronger microscope makes more phenomena available for investigation, and all activity patterns are captured, making it ideal for the measurement of wandering behaviors. The system is also quite stable, having been designed for 24/7 industrial applications that are mission critical. For these reasons, the Ubisense system has been used by other researchers and clinicians where precision is essential – to prevent and predict falls, to assess dementia and changes in cognition – in a wide variety of settings -- assisted living, hospital, nursing homes, and rehabilitation units. While the Ubisense software evolves as all software must, the basic features of the system, and properties are consistent over time – e.g., the gathering and graphic representation of raw location data, generation of spatial maps and administrative processing of tracking tags. Please see lines 80-100 and also where we discuss limitations, lines 445-464.**

Second, although I agree that is important to acknowledge and describe the tools used, the Ubisense system in this case. In my view, a method should not necessarily be coupled with a particular proprietary technology, software, or tool. I would have loved to see a more abstract description of the steps shown in the paper, that can be applied to any accurate enough RTLS.

**We have reduced the discussion of the proprietary technology throughout the MS and made our discussion more abstract as recommended here and by the editor. However, as discussed in the comment above, the Ubisense system is currently the solution for the precision level needed and is used across health care environments and so we maintained the specific hardware and software components clinicians and investigators would need to install and utilize this system.**

Third, there are not enough details as to how to implement the protocol. In my view, this protocol relies too frequently on the company's workers skills, availability, and expertise e.g. "Work with Ubisense to establish an appropriate tag update rate." Or "Work with Ubisense contractors who will install the appropriate number of sensors required for the facility layout and calibrate all sensors for accurate location tracking". In a research protocol, in order to properly replicate results, it is my belief that this should not happen. Also, related to this, in the section called "Using a Real-Time Locating System (RTLS) to Measure Physical Activity and Wandering", more details are needed in Step 1 as to how the facilities will be ultimately \*adequately equipped\* with sensors. The paper currently reads "Ensure the facility is adequately equipped with enough active Ubisense sensors (see Figure 1)". How many are enough? What is adequately? The authors mention in no few occasions to rely on the Ubisense contractors, but again, I think this should not be the case.

**Thank you for this comment. We agree, and have removed the contractor pieces. We have also added multiple detailed sections throughout the MS entirely focused on installation, calibration, setting up the software, and so forth. There are several installation methods: have a member of the scientific team receive training, use a contractor, work with facility management/building engineers, or some combination thereof. For this revision we provide enough detail that a member of the scientific team could get the system up and running with minimal support. We also address what we mean by "adequately equipped:" For a typical communal area in a long term care facility (about 10m x 13m or 1,000 square feet) four sensors are needed. These sensors could cover a larger area but this is depending on the environment – e,g., walls and glass partitions in the area which may have an impact on transmissions. Please see lines 130-134.**

Finally, there are steps that look more like pragmatic, anecdotic advice during the operation of the RTLS or during the implementation of it, which can be unrelated to a research method, but rather to issues with sensors or software from Ubisense (e.g., steps 11-14, Discussion), or to the users' behavior (e.g., having their tags soaking wet). Related to this, I think that some steps read like practical advice from users who have already implemented and perhaps struggled with some of those issues. For a novice, trying to implement this protocol, some questions may arise. For instance, at some point, there seems to be that some subjective criteria used. For instance, in the REPRESENTATIVE RESULTS section, authors state: "To ensure data are adequately smoothed, run several GIF files on resident travel over the course of a few weeks and visualize their walking activity." How the observer \*knows\* when a path has been adequately smoothed?

**We revised our discussion of smoothing as this is an important step in the analysis process. There is a default noise setting provided during installation/set up (see lines 192-198) and we provide these instructions in this revision. We also added more specifics on the smoothing accomplished after data are collected -- using a 5-second moving average time window (based on time provided in x and y raw data coordinates) and a threshold of 0.7m of movement (based on location provided in x and y raw data coordinates). This creates a stable series of coordinates, resembling the observed resident walking activity. To manage the jumps in data, when computing a day’s motion, only accrue distance and time (and path data) when time between points is less than 30 seconds.” This provides the formula to ensure data are representative of the resident’s actual activity and not jumps. See lines 271-276.**

Minor Concerns:  
- In step 8.1, the authors refer to "custom algorithms in Python and PHP" for smoothing older adults' paths, which are not shared. **We revised the smoothing discussion, please see lines 271-276.**- There are a few mistakes (or so they seem) in the numbering of consecutive steps e.g., Step 3 and then 4.1, and Step 6 and then 7.1. **Thank you, this has been addressed.**   
- In Figure 3's caption, there seems to be a mistake in the writing. From the paper: "The Location Engine Configuration program, sensor and cells tab. This is used ensure the system is recording events (e.g., tag/resident location and movement)." **The Figure 3 caption is correct.**  
- I would have loved to see more detail (or perhaps in an ordered fashion) about the formulas used to compute walking activity and related variables. **Please see lines 287-295.**

- Although by the end of the paper, it is clear that there is link between CI, the use of the RTLS, and other aspects of interest such as wandering or gait, this is not immediately clear at the beginning of the paper. What I mean by this is that, from what I could read, RTLS is not the \*only\* instrument needed to make a distinction between wandering and physical activity, for instance, but you need to measure their cognitive status using the Montreal Cognitive Assessment (MoCA). The RTLS in its own cannot be used to identify wandering behaviors. Similarly, with gait quality and balance, the Tinetti Performance Oriented Mobility Assessment (POMA) is needed, and this is based on annotations by a trained observer. **Thank you for this comment. We use additional paper and pencil tools to measure cognitive impairment level, gait and balance to better understand risk profiles for this project. Wandering behaviors are associated with fatigue and falls. Many older adults who wander already have poor gait/balance – but when coupled with wandering and fatigue this becomes even more pronounced. We introduce this idea in lines 97-100 and discuss gait and balance in terms of key factors associated with falls. We also point to the literature that has utilized a RTLS to measure cognitive impairment (e.g., Kearns, Nams, Fozard, 2010), gait and balance, alone and with paper and pencil tools (as this study does). Also, see lines 373-380 where we provide correlations between these measures.**