Confronting Common Assumptions About the Psychomotor Abilities of Older Adults Interacting with Touchscreens

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Abstract. This paper confronts commonly-made assumptions about older adults and their general levels of capability when interacting with technology by reporting from an evaluation involving 49 older adults (M = 81 years) where performance was studied during task solving on a touch-based interface. The tasks involved were derived from a set of corresponding psychomotor abilities that are commonly involved in interaction mechanisms associated with touchscreen devices: precision, steadiness, dexterity, speed, and coordination. The evaluation consisted of measuring the performance of participants as well as having them assessing their own performance. To provide empirical results on why it is argued that it can be dangerous to assume anything about the capabilities of older adults, multiple analyses of the gathered data were used to highlight individual, group-related, and general patterns. Important relations, levels of variance, and statistically significant effects are highlighted as the paper argues for how these particular results do not align with common assumptions. The discussion draws on both the empirical results as well as related research to advocate why designers should acknowledge individual capabilities to ensure maximized performance when designing enabling technology for older adults.

Keywords: Older adults · Touchscreens · Psychomotor abilities · Performance Enabling technology

1 Introduction

As the body grows older, the psychomotor abilities usually involved in interaction with enabling technology [1, 2], such as dexterity and steadiness, often tend to deteriorate [3]. The impact of age on the ability to execute precise and coordinated movements can manifest itself in different ways, e.g., inaccuracy or nonlinearity. This has been particularly evident in studies on tracking using a computer mouse, e.g., in [4]. However, a wide range of enabling technologies for older adults relies on interaction mechanisms that assume specific psychomotor skills in the hands and fingers of the users. This has been particularly prevalent in the many new digital and non-digital equipment found in care facilities in Norway [1].

This paper aims to challenge common assumption made about the capabilities of older adults. More specifically, five distinct psychomotor abilities commonly used in

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interaction mechanisms associated with touchscreens, e.g., during swiping or pinching, have been evaluated with 49 older adults ($M = 81$ years) and 20 younger adults in a control group. Our goal is not to compare older adults to younger generations, but rather to produce empirical evidence that supports our argument of why "solutionist" strategies [5] that consider all older adults as equal does not utilize the full capabilities of the user and does not realize the full potential to facilitate enabling interaction. As such, we report from an evaluation of self-assessment and measured performance during task solving of five tasks derived from a set of five corresponding psychomotor abilities, namely precision, steadiness, dexterity, speed, and coordination.

The results and analyses suggest that there is a high degree of variation in the capabilities and premises for interaction between the participants and that while older adults might not perform at the level of younger users, they still inhabit the potential to perform at near-perfect levels if provided with the appropriate interaction mechanisms. Multiple analyses studying statistically significant main effects are used to discuss the implications of observed variations. We also argue that the presented results demonstrating individual, group-related, and overall variance can challenge prevailing assumptions about older adults and their capabilities when interacting with touchscreens.

The findings presented in this paper are part of a broader research effort focusing on understanding more about older adults' capabilities when interacting with enabling technology [1]. While this paper concentrates on touchscreens, we bring in prior experience related to older adults and the use of psychomotor abilities to assess capabilities (from, e.g., [6]).

2 Related Work

This paper draws on past research from mainly HCI-related research communities as the focus is to report from an evaluation of common assumption made about older adults, their capability levels, and their readiness towards touch-based interfaces in particular. As such, most of the literature presented in this section addresses relevant topics found in the intersection between older adults and interaction with touchscreen devices. We also refer to results from our overarching research efforts to contextualize the presented results.

2.1 Studies on Psychomotor Abilities of Older Adults Using Touchscreens

Wood et al. [7] study the pattern of performance across interfaces for older adults. Their findings suggest that touchscreens may be challenging or inappropriate for activities requiring continuous contact when considering physical strain. The use of psychomotor abilities during assessment touches upon highly relevant issues, e.g., the study of the finger and motor dexterity during task-based evaluation. One of the input devices studied in [8] was touchscreens with finger input and their results on usage frequency provides a perspective on the breadth and depth of said technology. Caprani et al. [9] discuss several types of challenges such as psychomotor and physical challenges due to arthritis or stroke. Their research points to several challenges with touchscreen devices, e.g., difficulties with tasks requiring precision, speed, or positioning. The paper also raised interesting points on strategies and considerations for designing for disability, e.g., the challenge of adequately assessing and recruiting representative users. Rogers et al. [10] report from two experiments involving among others older adults performing tasks on both a touchscreen and a physical rotary encoder. There are interesting observations, statistically significant main effects, and experienced challenges reported in their paper. They also indicate that there was a deviation between expected patterns of performance and actual measured performance. In a related study, Pak et al. [11] also discuss the usability of touchscreens as an input device in the context of older and younger adults, and they also report results on performance. Other research inquiries have also studied the fit of the touchscreen in the context of older adults and smart homes, e.g., [12]. They raise pressing concerns such as how psychomotor challenges like tremor may affect both performance and perception of touch-based interfaces. The use of tablets to discuss touch-based interaction was also the case of [13] where senior citizens were guided through a series of tasks during an evaluation of performance on an iPad. Doyle et al. [14] present results from a long-term usability assessment of a touch-based communication device and the participants' attitude towards technology.

In [15], the author discusses direct, gestural input via multimodal touchscreen devices for older adults. In the proposed research outlining relevant lines of inquiry, several of the objectives are of relevance to this paper, for instance, ambidexterity issues when interacting with touchscreens or adaptations necessary due to motoric challenges such as arthritis or Parkinson's disease. Also in [16] do we see a study on benefits of multimodal interfaces tailored for older adults. Also [17] reports on the suitability of touch-based interfaces for older adults in the context of everyday life activities. Their results are anchored in user experiences of the users as they highlight the perceived experience of use. While their focus is not particular scoped to psychomotor abilities and related challenges, they do emphasize that physical changes, for instance, impaired motor skills, can make the use of certain types of technologies difficult. The authors of [18] present a study on tremor patients and their interaction challenges and opportunities with screen-based interfaces. Their target demographic includes older adults as tremor is considered a prominent trait associated with aging. They also emphasize the importance of acknowledging psychomotor abilities, in this case, fine motor skills, when assessing interaction opportunities. Specific examples such as frictional resistance are provided to highlight the relationship between abilities and appropriateness of different types of interfaces.

Other relevant studies include design recommendations suggest for touchscreens in the context of older adults [19]. Their emphasis on psychomotor abilities, for instance, manual dexterity, is highly relevant to the evaluation carried out in our study. They also conclude by stating that even design guidelines need to adapt design choices (e.g., the size and spacing of interface elements) to the abilities of the target demographic. Another study pointing out the lack of understanding of older adults and attempting to offer informal guidelines for the design of senior-friendly interfaces is [20]. Their main hypotheses answer interesting questions such as older adults' easiness of use when operating touchscreens and challenges with gestures such as pinching. Interaction mechanisms associated with touch-based technology, e.g., tapping, dragging, and pinching, are discussed in the paper and follows the same understanding as we adopted when designing the tasks for our evaluation. Page [21] also describes experiences with specific tasks such as navigation in the context of touchscreen and senior users. Another similar study on touchscreens and optimal reference levels is [22]. Chen et al. [23] also study interface accessibility and usability for older users with different backgrounds, including a range of physical challenges. A literature review found in [24] on older adults using touchscreen also contains relevant findings and recommendations on motor impairment and touchscreen interaction, e.g., arthritis. They highlight task types used during trials and experiments, typical interaction gestures, and data collection strategies.

3 Research Method

3.1 Empirical Context

This study reports from an evaluation of performance that was conducted at a local care facility in Oslo, Norway. More precisely, the evaluation consisted of a self-assessment and measured performance as older adults and a control group solved five specific tasks derived from a set of five corresponding psychomotor abilities. The evaluation initially consisted of four groups of 20 persons each. One of the four groups constituted the control group while the three others were experimental groups with representative users from the target demographic. The control group was used to indicate a comparable level of expected performance from a fully functional user for later analyses. The group consisted of faculty, Ph.D. candidates, and master students within the field of Interaction Design or Human-Computer Interaction. We conducted no pre-evaluation assessment of physical condition or psychomotor challenges, and the older adults were only spread across the three experimental groups based on gender to counteract any heavily skewed distributions of participants as the participant pool included 30 women and 19 men. The average age of the participating older adults was 81 years. However, several participants from the three experimental group were ultimately unable to attend due to health concerns or other commitments leaving the total number of participants at 69 out of which 49 were representative users. The final number of participants in each group is outlined in Table 1 below. While the sample size of older adults in this study is limited ($N = 49$), all participants were recruited from a more extensive study on enabling technology for older adults involving 542 participants (M = 83 years) [1]. The results presented in this paper align with previously discovered limitations and opportunities among this demographic, for instance, the prior findings on psychomotor abilities discussed in [6].

Table 1. Overview of groups, number of participants, and distribution of age

Group	Participants	Age distribution
Experimental group 1	16	72–83 ($M = 77.9$, $SD = 3.44$)
Experimental group 2	18	71–87 ($M = 79.2$, $SD = 4.38$)
Experimental group 3	15	78–89 ($M = 83.6$, $SD = 3.20$)
Control group	20	24–44 ($M = 32.7$, $SD = 6.07$)

3.2 Selection of Psychomotor Abilities and Tasks

The evaluation comprised five assessments of psychomotor abilities in hands and fingers: precision, steadiness, dexterity, speed, and coordination. These five abilities used to structure the evaluation were all borrowed from Fleishman's taxonomy of psychomotor abilities and skills [25, 26]. *Precision* refers to the ability to move and quickly repeat exact positions and tasks; *steadiness* refers to the ability to suspend the hand in air while moving; *dexterity* refers to finger dexterity (as opposed to manual dexterity) and the ability to make skillful movements with the fingers; *speed* refers to wrist-finger speed and the ability to quickly repeat movements; and *coordination* refers to the ability to coordinate movements when the body is not in motion. All these descriptions are based on the original taxonomy of Fleishman [25].

These five particular abilities were selected due to two main reasons: firstly, they allowed us to map common interaction mechanisms associated with touch-screen devices (e.g., drag-and-drop and swiping) back to one distinctive psychomotor ability; and secondly, they had all been previously used as a part of a similar study involving evaluation of psychomotor abilities [6]. We do not claim these five abilities to provide a holistic or definitive representation of psychomotor capability of older adults. However, we argue that these five factors in conjunction can indicate patterns of limitations and support a discussion of common assumptions about older adults interacting with technology. This particular study focuses on screen-based technology, but our past research efforts have concentrated mainly on tangible interaction and physical devices (see, e.g., [1]). Thus, the intention of expanding explored and evaluated technology is to further complement our general understanding of what we can expect from older adults' capabilities regarding readiness towards enabling technology.

During the evaluations, each participant performed a set of five simple tasks involving independent and coordinated movements and gestures that were calculated to a performance score ranging between 1 and 10. Each task mapped back to one of the five psychomotor abilities. The task order was also randomized to avoid learning effects, and each task relied on specific metrics to assess the performance of the participant. Table 2 gives an overview of the involved tasks, a brief description, and related evaluation metrics. The rightmost column indicates the level of performance required to achieve a perfect score of 10. The level of this upper bound was intended to represent the expected performance of a fully functional user and was calculated using the weighted average performance score of the 10 participants in a pilot evaluation. The goal of this pilot evaluation was to run through the test procedure as well as to help us normalize the difficulty of the tasks and determine the upper bounds. These 10 participants were recruited through similar means as the control group and consisted mostly of faculty, Ph.D. students, and master students. As such, the automatic calculation of performance required us to first evaluate the tasks with the pilot group without any upper bound. All performance scores for the participants in the pilot group were mapped post-evaluation once their weighted average scores were calculated. Their results are not included in this paper, but a paired sample t-test did not reveal any statistically significant difference from the performance of the control group.

Table 2. Overview and description of tasks, metrics, and upper bounds

Task/ability	Task description	Evaluation metric	Upper bound
Navigation and selection *(precision)*	Select a specific option from a set of selective menus such as drop-down bars without making wrong selections	Completion time in seconds and number of errors traced with mouse/touch events	Completion time of fewer than 10 s and maximum two errors
Reproducing hand positions *(steadiness)*	Reproduce a set of hand positions and swiping movements in front of the screen with minimal trembling	Tremble factor (0–1) decided by shaking and rapid movements traced using Leap Motion	Tremble factor of less than 0.85
Mimicking finger movements *(dexterity)*	Reproduce a set of three finger movements mimicking movements associated with pinch and zoom gestures as exact as possible	Mimic factor (0–1) decided by reproduction precision traced with Leap Motion	Mimic factor of 0.85 or above across all three finger gestures
Reaction *(speed)*	Click on the correct option among randomly appearing icons and dialogue windows as fast as possible	Reaction time in seconds and number of errors traced with mouse/touch events	Reaction time of fewer than 5 s on average and maximum one error
Drag-and-drop *(coordination)*	Drag a specific icon into a designated area without colliding with adjacent objects	Placement accuracy in relation to origin measured with percentage-wise deviation and dragging accuracy measured with number of errors	90% accuracy and maximum one collision error

In addition to the automatically calculated score based on performance, each participant was also asked post-completion to assess their own performance on a scale from 1 to 10. The intention with this self-assessment was to study the relationship between the self-perception of the users' performance and their actual performance, hence using a similar scale as the automatic calculation of performance score for a more natural comparison. The rest of the paper will refer to these two measurements as the *self-assessment score* and the *measured performance score*, respectively.

3.3 Testing Devices

The web-based system permitted assessment of performance independent of device or operating system, which in turn allowed us to offer all participants a selection of three compatible devices: a 9.7-in. 3rd generation iPad running iOS; a 10-in. Samsung tablet running Android; an 11-in. custom tablet running Windows. The custom tablet was pre-installed in the homes of most participants at a local care facility as part of the municipality's welfare technology initiatives and was used to offer residents social and recreational services. These three tablets helped us further reduce the statistical significance of any learning bias, familiarity challenges, or issues understanding the basic modes of operation. Figure 1 presents a screenshot from the web interface used during the evaluation on the left, and a photo from the empirical context where the evaluations were performed on the right (photo by C. Haug and F. H. Kvam).

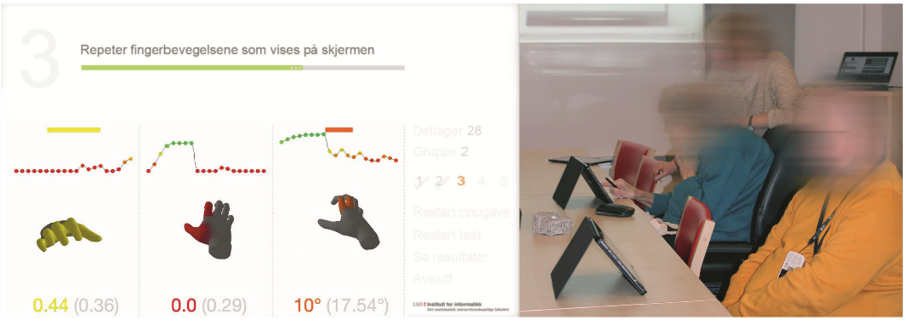

Fig. 1. Screenshot of the web interface on the left and the empirical context on the right

4 Results

The purpose of the evaluation was first to identify a general level of expectancy of both self-perception and actual performance for older adults using psychomotor abilities as the unit of measurement and then later study group-related and individual variances. Thus, the results are reported in chronological order following the same sequence in which the various analyses were carried out.

4.1 Analyzing Average Scores for Self-assessment and Measured Performance

The first set of results we present is the examination of score distribution for each of the two sets of scores independently. This is intended as a general, descriptive depiction of the average trends between the control group and the three experimental groups. As the values indicated a difference between the control group and the experimental group, the descriptive statistics reported in this paper will mainly focus on separate analyses. Table 3 below presents two independent sets of univariate analyses of self-assessment and measured-performance, respectively. It should also be noted that while each of the three experimental groups was spread across the whole scale from 1 to 10, either in self-assessment, measured performance or in both, the control group had a minimum value of 4 and a maximum value of 10 for both types of measurement. A z-test for mean scores of self-assessment confirmed a statistically significant difference ($z = -11.103$, $p < .001$, two-tailed) when comparing all samples from the experimental group ($M = 5.420$, $SD = 2.319$) to the control group ($M = 7.880$, $SD = 1.647$). A similar comparison of measured performance ($M = 5.408$, $SD = 2.337$; $M = 8.010$, $SD = 1.521$) yielded a similar difference ($z = -12.207$, $p < .001$, two-tailed).

Table 3. Overview of groups and the descriptive statistics for the two sets of scores per group.

Group	Measurement	Mean	N	Std. Dev.	Std. Err. Mean
Experimental	Self-assessment	5.42	245	2.319	.148
	Measured performance	5.41	245	2.337	.149
Control	Self-assessment	7.88	100	1.647	.165
	Measured performance	8.01	100	1.521	.152

A factorial analysis of variance was performed *(group x ability)* for self-assessment and measured performance scores. Figures 2 and 3 present the estimated marginal means for these two sets of scores. Beginning with the self-assessment, the results revealed multiple main effects worth presenting. First, there was a statistically significant main effect for the groups, $F(3, 325) = 31.994$, $p < .001$. This suggests that the null hypothesis does not hold. Second, there was also a statistically significant main effect for the type of test, i.e., which ability that was tested, $F(4, 325) = 5.876$, $p < .001$. For the measured performance, the patterns were similar. There were statistically significant main effects for both groups and type of test: $F(3, 325) = 39.352$, $p < .001$ for groups and $F(4, 325) = 12.152$, $p < .001$ for the ability being tested.

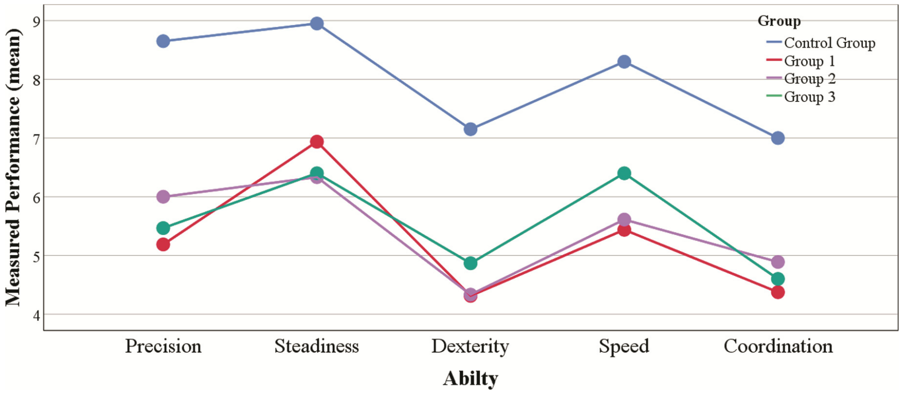

Fig. 2. Estimated marginal means for measured performance

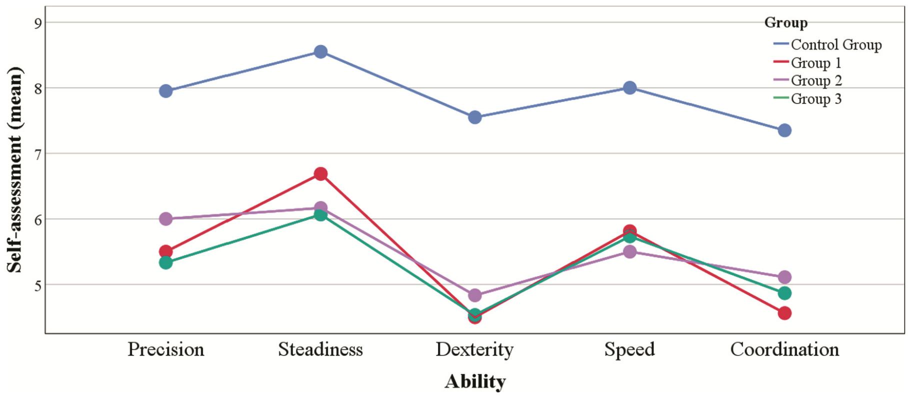

Fig. 3. Estimated marginal means for self-assessment

As reported previously with the z-test scores, the control group held a higher average score for both self-assessment and measured performance. While the control group in total only constituted 29% of the total participants, due to withdrawals amongst the older adults, they ended up as the largest group with 20 participants. Thus, when pairing each of the four groups, the better average score in the control group for both self-assessment and measured performance results in main effects for the group. If we isolate the three experimental groups, there is no longer a statistically significant main effect for groups for neither self-assessment nor measured performance. Levene's test for equality of variances was found to be violated for both sets of analysis, with $p < .05$ for self-assessment, and $p < .01$ for measured performance. A post hoc analysis using Bonferroni confirmed two essential factors. First, the control group statistically significant difference in both sets of scores against all the experimental groups. Second, none of the experimental groups showed any statistically significant difference against each other in the post hoc analysis.

To remain in line with the outlined topic of this paper, i.e., common assumptions about older adults and their psychomotor abilities, the rest of this result section will focus on comparing the control group against the whole experiment group as one. It will also look at the participants' individual scores when analyzing the effects of the abilities on performance.

4.2 Observing Gaps in Perception and Performance

The second set of results present inferential statistics on the relationship between the two score sets. Figure 4 shows a scatterplot of the relationship between the self-assessment made by the participants and the corresponding mean levels of measured-performance. The increased color intensity suggests a higher frequency. A test for Pearson Correlation confirmed a strong relationship between the two sets of scores ($r = .829$), indicating that an increased self-assessment would most likely also result in actually increased performance. For both groups, we saw a positive covariance (4.298 for the experimental group and 1.712 for the control group). While we do not find best-fit regression lines particularly relevant to our overarching research interest, the r^2-levels were also calculated: r^2 = .482 for the control group and r^2 = .634. One immediate conjecture about why we can account for a higher level of variability in the case of the experimental group would be that the overall sample size was more substantial and the spread of data points was more distributed. However, further analysis revealed another interesting relation: the experimental group saw a smaller gap on average between self-assessment and actual performance, i.e., they had a smaller distance on average between the self-assessment and the actual performance for each task performed. Thus, it is possible to speculate whether a more realistic understanding of own performance caused some of the differences in r^2-values.

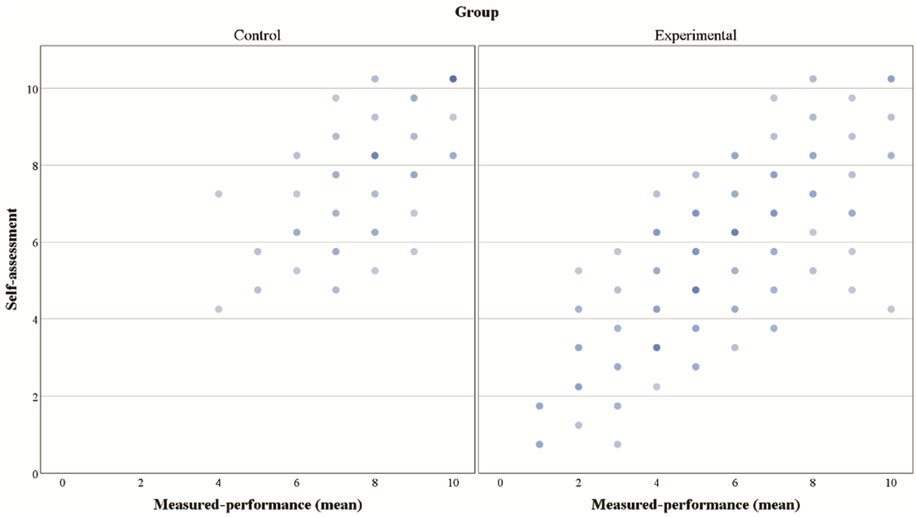

Fig. 4. The plotted relationship between self-assessment and measured performance

To investigate this further, the average difference between self-assessment and measured performance was calculated for each task for each participant. For the experimental group, the average difference between these two values was $M = 0.012$ ($SD = 1.486$), while it was $M = -0.130$ ($SD = 1.244$) for the control group. This result suggests that the older adults in the three experimental groups were marginally better at assessing their actual performance than the control group, albeit with the caveat of a smaller sample size for the control group. When only accounting for the largest discrepancy for each participant across all five tasks, the difference between the groups increased as the new mean values were $M = 0.100$ ($SD = 2.160$) and $M = -0.796$ ($SD = 2.150$), respectively. Only on a few occasions did the older adults overestimate their own performance (i.e., a positive difference between self-assessment and actual performance) while the over-estimation frequency was comparatively more common within the control group. Thus, we attempted to understand the causality of this difference by examining the particular intersections of groups and abilities tied to each task. When looking closer at the tendencies across both groups and abilities, there was not enough data to conclude with any directional difference between self-assessment and measured performance. This means that while the overall tendency suggests that the older adults may be better at not over-estimating their actual performance, there are no guarantees when examining a particular ability. This is illustrated in Fig. 5, where the interpolation line suggests a correct estimation, or an over- or underestimation.

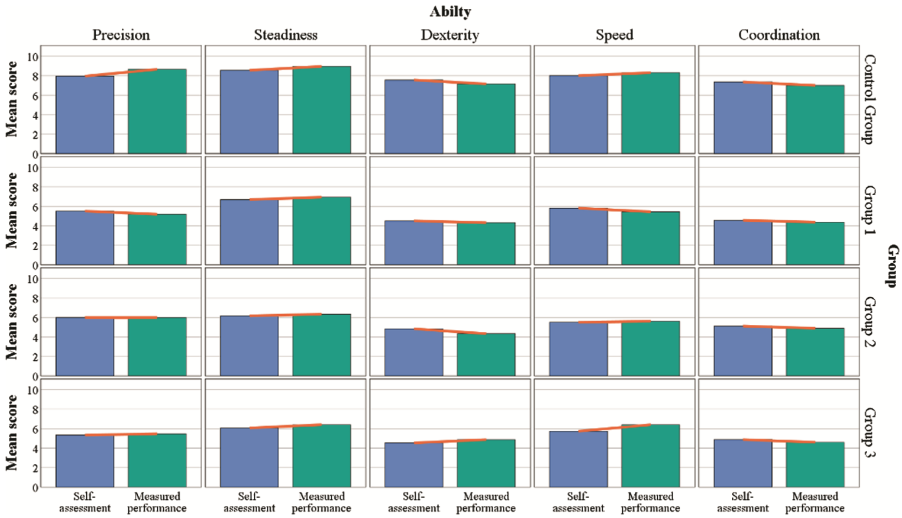

Fig. 5. The mean scores for self-assessment and measured performance *(ability x group)*

We see from the figure that for the control group, the self-assessment was only higher than the actual performance on two occasions, during the test of coordination and dexterity. As we have seen previously, these exact two tasks yielded a noticeable lower average score across all group. Only in one of eight rounds of testing did a group on average not overestimate their own performance for these two tasks (*dexterity x group 3*). We also see how all groups, including the control group, overestimated their performance for coordination, despite this not being neither particularly tricky nor straightforward if measured by mean score and standard deviation. As such, the data does not suggest any relationship between over- or underestimation on the one hand, and the difficulty level of the task on the other.

4.3 Investigating the Role of Psychomotor Abilities on Measured Performance

While we discovered early that the older adults were unable to maintain measured performance score at the average level of the control group, we continued our study by examining the performance scores across the five tests to assess their significance. Figure 6 illustrates both self-assessment and measured-performance scores for the five types of abilities tested.

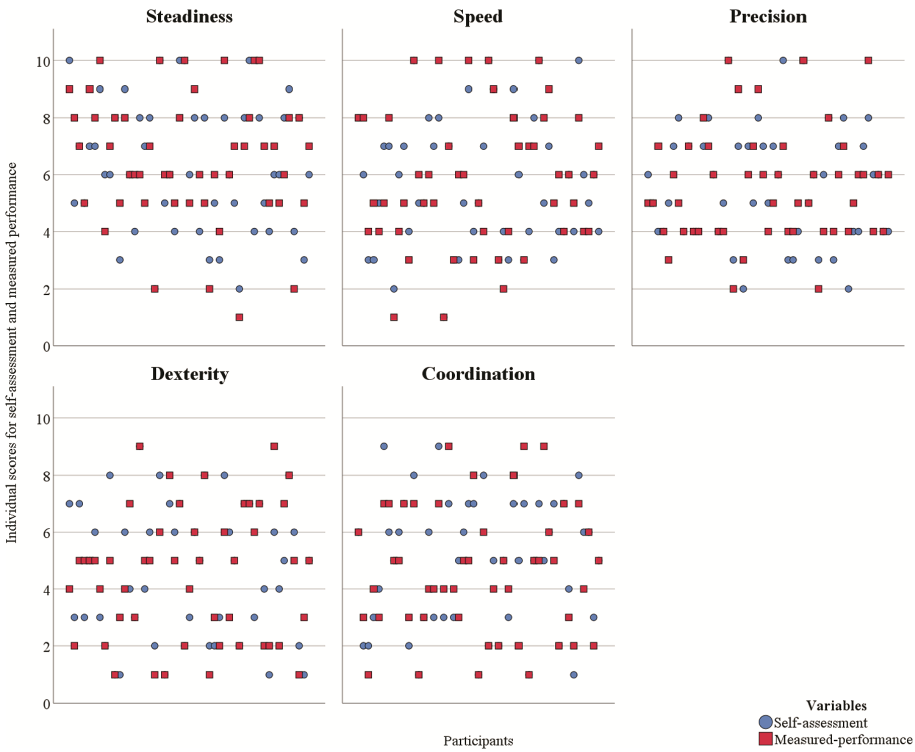

Fig. 6. All individual levels of self-assessment and measured performance across all abilities

An analysis of variance *(participants x ability type being tested)* showed a statistically significant main effect for the types of ability being tested, $F(4, 240) = 7.235$, $p < .01$. A Bonferroni post hoc analysis indicated that the two tasks testing dexterity ($M = 4.490$, $SD = 2.283$) and coordination ($M = 4.633$, $SD = 2.243$) yielded a clearly lower measured performance score than the rest. When compared against the highest-yielding task, steadiness ($M = 6.551$, $SD = 2.227$), the main effect was statistically significant at a .01 level. The rest of the comparisons were non-significant even at a .05 level.

If we zoom in on the results pertaining to one of the abilities, we can identify additional patterns that are relevant to the overarching topic of this paper. For instance, the ability coordination yielded a lower score than the average for both self-assessment and measured performance. However, this deviation was not due to consistent patterns of a lower level of performance. If we study the individual assessment and performance, we can see from a frequency table (as well as from Fig. 6) that there were multiple occurrences of extreme results in both directions – for both self-assessment and measured performance. Four individuals only scored 1 point, and there were also individuals who scored 9 points. As such, it is hard to comment on the expected performance without zooming into the specific ability required to complete a task and the particular individual doing it. Along with dexterity, coordination was also the only task with a statistically significant main effect of ability being tested when isolating the control group. Thus, these tasks can be considered relatively more challenging.

We do not have the appropriate data to analyze whether it was the ability being tested or the difficulty level of the task itself that caused this consistent pattern, but what we do have sufficient data to comment on is the extremities. Even for tasks that were both perceived and measured as relatively more laborious tasks, e.g., coordination, the experimental groups still saw participants both assessing and performing at near perfect levels (with a score of 9). For relative straightforward tasks such as steadiness, there were still low-performance scores registered (e.g., four instances of a score 2 or lower for measured performance). Thus, the data does demonstrate the challenge of assuming abilities of older adults in either direction. A final analysis of participants' performance pattern across these five tasks (that were presented in randomized order) did not reveal any statistically significant patterns of performance that would indicate causality between task order and performance.

5 Discussion

5.1 Searching for Causality by Unpacking Individual Performance Scores

From the first set of results (Figs. 1 and 2), we see that it is easy to conclude that older adults perform at a relatively lower average level and that downgrading any and all expectations regarding capabilities may seem like a viable strategy. Responding to the challenge of designing enabling technology by assuming a reduced capacity across cognitive, sensory, and motor capabilities for the whole demographic of older adults can be one approach [27]. Our goal is instead to remain positive and look for patterns that may suggest new lines of inquiry not building on disabilities but rather capabilities [1, 6].

The control group performed better than the older adults on average with higher minimum values for both self-assessment and measured performance. However, the control group represented a younger and more technology-oriented user group, and the comparison was not intended as a generational analysis (as seen in, e.g., [8, 10, 11]), but rather to have participants representing fully functional users for later comparison. This was important to study if older adults managed to perform well at specific tasks, but also to investigate how close they could potentially get to an optimal level of performance if presented with the right interaction opportunities.

Once we unpacked the individual performances in the last analysis (Fig. 6), we saw how participants were able to perform at the level of the control group if presented with the right type of interaction mechanism. There are empirical studies suggesting that touchscreens can yield positive experiences (e.g., [13]), but we argue that the correct order is to adapt the technology to the capabilities of the user rather than assuming anything about the users' expected performance. There are enough studies pointing to the effects motor impairment can have on interaction opportunities (e.g., [7–9, 18, 19]), and we have previously argued that this change in capability should be seen as an opportunity to shift the way the technology is presented rather than just summarizing it as a decline [1]. This study has demonstrated how performance varies with interaction mechanisms rather than with the touchscreen as an interface itself. Hence, we argue that there are many opportunities to remain on the same interface at a proficient level if the technology allows the users to adjust their interaction to their changing capabilities. Adaptation of technology has also been extensively discussed in prior studies, e.g., in [20, 24, 27].

5.2 Isolating Psychomotor Abilities

We want to stress that the results presented are not intended for the medical technology community, nor did the evaluation follow the same level of clinical practice for testing [28]. If compared to past studies, the average age of the older adults in this study stands out. However, our study is not without weaknesses regarding the strength of the results. One factor ignored was time, learning, and adaptation [14]. The study in [10] collected more detailed data points than most of our study did. For instance, we only had the same level of precision for time *(ms)* in the two tests using tracking with Leap Motion (steadiness and dexterity). Another important factor not addressed in this paper is how cognitive deficiencies may influence performance. Past studies have emphasized the role of cognitive deficiency in terms of reduced ability to interact with touchscreen [7, 9, 10, 12, 21, 24, 29]. All our tasks were also created to solely address psychomotor-related challenges. To minimize the chance of any severe cognitive issues, all tasks were intended to be single-purpose, short, and simplistic. However, we do emphasize that this study does not attempt to study effects of cognitive challenges as discussed by [10], who, for instance, considered working memory when designing instructions for activities.

The selection of tasks was revised several times and later polished during the pilot evaluation, but the means of measure may have been influential in terms of observed results. The point of a high degree of variance performance, e.g., captured through movement time, among older adults was also made by [10]. It should be noted that the post hoc analysis did not reveal any statistically significant difference between the three experimental groups, which does suggest that it is most likely the overall sampling rather than the distribution of participants into groups that should account for most of the observed variance.

Furthermore, our goal was also to allow everyone to join without any screening test (as seen in, e.g., [10]). Nor did we try to control variables like age differences, technological experience, or specific disability that could reduce the variance as proposed by [16, 20], or as we have done ourselves in past research [6]. However, this decision naturally challenges the "representativity" of the participants [9], but in our opinion, it simultaneously gives a more realistic expectation to those that consider "older adults" to constitute an appropriate scoping in terms of target users.

5.3 Reduced Performance Does not Equal Reduced Self-perception

The relationship between self-assessment and measured performance was studied in the search for patterns in the observed gap between the two sets of scores. This paper does not comment on related issues such as willingness to learn or adopt new practice which has previously been discussed by [8, 9, 17, 30], but the topics of self-perception, technology acceptance, and understanding of technology are all related issues. Only a few participants had previously participated in any of our research efforts (e.g., [6]), but that may have familiarized them with technology in a way that they would not have had the opportunity to do themselves. Prior experience with relevant technology may have a strong influence on the observed performance [24], and the same might be said for domain-related or social factors [8, 14, 23, 27]. Another main reason for including both self-assessment and measured performance was due to the performance scores not always revealing accurate perceptions or intentions behind specific actions. The gap between intended and actual use was also raised by [20].

The results of our analyses suggested that the participants mostly made excellent assessments of their performance. While we observed overestimation from the control group in some instances (Fig. 5), no notable patterns of either over- or underestimation emerged during the analysis that would help us predict future performance, even with similar tasks. The most important takeaway from this analysis would be that older adults, while performing at a lower average level, did not demonstrate any lower capacity to assess their own performance. In fact, the correlations suggested that the older adults were better at not overestimating their own performance when the tasks became statistical significantly more difficult – as seen in the case of dexterity and coordination.

5.4 The Challenge with General Assumptions

As mentioned in the introduction, this paper intends to broaden our understanding of how older adults are affected by changes in psychomotor abilities when interacting with technology. While this paper focuses on touch-based systems, our past efforts have focused on tangible and physical interfaces. The purpose of this specific study was to gather enough empirical evidence to demonstrate the dangers of assuming that older adults inhabit specific psychomotor capabilities regardless of whether they are positive or negative assumptions. Older adults remain a heterogeneous population in terms of being end-users of enabling technology [1]. It should be mentioned that we did not record any similar patterns as previously reported [6] despite using the same abilities and target demographic, albeit with an entirely different set of interfaces. The effects that the type of technology can have on performance have been discussed in past research [6, 31]. For instance, while we have seen an increase in performance in past research efforts when switching from touch-screens to physical interfaces (e.g., in [31]), the results of [10] suggest that this is not a guaranteed relation. Other studies also suggest that touchscreens can offer proficient usability in terms of readability, writing, and gesture control (e.g., [13]). We do not consider these results to be conflicting but rather empirical examples of how performance patterns for such a substantial demographic cannot be easily reduced down to universal truths. Even with similar results, the reported reasons behind the specific results may vary [7]. These arguments are also supported by other studies, e.g., [9, 16, 21].

Our general belief is similar to [10]: no single device will be consistently perceived as the best one. Allowing freedom of choice is about not only our responsibility but also a matter of liability in certain situations [27]. There are concerns related to both inappropriateness and ethical responsibility on the line when suggesting that a specific device will be suited for a particular context – especially in the case of users who might be more vulnerable or technology-dependent in their everyday life than others. The point of ethical considerations arising when designing or discussing technology in the context of lost abilities was also raised by [12, 28, 32]. This paper aligns with these past discussions and attempts to demonstrate why a "one solution fits all" [5] may cause challenges for individual users, and that there is a benefit of having a conscious attitude towards the variance in performance amongst older adults. A positive attitude may contribute with new ways of facilitating technology-related well-being for older adults (as seen, e.g., in [33]). Wrongful assumptions, even those with good intentions, may drastically affect the performance of the users. As also reported in [6], the results presented in this paper suggest that the distance between best and worst performance can be very high and that loss or reduction in one ability does not translate to an equal reduction for all other abilities. We advocate an approach that does not attempt to generalize the traits and capabilities of older adults but instead seek to adapt interaction mechanisms to the continuously changing abilities of all people, including those who fall into the category of older adults.

6 Conclusion

This paper has argued for why older adults should not be considered one large homogenous population with similarly reduced capabilities when interacting with technology. To support our belief of how common assumptions made about older adults can be wrong, we have reported results from an evaluation of psychomotor abilities carried out with 69 participants. Our evaluation highlighted both challenges and opportunities found when older adults engage in interaction with touchscreens using their hands and fingers. The evaluation studied self-assessed and measured performance during task solving of five tasks corresponding to a pre-selected set of psychomotor abilities commonly involved in interaction with touchscreens: precision, steadiness, dexterity, speed, and coordination. Statistical analyses of variations and tendencies were used to study both the self-assessment and the measured performance for the five psychomotor abilities. The discussion revolved around a comparison between the results found in this study and results from similar studies involving either older adults or psychomotor abilities as the unit of analysis. We have attempted to raise important concerns about individual capabilities and challenges with general assumptions about older adults as we argue against common assumptions often made in the context of older adults and enabling technology.

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