How Skill Balancing Impact the Elderly Player Experience?

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***Abstract*—Skill balancing increases game engagement by providing users with suitable challenges. Two common methods of skill balancing are manual difficulty adjustment (MDA) and dynamic difficulty adjustment (DDA). However, little is known about the effect of skill balancing on elderly player experience (PX). We compared two types of skill balancing (MDA and DDA) across two controller types (GamePad and Microsoft Kinect). Our results demonstrate that MDA has higher impact on PX of the elderly. Also we found eagerness of the elderly to attempt playing higher challenges.**
Keywords:Elderly, older adults, game experience, skill balancing, game controller.

I. Introduction

The benefits of sedentary [1] and motion-based video games [2] for elderly have already been demonstrated in previous work. One important component that contributes to the success of these games is skill balancing. Skill balancing is the concept of adjusting skill and challenge to increase the level of engagement [3]. Manual difficulty adjustment (MDA) and dynamic difficulty adjustment (DDA) have previously been developed as main skill balancing methods. Recent work has studied the effect of skill balancing on player experience (PX) for young players [4].

However, little is known about the impact of skill balancing on PX of the elderly. DDA tailors proper challenge regarding users' ability, while MDA provides more autonomy to choose desired difficulty level. Furthermore, another open question is whether skill balancing is influenced by controller type or not. Our work asks the following five questions: (Q1) Which skill balancing method is more effective on PX of the elderly? (Q2) Do the elderly like to use body movement for playing either with MDA or DDA methods? (Q3) Is there any interaction effect between skill balancing and controller type? (Q4) How is game performance affected by skill balancing? (Q5) Do the elderly prefer to play easy games or, like young people, do they prefer to play challenging games?

To clarify these questions, we assessed the PX of 20 elderly adults. Participants were asked to play a custom made game in sedentary and motion-based positions while difficulty was adjusted by MDA and DDA methods. We then measured the following four variables: affect, satisfaction of needs, intrinsic motivation and performance after playing.

Although our results are consistent with previous studies concerning controller type, they contradict findings about skill balancing. We found that MDA had a higher impact on the positive affect of the elderly participants. Also follow-up interviews with our participants revealed that they preferred MDA to DDA. Besides, the Kinect controller was much more effective than GamePad on positive affect and autonomy. We also found that controller type preference did not impact the skill balancing effect on PX of the elderly. Furthermore, the elderly got higher scores when they used the Kinect controller or the MDA method for difficulty adjustment. Finally, game difficulty analysis indicates that even though the elderly like to try more challenges, their limited abilities prevent them from achieving higher scores.

II. Related Work

A. Balancing Skills

Researchers designed video games for the elderly with different objectives like rehabilitation [2], cognitive training [5], entertainment [6] or enhancing physical balance [7]. One of the essential key points for successful game design is engagement. Csikszentmihalyi [3] proposed the relationship between user experience and engagement by flow theory. He explained flow as a state of being fully "in the zone". Flow is achievable when the balance between skill and challenge is optimally adjusted.

There are two common strategies for skill balancing. Basic skill balancing method is MDA which players choose the difficulty level among several levels according to their current feeling or previous experiences. However, most of the players can not predict their skills well, and also MDA is static and the level of difficulty is constant while playing. The second major method is DDA. Researchers developed DDA using different algorithms. For instance, Drachen et al. [8] developed DDA using machine learning in the Tomb Raider game. Hunicke and Chapman [9] explored computational requirement to design threshold heuristics for DDA. However, most of the DDA have cold-start problems. Also they have difficulties in balancing challenge, particularly when encounter with players with special abilities (e.g. elderly). Sill balancing methods mostly have been developed for young players [4]. We will develop the MDA and DDA for difficulty adjustment for elderly players.

B. PX Evaluation

Evaluating PX has been a challenging topic among game researchers. Previous work used questionnaire based on gaming context [10]. Furthermore, Johnson and Gardner [11] proposed an online survey to measure relation between PX, personality and game genre. Kim et al. [12] used event log analysis to track real-time user experience. However, PX measurement was not theoretically grounded in these studies.

A recent work [13] described a comprehensive theory to ground the PX measurement. PX were discussed using needs, motivation and affect. *Player Experience of Need Satisfaction* (PENS) [14] measures competence, autonomy, relatedness, presence and intuitive controls. Competence is derived from challenge, while autonomy is related to a sense of willingness. Presence is "belonging to a group" and intuitive controls is the degree of intuitiveness of the game controls. *Intrinsic motivation inventory* (IMI) [15] was designed to measure motivation. Interest-enjoyment and effort-importance dimensions are the self-report measures of intrinsic motivation. Also, *Positive and Negative Affect Schedule* (PANAS) questionnaire [16] was designed to measure positive and negative affects.

Discussed questionnaires have been recently used in game research to evaluate PX. Peng et al. [17] conducted an empirical study to assess validation of PENS for motion-based games. Moreover, Birk and Mandryk [13] used PENS, IMI and PANAS to evaluate differences between controller types. We will apply these questionnaire to evaluate PX of the elderly.

C. Controller Effect

On the other hand, considering the objective of the game, selecting proper controller is a determining factor in PX. Kavakli et al. [18] found that for higher precision in the game, players prefer to use joystick controller. User's ability also can affect choice of controller. For instance, elderly who suffered from tremor problem has higher efficiency when using the keyboard rather than a mouse [19]. Gerling et al. [20] studied PX after using Mouse, GamePad, Microsoft Kinect and PS Move. They concluded that overall elderly can play with motion-based controllers efficiently. Beside, a recent work [21] showed that despite lower performance, the elderly prefer to play using motion-based controllers. Previous studies did not mention that whether controller type can influence skill balancing or not. We will use GamePad and Kinect controller to study possible interaction effect between controller type and skill balancing.

III. Game Design

We designed a casual game called *Safari*. Figure 1 shows the screenshots of the game. The game has two versions: *Safari Tap* was played using GamePad controller in a sedentary position, and *Safari Move* was played as a motion-based game while the player body was tracked by Kinect. The *Safari* was designed in zoo theme and was inspired by *Whac-A-Mole* arcade game. The *Safari* has enjoyable stimulus-response gameplay where players were asked to act according to the two targets at left and right. There are four holes as the right target. To simplify game playing for the elderly, targets' positions were directly mapped to the controller. In the *Safari Tap*, they were mapped to the position of four buttons of the GamePad. In the *Safari Move* four holes were mapped to the positions of player body parts (e.g. right-up hole were mapped to the right arm).

The left target is a billboard which shows randomly one of the five different shapes (circle, triangle, lozenge, pentagon and square) in four different colours (red, green, blue and yellow). In the game, the player has a basket of apples and water bottles. The goal of the player is to feed animals which pop out from their holes randomly while paying attention to the shape on the billboard. Green triangle indicates feeding with water, while all other conditions determine to feed with apple. The player takes the action either with a pressing button or moving body part. For water feeding in the *Safari Tap*, the player needs to press fifth assigned button simultaneously with other buttons, whereas in the *Safari Move*, the player instructed to first step forward, then move the body part and after that come back to the main position to prepare for the next movement. Each two consecutive successful actions were determined and shown as "*Combo!*" as a clear goal in the game. To sustain players' motivation, "*Nice!*", "*Great!*" and "*Cool!*" visual feedbacks were shown, when the player gets 5, 15 and 30 "*Combo!*", respectively. The player performance was displayed on the bottom-left side of the screen. Suitable background music and audio feedback were used in game design.

IV. Experiment

To compare the effectiveness of skill balancing methods on PX of the elderly, experiment was conducted in within-subjects design with two independent variables. The *Skill Balancing* was within-subjects, comparing the DDA and MDA. The *Controller Type* was within-subjects, asking the participant to play with GamePad or Kinect.

A. Participants

20 elderly adults (5 females) aged 65-85 (M=71.5, SD=6.3) were recruited. None suffered from any visual, auditory, physical or mental impairment. Three participants reported experience of playing video games. However, they never experienced playing motion-based games. Each participant was paid $20.

B. Apparatus

The *Safari* was built using Unity 5.0.0 and C#. The Microsoft Kinect (v1) and the PC GamePad were used for motion-based and sedentary games, respectively. The games ran on a 2 GHz Intel Xeon CPU PC with Windows 8. A 40" Phillips LCD screen with a resolution of 1920 by 1080 was used to display the game.

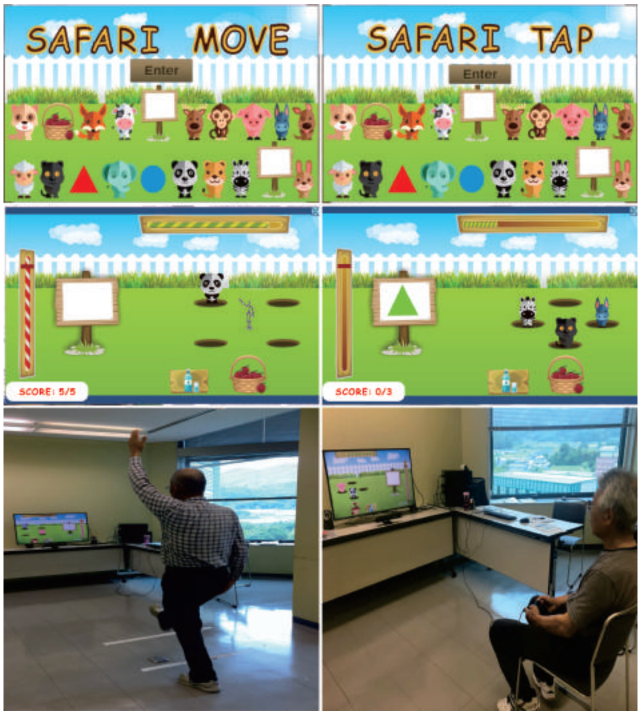

Fig. 1. Screenshots of *Safari Move* (top-left) and *Safari Tap* (top-right), when participants were playing motion-based (bottom-left) and sedentary (bottom-right) games.

C. Difficulty adjustment

Design space of all parameter settings (e.g. action time and time interval) was investigated to define the difficulty. Pilot studies with ten users was conducted where the different parameter settings were played and error rates were recorded. To model the parameter settings, they were mapped to the average error rates. Using the model, 75 categories from easy to hard were generated. Finally, the categories were divided to five levels including *Very Easy*, *Easy*, *Normal*, *Hard* and *Very Hard*.

1) MDA: MDA was implemented using menu interface to let user choose desired level before playing. For each level, a specific category was assigned.

2) DDA: To adjust challenge, the DDA system turned up the categories when the players keep a low error rate, and turned down when they got a high error rate. To avoid cold-start problem, in the easier levels, the fast turn up and slow turn down policy was adopted, which turned up the more categories when the players got the score continuously and turned down less levels when they got wrong. However, to keep challenge, an immediate response policy on the *Very Hard* level was used. When players reached this level of difficulty, next category was played when they got score from the previous category and the previous category was played when they lost.

D. Task and Procedure

Participants first were asked to sign letter of consent and then informed about the goal of study. Demographic information including health background and gaming expertises were gathered. Participants were instructed about game rules, and then they played ten minutes warmup round. Participants played both sedentary and motion-based games approximately 1.7 meters away from the display.

Totally, four games including *MDA-GamePad*, *DDA-GamePad*, *MDA-Kinect* and *DDA-Kinect* were played. To avoid the learning effect and fatigue problems, conditions were counterbalanced using Latin square. During the main experiment, participants played each game in three rounds which each contained 5-minutes playing with 3-minutes rest in between. In *MDA-GamePad* and *MDA-Kinect*, participants chose the difficulty of the game before each round. After each game, participants filled PX questionnaires. Each game including questionnaires lasted about 50 minutes, and total experiment was conducted within two days. A short semi-structured interview was conducted at the end of the experiment. The whole experiment was video-recorded for latter analysis. In summary, the experiment consisted of:

20 participants $\times$
2 skill balancing methods $\times$
2 controller types $\times$
3 rounds $\times$
$=$ 240 trials.

E. Measures

Before playing, health background and gaming expertises information were gathered. During playing, the overall performance of the player and the level of difficulty were logged. *Intrinsic Motivation Inventory* (IMI) [15], *Positive and Negative Affect Schedule* (PANAS) [16] and *Player Experience of Need Satisfaction* (PENS) [14] questionnaires were used to measure *PX*. *Affect* was measured using PANAS. It was filled by the player before and after each condition to calculate offset between individuals before playing. PANAS was rated on 5-point Likert-scale.

Interest-enjoyment and *effort-importance* dimensions from the IMI were used to assess motivation. *Autonomy*, *competence*, *presence* and *intuitive controls* dimensions from the PENS were used to measure needs. IMI and PENS were completed after each condition and rated on 7-point Likert-scale. Finally, semi-structured interviews were conducted to assess overall feeling of participants about four conditions.

V. Results

The Kolmogorov-Smirnov test and homogeneity of variance using Levenes test were performed for parametric evaluation. Cronbach's-α was reported to show consistency of the scale items for each questionnaire. We analyzed PX comparing between *Controller Type* and *Skill Balancing* using repeated-measures analysis of variance (ANOVA) at Mauchly's sphericity tests. Post hoc tests with Bonferroni correction were used for learning effect analysis. Significance was set at $\alpha = 0.05$. SPSS was used to perform analysis. Results were summarized in Table 1.

TABLE I
MEANS, SD AND CRONBACH'S-α FOR IMI, PANAS, PENS, PERFORMANCE AND PLAYER'S RATING.

	GamePad				Kinect				
	Menu		DDA		Menu		DDA		
	M	SD	M	SD	M	SD	M	SD	α
Interest-enjoyment	4.75	1.05	4.65	0.93	4.67	1.21	4.75	1.17	0.93
Effort-importance	4.07	0.94	3.89	0.77	4.13	0.67	3.93	0.60	0.78
Positive affect*,**	2.71	0.44	2.60	0.51	3.01	0.58	2.80	0.62	0.80
Negative affect	2.14	0.61	2.23	0.69	2.10	0.61	2.16	0.68	0.89
Autonomy*	4.40	1.22	4.10	1.28	4.76	1.38	4.63	1.40	0.90
Competence	2.91	1.25	2.70	0.93	2.75	1.27	2.86	1.27	0.83
Intuitive control	3.80	1.06	3.80	0.99	3.86	1.01	3.65	1.04	0.88
Presence	4.02	1.24	3.96	1.23	4.20	1.14	4.06	1.10	0.95
Performance (%)*,**	72.6	15.68	51.5	8.51	90.6	10.60	64.4	5.23	-
Rating*	5.20	1.28	4.60	1.35	5.15	1.34	4.80	1.39	0.79

(*) indicates main effect in Controller Type. Main effect in skill balancing is indicated by (**).

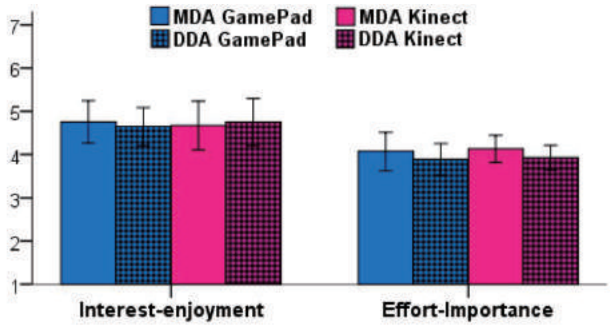

Fig. 2. Means (95% Confidence Interval) for IMI

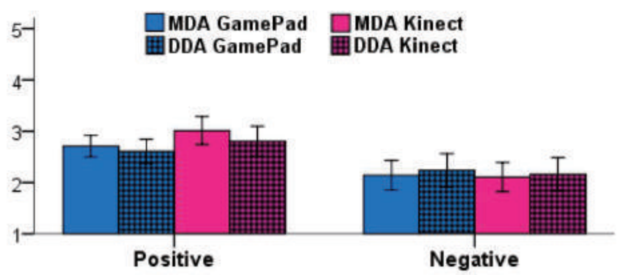

Fig. 3. Means (95% Confidence Interval) for PANAS

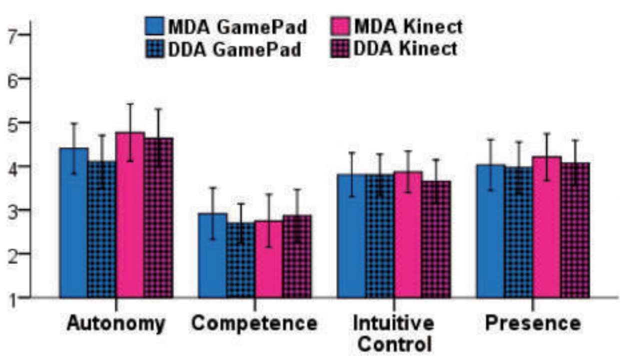

Fig. 4. Means (95% Confidence Interval) for PENS

A. Motivation (IMI)

Figure 2 shows IMI subscales. There is no main effect on the *interest-enjoyment* or *effort-importance*. The results show that enjoyment and motivation of the players did not changed after playing with different *Controller Type* or *Skill Balancing*. However, motivation with the MDA is higher than the DDA ($p = 0.09$). There is no interaction effect in *Controller Type* $\times$ *Skill Balancing*.

B. Affect (PANAS)

Figure 3 shows PANAS subscales. There is a main effect in *Controller Type* ($F_{1,19} = 6.09$, $p < 0.023$, $\eta^2 = 0.243$) on *positive effect*. The players experienced higher *positive effect* for the Kinect ($M = 2.91$, $SD = 0.60$) than the GamePad ($M = 2.65$, $SD = 0.47$). There is also a main effect in *Skill Balancing* ($F_{1,19} = 7.68$, $p < 0.012$, $\eta^2 = 0.288$) on *positive effect*. The MDA ($M = 2.86$, $SD = 0.53$) has higher *positive effect* than the DDA ($M = 2.70$, $SD = 0.57$). *Positive effect* is significantly higher that *negative effect* ($F_{1,38} = 15.24$, $p < 0.001$, $\eta^2 = 0.28$). No main effect was found on *negative effect*. There is no interaction effect in *Controller Type* $\times$ *Skill Balancing*.

C. Need Satisfaction (PENS)

Figure 4 shows PENS subscales. There is a main effect in *Controller Type* ($F_{1,19} = 4.32$, $p < 0.05$, $\eta^2 = 0.18$) on *autonomy*. The results indicate sense of *autonomy* is higher for the Kinect ($M = 4.70$, $SD = 1.38$) compared to the GamePad ($M = 4.25$, $SD = 1.25$). There is no main effect in *Skill Balancing*. But, the MDA ($M = 4.58$, $SD = 1.30$) has higher score of *autonomy* compared to the DDA ($M = 4.36$, $SD = 1.36$, $p = 0.14$). There is no main effect in *Controller Type* or *Skill Balancing* on *Competence*, *intuitive controls* and *presence*. Also, there is no interaction effect in *Controller Type* $\times$ *Skill Balancing*.

D. Performance

Results are shown at Figure 5. There is a main effect in *Controller Type* ($F_{1,19} = 45.67$, $p < 0.001$, $\eta^2 = 0.70$). *Performance* for the Kinect ($M = 77.50$, $SD = 15.61$) is higher than GamePad ($M = 62.14$, $SD = 16.41$). There is also a main effect in *Skill Balancing* ($F_{1,19} = 175.25$, $p < 0.001$, $\eta^2 = 0.90$). The MDA ($M = 81.64$, $SD = 16.02$) *performance* is notably higher than the DDA ($M = 57.99$, $SD = 9.53$). There is no interaction effect in *Controller Type* $\times$ *Skill Balancing*.

E. Learning effect

Figure 6 shows learning effect analysis of difficulty level for MDA. There is a main effect in *Order* ($F_{2,76} = 71.880$, $p < 0.001$, $\eta^2 = 0.65$, Mauchly not sig.). Post hoc comparison revealed a significant difference between the first ($M = 2.07$, $SD = 0.94$), second ($M = 2.90$, $SD = 1.08$) and the third ($M = 3.75$, $SD = 1.23$) rounds ($p < 0.001$).

Figure 7 shows learning effect analysis of performance. Results indicate main effect in *Order* ($F_{2,158} = 17.440$, $p < 0.001$, $\eta^2 = 0.18$). Post hoc tests showed third round performance ($M = 63.9$, $SD = 20.9$) is significantly lower than ($p < 0.001$) first round performances ($M = 73.6$,

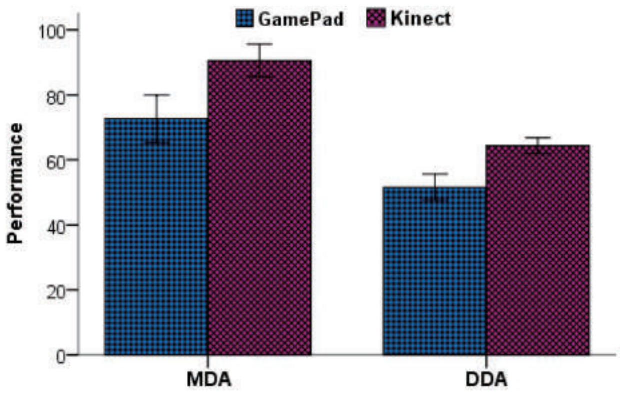

Fig. 5. Means (95% Confidence Interval) for Performance

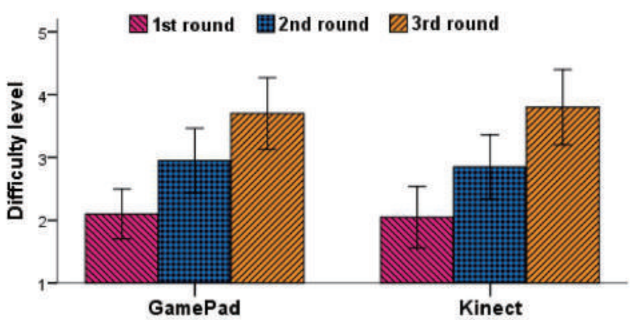

Fig. 6. Learning effect. Means (95% Confidence Interval) for Difficulty level using MDA.

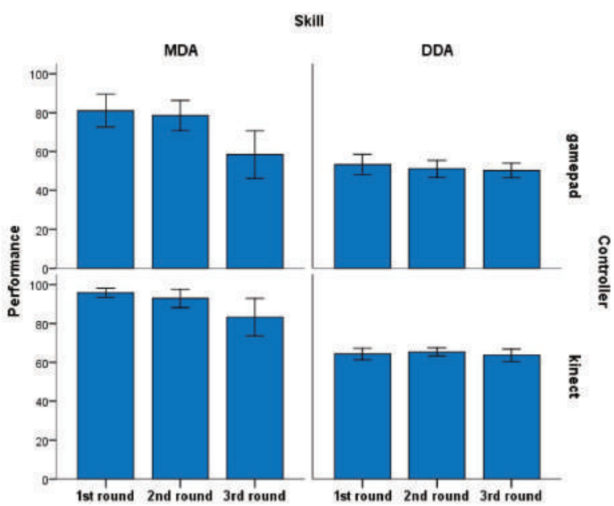

Fig. 7. Learning effect.Means (95% Confidence Interval) for Performance

$SD = 19.7$), and lower than ($p < 0.001$) second round performances ($M = 71.9$, $SD = 18.9$). But there is no difference between first and second round performances.

F. Interviews

In the interviews, participants were asked to give a score for each game regarding overall preference. The scores were rated on 7-point Likert-scale (1 = *not useful*, 7 = *very useful*). Friedman test was used. There is no main effect in *Controller Type* or *Skill Balancing*. Overall preference for the MDA is higher than the DDA, but the GamePad and Kinect are equal. 13 participants said *they like to play the Safari Tap rather Safari Move*. Four out of five participants said that *they prefer to change game difficulty by themselves*. 14 participants presented positive feelings about playing the games. The most used keywords were *"healthy"*, *"happy"*, *"interesting"* and *"good"*. While other 6 participants used *"difficult"*, *"aimless"*, *"uninteresting"* and *"nervous"* words to express their feelings about the games.

VI. Discussion and Conclusion

Our work explores PX of elderly players. We focused on affect, need of satisfaction and intrinsic motivation. We describe significance of the findings according to the five questions which were asked before.

Previous studies have measured need, motivation and affect to assess effect of different modalities (e.g. controller or difficulty choice method) on PX of young players [4], [13]. We used same method in our work to find how controller type and skill balancing affect PX of the elderly. Our findings shed lights preference of the elderly particularly about skill balancing methods. Analyzing PANAS data shows that overall positive affect is higher than negative affect, indicating the elderly enjoyed playing our game.

Q1: We found that the elderly have higher motivation when they adjust difficulty by themselves (MDA) rather than playing with DDA. Also, elderly felt higher positive effect when chose difficulty manually before game playing (MDA) rather than DDA. Comparing sense of autonomy between the MDA and DDA methods indicates that elderly when playing with MDA has higher feeling of independence. Elderly players likes MDA because it gives more sense of freedom to choose the desired difficulty level.

Q2: Researchers [13] found that Kinect is much more interesting than GamePad for young players. Our finding indicates that elderly has the similar motivation between controllers types. We also found that elderly after playing with Kinect has higher positive affect than GamePad which is consistent with previous findings about young players [13]. Consistent with previous studies, players after Kinect gameplay experienced higher autonomy than GamePad. The elderly can freely move body when using motion-based controller, while playing with GamePad is more restricted.

Q3: Controller preference did not influence skill balancing method. However both factors had notable impact on PX of the elderly.

Q4: The elderly after playing with MDA has higher performance rather than DDA. Additionally, performance for Kinect is higher than GamePad while there is no difference in game difficulties between controller types.

Q5: Examining log files related to difficulty levels shows that selected level of difficulty with MDA is lower than DDA. However learning effect analysis in performance and difficulty level of MDA shows that the elderly surprisingly increase difficulty level between rounds even performance goes down. So we conclude that it is a misconception that the elderly do not like challenge. DDA attempts to increase challenge to the borderline of elderly's capacity, which affect negatively PX of elderly.

In general, considering PX of the elderly, we can conclude that although there is no interaction effect between controller type and skill balancing, both are effective on PX of elderly. MDA causes higher positive effect performance for the elderly. Also, interview results support our findings that MDA is more popular than DDA. The current findings indicate that to design more effective DDA for the elderly, researchers need to develop new strategies which can be better adopted with abilities of the elderly. On the other hand, the controller type analysis shows that the elderly can efficiently play motion-based games. The elderly using Kinect achieve higher performance, feeling of positive affect and autonomy compared to GamePad.

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