Belief in Health Benefits of Digital Play Modulates Physiological Responses to Games Played for Cognitive Benefits

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BACKGROUND AND AIMS

In recent years, digital games have been promoted as health-boosting activities for older adults [1,2]. However, the novelty of the digital medium of play, combined with pressure on 'ego' resulting from the implied link between cognitive health and game performance, may create stressful experiences for them[3].

We have previously proposed an empirical framework, Affective Game Planning for Health Applications (AGPHA) based on Lazarus's Transactional Theory of Stress Appraisal and Coping[4]. AGPHA emphasizes the importance of iterative interactions between appraisal of the benefits or harms of facing a new challenge, in relation to physical and cognitive and behavioral traits as factors that motivate or de-motivate an individual to approaching or avoiding a new experience.

In this study we deployed the AGPHA framework (**Fig 1**) to investigate

H1: The primary appraisal (PA) of health benefits of playing predict differences in physiological response to games.

H2: Physiological response to game-playing predict differences in secondary appraisal (SA) of games.

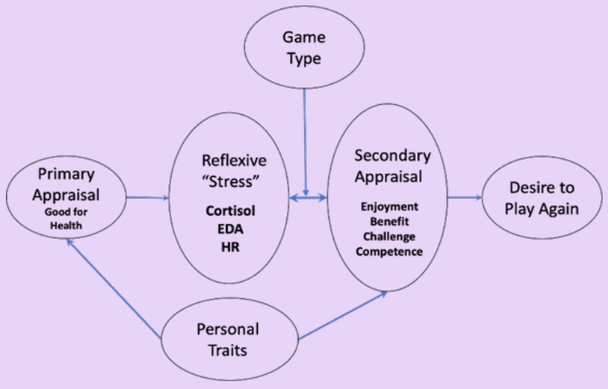

Fig. 1, Schematic diagram of AGPHA tested in this study.

MATERIALS AND METHODS

Experimental Design (Fig 2): Eighteen older adults (**Table 1**) joined a 3-session study and were introduced to incrementally difficult games starting with a Brain Training game (Simple Mind Games, for iPad MG in session 1), a Car Race Game (RealRacing 3 for iPad, CRG in session 2) and an exercise dance game (Dance Central, for Xbox 360 Kinect, EG in session 3). PA questions were asked in the screening session. SA questions were asked at the end of each session. Sessions were identical in procedure and timing, with the only difference being the game type. Each session consisted of a Baseline epoch (Demo of the game), Play 1 (playing for 10 mins with help from an RA), and Play 2 (playing for 10 mins without help from RA, but under observation.)

Explanatory Variables: **Primary appraisal (PA)**: "Playing games is good for health". **Secondary appraisal (SA)**: Based on the Intrinsic Motivation Inventory (IMI) , we asked participants to rate whether they agreed or disagreed with statements about the playing experience being Enjoyable; Difficult; Stressful; Frustrating; Visually intense, good for mental wellness; and cognitively stimulating. Responses were binarized to 'agree' and 'disagree'. **Physiological responses**: Electrodermal activity (EDA) and heart rate (HR) (6 timepoints) were continuously monitored from a wristband (E4, Empatica) and data was averaged over the duration of each Epoch per Session (Baseline, Play 1, Play 2). Salivary cortisol was measured at the beginning of each Epoch. **Personal Factors**: Perceived Stress Scale, UCLA loneliness and General Self Efficacy were measured.

Outcome Variable: "I would like to play the game again in the future." (yes/no)/ **Statistical Analysis:** In order to account for within-subject variance, all tests were done using generalized estimating model (SPSS 20, IBM).

Table 1: Participant Characteristics

Personal Characteristics	Primary Appraisal Good for Health?		Statistical Difference
	Yes	No	
Gender(M/F)	2/9	4/3	χ^2=2.9, p=.09
Age (mean, sd)	71.2, 4.8	70.0, 4.2	t=.53, NS
Generalized Self Efficacy	34.7, 2.6	33.6, 2,7	t=.39, NS
Perceived Stress Scale	15.8, 3.7	19.4, 2.3	t=-2.3, p=.036
UCLA Loneliness Index	9.91, 2.98	8.57, 22	t=.36, NS

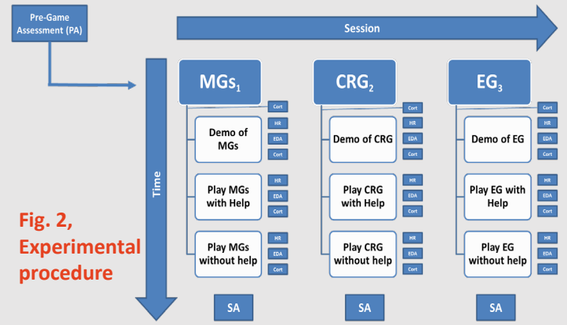

Fig. 2, Experimental procedure

RESULTS

H1:Belief in positive health effects of playing games, is associated with significant physiological differences in response to the game. Higher levels of EDA and Cortisol in those who find games more beneficial suggests that these individuals invested more effort and attention to the games. The more difficult the game (EG) the more pronounced the effect. **(Fig 3)**

H2: Differences in physiological response to games predicted differences in SA (**Table 2**) but this was game dependent . For example, higher cortisol and HR during CR was associated with finding the game more cognitively stimulating, but higher HR during the EG was associated with finding the game stressful. Both Cortisol and EDA were significant predictors of desire to replay in MGs. Those with higher Cortisol during MG were less likely to wish to play again, but those with higher EDA were more likely to wish to play it again.

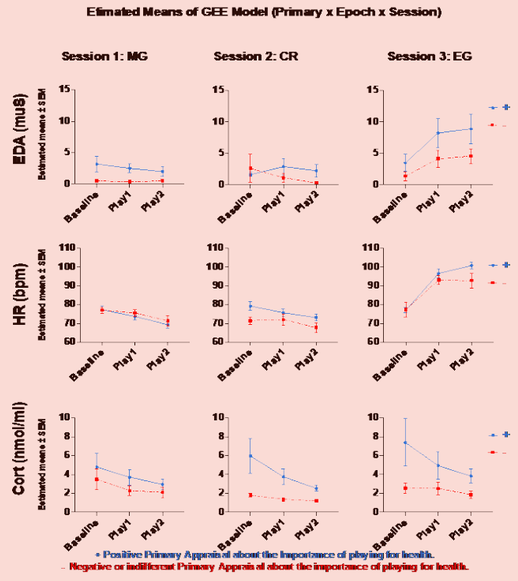

Fig. 3, Effect of PA on physiological reaction to games

Table 2: Logit GEE: effect of physiological factors on SA

Secondary Appraisal (DV)	Cortisol	HR	EDA
Difficult	NS	NS	NS
Stressful	NS	7.99, p<0.02	12.0, p<.002
Mental Wellness	NS	NS	12.9, p<.002
Cognitive Stimulation	6.29, p=.043	5.58, p=.06	NS
Intense	NS	NS	NS
Frustrating	NS	NS	NS
Like to play again	12.4 p<.002	NS	4.6 p<.10

Note, all statistics are Wald $\chi^2_{(df=2)}$, p; NS: statistically not significant p>0.1

CONCLUSION

Our results illustrate that the AGPHA framework is sensitive to detecting physiological variations that arise from PA and SA appraisal of different games.

The relationship between appraisal and stress response is complex and game-dependent, therefore, in designing game-based health interventions and iterative and adaptive evaluation of reflective and reflexive reaction to the game is necessary.

References: **[1]** Anguera, J.A., et al. (2013). Video game training enhances cognitive control in older adults. Nature, 501(7465): p. 97-101; **[2]** Loos, E. and A. Zonneveld (2016). Silver Gaming: Serious Fun for Seniors?, in Human Aspects of IT for the Aged Population. p. 330-341; **[3]** Khalili-Mahani, N., et al. (2020). For Whom the Games Toll: A Qualitative and Intergenerational Evaluation of What is Serious in Games for Older Adults. The Computer Games Journal, 9(2): p. 221-244; **[4]** Khalili-Mahani, N. & B. De Schutter (2019), Affective Game Planning for Health Applications: Quantitative Extension of Gerontoludic Design Based on the Appraisal Theory of Stress and Coping. JMIR Serious Games 7(2): p. e13303.